OKLAHOMA
AGRICULTURAL AND MECHANICAL COLLEGE
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History and Control of the Boll Weevil In Oklahoma

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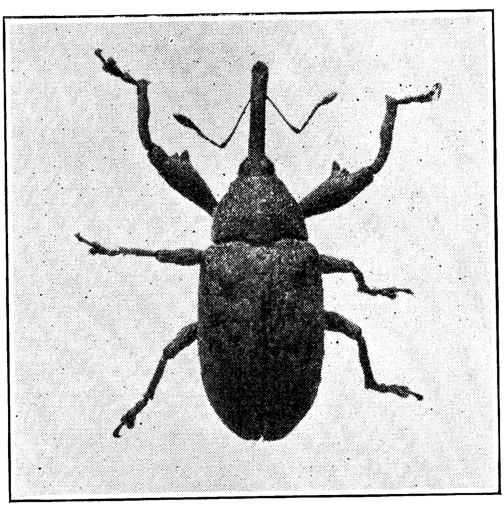

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EXPLANATION AND ACKNOWLEDGMENT

This bulletin combines the results of research, observation and demonstrations carried on in the study and control of boll weevil in Oklahoma by the U. S. Department of Agriculture, Bureau of Entomology; the Oklahoma A. & M. College Agricultural Experiment Station and the Oklahoma A. & M. College Extension Division. Each group of workers acknowledges the contributions of the others toward the joint result.

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For a uniform distribution of poison in sections of heavy weevil infestation where poisoning is desirable.

I. HISTORY AND DISSEMINATION

EARLY HISTORY AND DISSEMINATION OF THE BOLL WEEVIL IN OKLAHOMA, AND BRIEF LIFE HISTORY

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INTRODUCTION

This is a joint publication made by the Department of Entomology of the Oklahoma A. & M. College and Experiment Station, the Bureau of Entomology of the U. S. Department of Agriculture, and the Extension Division of the Oklahoma A. & M. College, the U. S. Department of Agriculture cooperating.

The experiments and demonstrations as herein given were carried on mostly in the southeastern part of the state where the weevil generally prevails throughout the cotton growing season.

Infestation has never been of sufficient uniformity and duration on the State Experiment Station grounds near Stillwater to justify seasonal experimentations, consequently it has been necessary to obtain the cooperation of farmers owning fields in the more typically infested areas in the southeastern part of the state in order to carry on experiments and demonstrations.

The writers of this publication are familiar with the voluminous data and methods of procedure of other entomologists who have published on this subject. The usual inclusion of such bibliography has not been thought to be necessary in this publication because it is available in other publications on the same subject.

EARLY HISTORY AND DISSEMINATION OF THE BOLL WEEVIL

The first boll weevils found in Oklahoma (then Indian Territory) were near the town of Caddo, in Bryan county, during the summer of 1905. Specimens were sent to the Texas A. & M. College at College Station, Texas, and identified as genuine Mexican cotton boll weevils. A year or two later a statement pertaining to boll weevil damage was published in the Sixteenth Annual Report of the Oklahoma Experiment Station for the years 1906-1907, pp. 50-51, as follows: "The cotton boll worm and Mexican cotton boll weevil are threatening our cotton industry with disaster." This was about 14 years after the weevil first entered Texas from Mexico.

Peculiarly enough, however, no state funds were made available during those times in Oklahoma for the State Experiment Station to conduct any experimental work pertaining to the habits or control of the weevil in Oklahoma.

Meantime, the U. S. Bureau of Entomology was conducting experiments on the weevil in southern Texas. Its life history was worked out for that region and many suggested methods of control were tested and found to be more or less inefficient. Its average annual mileage rate of dispersion northward and eastward was found to be about 65 miles.

Meantime, in Oklahoma (Indian Territory) cotton was found to be the principal cash crop. Its new pest which came from Texas into the southeastern part of the state disseminated rapidly northwestward. (See Figs. 4, 5, 6 showing the annual dispersion in Oklahoma to date except for the years 1926, 1927 and 1928). At the end of the summer of 1916 it had spread practically over the then entire cotton growing area of Oklahoma. Since then its boundary line of infestation to the west and north has annually increased or decreased, depending largely on the number of weevils going into winter quarters and the effect of the weather on the hibernating forms. During all this time the boll weevil was reaping an annual toll of from 20 to 40 percent of the infested cotton crop in Oklahoma.

From 1916 to 1932 the average annual cotton production in Oklahoma was 1,048,062 bales.[1] The average price per bale was $91.81. Since the boll weevil destroyed from 20 to 40 percent of the crop, it is seen that the annual production should have been at least 20 percent more, or 1,310,078 bales. In other words, the weevil caused an annual loss of 262,016 bales, valued at $24,055,688.96. For the 16 years considered this loss amounted to $384,891,023.36.

BRIEF LIFE HISTORY OF THE BOLL WEEVIL

The boll weevil is not known to develop in Oklahoma on any other plant than cotton. Some of the overwintering weevils may begin to emerge as soon as cottonseed germinates. The largest number, however, issue during June but some emerge as late as the first part of July. (For percentage of overwintering weevils see Table III.) The early issuing weevils feed on the tender young leaves of the plants. During midseason the interior of the squares is practically the only part of the cotton plant eaten by them. Later in the season they will feed on the interior of green bolls or on tender leaves when no squares are present.

[1]Basic figure obtained from U. S. Year Books for the years considered.

In the developing squares and green bolls the females deposit the eggs in punctures made by a set of mandibles or teeth in the end of the beak. (See Fig. 1.) The punctures made for the reception of the eggs are very similar to the punctures made in the squares for food purposes. In addition to these punctures the presence of yellowish excreta is an added indication of weevil prevalence.

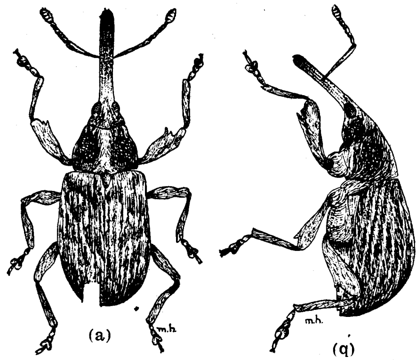

Fig. 1.—Cotton boll weevil: (a) Beetle, from above; (b), same, from side. About five times natural size.

Rarely more than one egg is deposited in one square. When weevils become numerous and squares become scarce, they will lay eggs in the developing bolls. Each female may deposit an average of 140 eggs. During warm weather the eggs hatch into larvae within two or three days.

The larvae, grubs or maggots, as they may be called, are footless and develop only in the squares (see Figs. 2a and 3) or bolls and ordinarily within a period of from seven to twelve

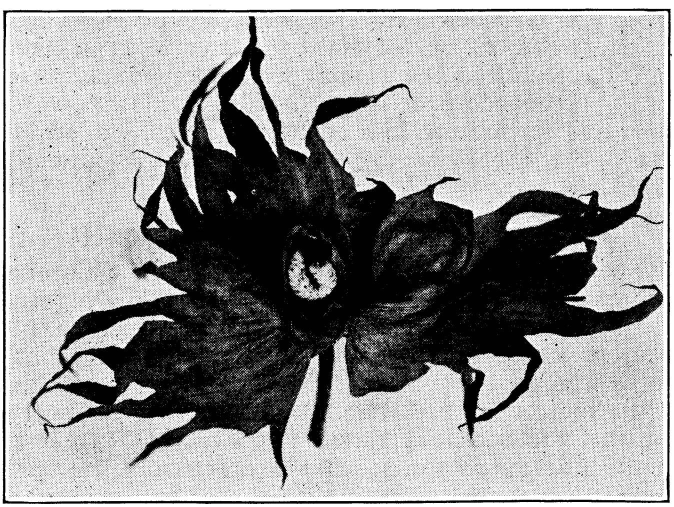

Fig. 2a.—Cotton square showing larva of boll weevil. One and one-half times natural size.

days. Cold weather delays and warm weather hastens development. Very hot, dry weather may either kill the immature forms or dry the green fallen squares sufficiently to prevent their development.

The pupal state (see Figs. 2b and 3) is found in a cavity of the square or boll made by the larva in obtaining its food. This stage requires from three to five days. The total length of time required for the hatching and development of a boll weevil is from two to three weeks.

Three to four generations and a portion of a fifth and sixth generation may develop in this state in one growing season. The total progeny of one pair may amount to between four and five millions of boll weevils in a season.

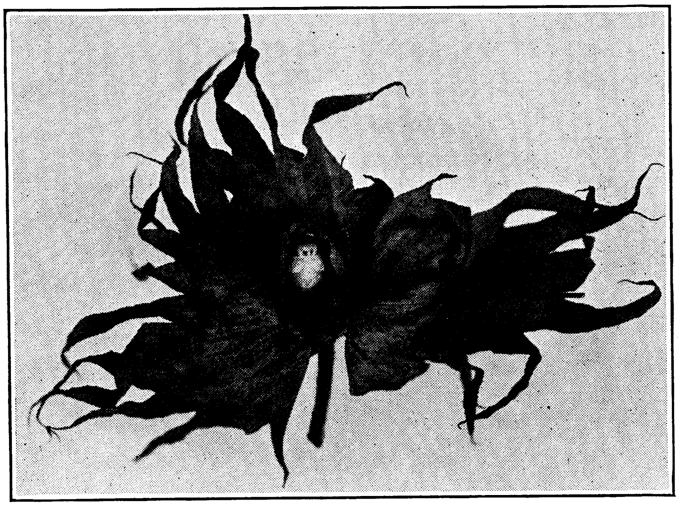

Fig. 2b.—Cotton square showing pupa of boll weevil. One and one-half times natural size.

Cotton squares are sufficiently developed in early advanced fields of the southeastern part of the state by the middle of June each year to become infested.

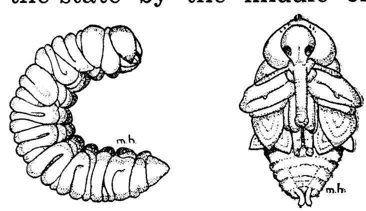

Fig. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size.

Egg laying is begun at this time by some of the overwintered weevils. Young weevils of the first generation may begin to appear by July 1, and begin laying eggs one week later. Meantime, however, the hibernating individuals will have been issuing from winter quarters so that these, together with the first generation, may cause a very noticeable flaring of squares by the 10th of July. Some of the hibernated weevils probably survive until the appearance of the second generation which is approximately July 18, but they doubtless disappear before the appearance of the third generation which is about August 4. A general weevil migration usually occurs about August 1. Temperature and rainfall have much to do with the weevil increase or decrease during the important square and boll production months of June, July and August.

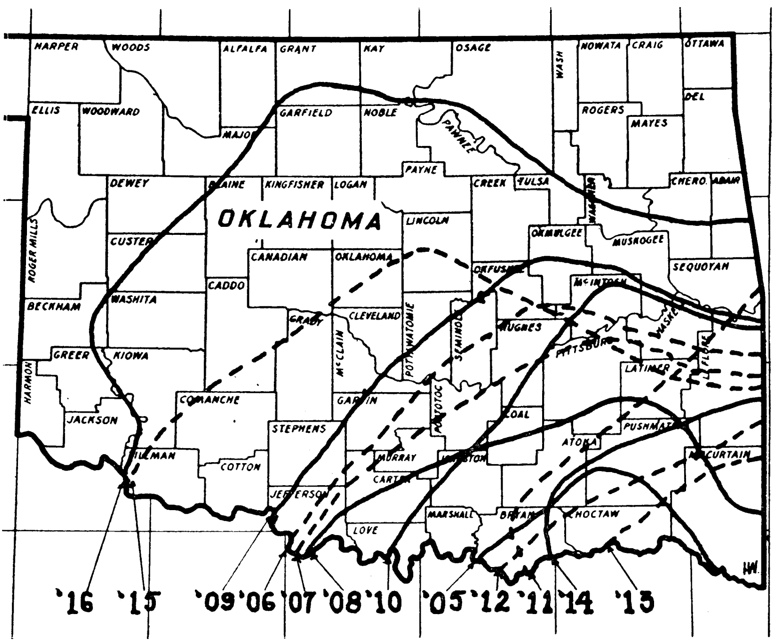

Fig. 4.—Annual northern and western boundary line of boll weevil dissemination in Oklahoma from 1905 to 1916.

One pair of weevils under proper conditions can be the direct source of enough weevils in four generations to furnish a weevil for every square of cotton grown on 384 acres of land having 10,000 plants in each acre and 100 squares to each plant.

It is assumed from a study of the life history of the summer broods that the first generation will begin to decrease during August. Briefly summarizing the prevalence of particular broods during the cotton productive season, therefore, we find that the hibernating brood and the first generation augmented by a partial second generation is prevalent during July.

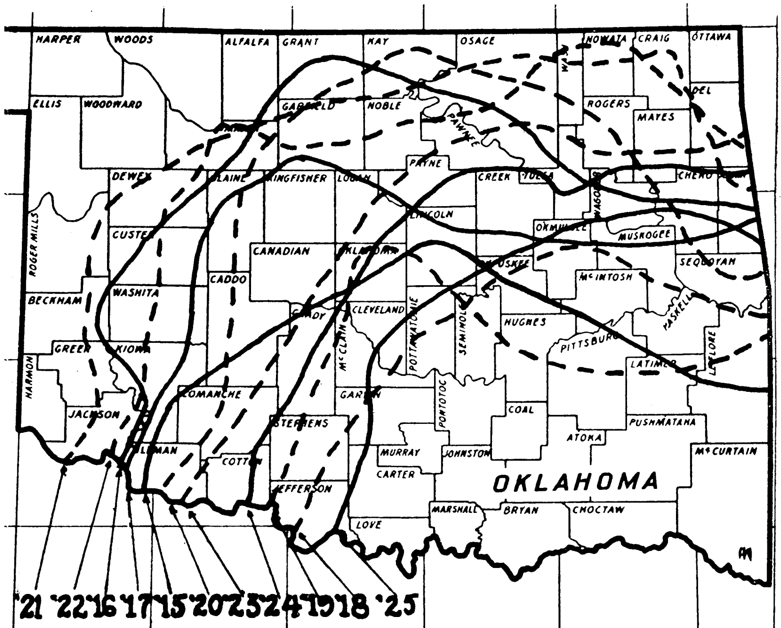

Fig. 5.—Annual northern and western boundary line of boll weevil dissemination in Oklahoma from 1916 to 1925.

The second generation, augmented by a partial first and with complete third and fourth broods, is prevalent during August. These continue into September and are augmented by a partial fourth and perhaps fifth generation. The sixth generation begins during the first part of October and continues until the plants are killed. During some years parts of the third, fourth, fifth and sixth broods continue to develop until the middle of December.

About the time of the first killing frost (October 19 to November 30, or later) the weevils are compelled to enter hibernation quarters or perish. They may begin to seek hibernation quarters, however, several weeks before being compelled to do so by the advent of cold weather. They seek such places as piles of brush, leaves, weed rows, meadows, corn fields, woodlands, cotton bolls, stored cottonseed, hulls, and gin trash, which furnish protection from excess moisture and variable temperature.

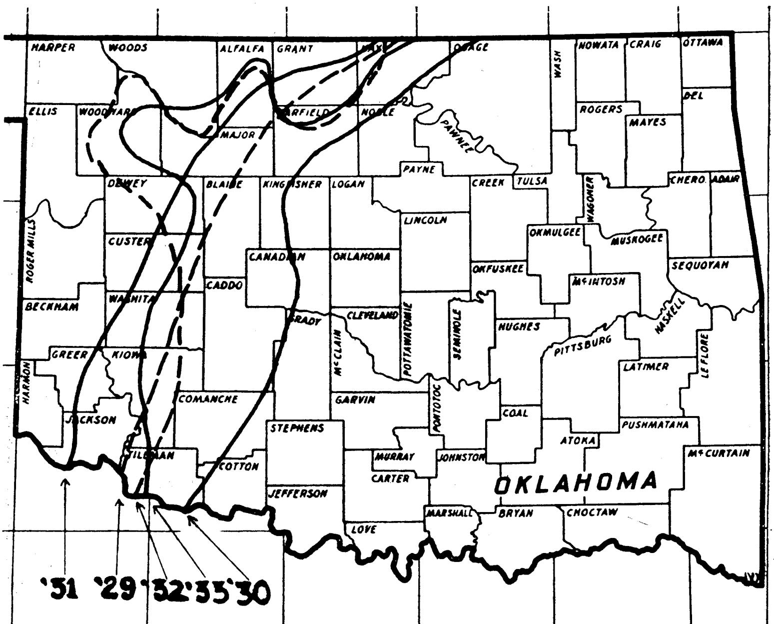

Fig. 6.—Annual northern and western boundary line of boll weevil dissemination in Oklahoma from 1929 to 1933.

II. CONTROL EXPERIMENTS BY THE COLLEGE

By EPHRIAM HIXSON
Assistant Entomologist

The plats used in these experiments were laid out in fields of uniform drainage, soil and fertility. The plats were one acre in area, except in fields where the rows were so short that more than 30 rows were required to make an acre, in which cases less than one acre plats were used.

In each field, check or unpoisoned plats were used to determine the effect of the poison both on infestation and yield. All plats were cultivated and handled the same except for the poisoning.

The time of applying the poisons was determined by making weekly counts for weevil infestation by the three- or five-point method depending upon the size of the plat.

The presquare treatment was applied after most of the hibernated weevils appeared and before the squares were large enough to be punctured by the weevils.

Sweet bait was used as a presquare application at the rate of one gallon per acre, applied with a rag mop to the bud terminals or tops of the cotton by hand labor. In 1931, one plat was poisoned with calcium arsenate dust as a presquare application and poisoned the same as the other dust plots after 10 percent infestation, but the results were no better than the ordinary dust applications.

Calcium arsenate dust was used at the rate of five to seven pounds per acre except the first three applications in 1932 when four pounds per acre were used while the cotton was small. Later applications were six to eight pounds per acre. The applications were made at night while the cotton was moist with dew, except in 1931 one plat was dusted in the day after the plants were dry. Applications were started as soon as the infestation reached 10 percent, except as presquare and in 1928 when most fields did not reach 10 percent infestation, and applied every four days or weekly until the experiment was closed or the infestation dropped below 10 percent.

The dust was applied with hand dust guns and a power duster. The power duster was used only in one field each year.

Sweet bait was applied at the rate of one gallon per acre, following the presquare treatment, after 10 percent infestation and thereafter weekly, except in 1928 when the infestation did not reach 10 percent in some fields. In large cotton the applications were slightly more than one gallon per acre.

Sweet bait was made with one gallon of molasses, or other sweet material, one gallon of water and one pound of calcium arsenate. Blackstrap, honey, coca-cola, and white karo molasses were used alone or in combinations in the place of molasses in the bait. There was very little difference in the gains made by the various sweet baits used. They are not shown separately, but designated only as "sweet bait" in Tables I and II.

When sweet bait was followed by dust, the sweet bait was applied in the regular way from one to four times either as a presquare treatment or after 10 percent infestation, following which calcium arsenate dust was applied in the regular manner until the experiment was closed.

Sodium fluosilicate was used in place of calcium arsenate in the mixture of sweet bait to compare with the regular sweet bait and the dusts. It was applied in the same manner as the other sweet baits. The gains were about the same as for the other sweet baits.

Synthetic cryolite was used as a dust in 1932 in comparison with calcium arsenate. It dusted fairly well, but did not stick to the foliage as well as the calcium arsenate, but better than sodium fluosilicate. The results are shown in Table I. In Table I, the difference in the check yield and treated yield will not always give the amount of gain or loss shown, due to using the average of all plats regardless of whether they were in the same field or in the same year or the same number. Note there are 19 check plats for 1922-1924 and only three molasses plats for 1924 only. The check plats comparable to the three molasses plats are averaged with other check plats and the gain shows more than it actually was when compared to the plats used in the same field the same year. Note in Table II the check plat yield is higher in 1924 than in 1922 or 1923.

Calcium chloride was used at the rate of one pound to one gallon of molasses in the regular sweet bait in 1931 and 1932, in order to prevent the latter from drying rapidly after application. The gains were about the same as for the other sweet baits.

The cost of poisoning was figured on the basis of the current price for farm labor and materials used.

The profit was determined by multiplying the gain in pounds by the current price of seed cotton and subtracting the cost of treatment. The cost of picking the gain, ginning, and hauling is considered as an additional expense, but is not included in the total cost of treatment. The profit from poisoning will always vary with price and yield.

As the price of cotton rises, the lower yielding lands can be poisoned with a profit, but as the price lowers, only the higher yielding lands will return a profit from poisoning, provided always of course that there is sufficient weevil infestation to necessitate the treatment.

A low infestation, when treatment is applied, has the same effect as low yield per acre. Note (in Table I) the low infestation of 9.7 to 13.2 percent for the year 1928. It can be seen that there was a margin of less than four percent infestation between the check plats, and the poisoned plats.

Under low infestation conditions, the results of treatment are never consistent, but depend more on soil variation than on poison for the gain or loss. To get a gain from poisoning, the infestation in unpoisoned cotton must rise almost constantly, and the higher the infestation goes the better the chances of making a gain.

Note also in Table I the data for 1922, 1923, 1924, (taken from Oklahoma Experiment Station Bulletin No. 157) show that the gains are small. In 1922, the check plats made 382, 475, 749,

TABLE I.—This table shows the average results of treatments for boll weevil control of 1922, 1923, 1924, 1928, 1929, 1931, 1932, and gives the price of seed cotton for each of these years as 8, 8, 8, 7½, 6, 2½ cents per pound respectively, from which prices the profit or loss for the years considered was figured.

No. of plots	Kind of treatment	APPLICATIONS		Percent of infestation	Yield lbs.	Gain lbs.	Net profit cotton
		No.	Cost				
	1922-1924						8 cent
16	Calcium arsenate dust		$ 6.30		670	45	—$2.70
19	Check (unpoisoned) (1924 only)				639		
3	Molasses arsenate		5.49		798	78	0.75
2	Nicotine arsenate		11.71		833	—7	—12.31
	1928						7½ cent
8	Calcium arsenate dust	4.7	3.86	10.4	756	31	— 1.54
11	Sweet bait	3	2.75	9.7	817	92	4.15
11	Sweet bait plus Calcium arsenate dust	5.2	5.01	10.6	922	197	9.76
7	Check (unpoisoned)			13.2	725		
	1929						6 cent
32	Sweet bait	4.7	3.64	19.5	705	134	4.40
5	Calcium arsenate dust	5.4	2.59	20.5	757	126	4.97
15	Sweet bait plus Calcium arsenate dust	5.8	3.98	34.2	777	131	3.68
6	Check (unpoisoned)			31.5	638		
	1931						2 cent
6	Sweet bait	8.9	4.65	21.0	1460	240	0.15
9	Calcium arsenate dust	7	4.81	13.0	1840	620	7.59
3	Sweet bait plus Calcium arsenate dust	8	4.79	8.3	1506	311	1.43
3	Sodium fluosilicate dust	8	8.95	17.9	1628	354	— 1.87
6	Check (unpoisoned)			32.5	1220		

TABLE I.—(Continued)

No. of plots	Kind of treatment	APPLICATIONS No.	APPLICATIONS Cost	Percent of infestation	Yield lbs.	Gain lbs.	Net profit cotton
	1932						2½ cent
9	Sweet bait	9.4	3.50	27.4	1158	103	– 0.94
7	Calcium arsenate dust	8.5	4.59	19.4	1429	433	6.37
3	Cryolite dust	8.3	7.86	37.1	1268	270	– 1.11
2	Adhesive calcium arsenate dust	6.5	4.82	28.1	1549	479	7.15
2	Sodium fluosilicate dust	9	8.96	38.6	808	–49	–10.18
7	Check (unpoisoned)			49.16	1053		

TABLE II.—Comparison of gains from treatment with calcium arsenate dust on 45 plats and 61 sweet bait plats, and cost of treatment in Oklahoma, 1922-1932.

Year	No. of tests	Check yields in pounds of seed cotton per acre	CALCIUM ARSENATE DUST: Av. gain in pounds of seed cotton per acre	CALCIUM ARSENATE DUST: Av. number of applications	CALCIUM ARSENATE DUST: COST OF TREATMENT: Per acre	CALCIUM ARSENATE DUST: COST OF TREATMENT: Per 100 pounds of gain	SWEET BAIT APPLIED WEEKLY INTERVALS THROUGHOUT SEASON: No. of plats	SWEET BAIT: Av. gain in pounds of seed cotton per acre	SWEET BAIT: Av. number of applications	SWEET BAIT: COST OF TREATMENT: Per acre	SWEET BAIT: COST OF TREATMENT: Per 100 pounds of gain
1922	4	608	62		4.91	7.91					
1923	9	602	57		5.10	8.94					
1924	3	719	–13		8.88		3	78	3	4.49	5.75
1928	8	725	31	4.7	3.86	12.45	11	92	3	2.75	2.98
1929	5	638	126	5.4	2.59	2.05	32	134	4.7	3.64	2.71
1931	9	1220	620	7.0	4.81	.77	6	240	8.9	4.65	1.93
1932	7	1053	433	8.5	4.59	1.06	9	103	9.4	3.50	3.39

and 827 pounds per acre respectively; in 1923, the check yields were 188, 297, 413, 462, 443, 470, 895, 1000, and 1,249 pounds of seed cotton per acre; and in 1924 the check plat yields were 560, 478, and 1,120 pounds per acre. There was no gain of the poisoned over the unpoisoned in plats where the yield was less than 600 pounds per acre. These data should warn anyone against poisoning for boll weevil on low-yielding soils. The application of poison to cotton as recommended will not cause a decrease in yield unless leaf burning takes place, which scarcely ever happens.

Table II shows the results of the major treatments for the years under consideration.

The data in Table I show that the average yield of seed cotton in the experimental plats in 1922, 1923, 1924, 1928 and 1929 was comparatively low. Such gains as were recorded as due to the various treatments were very low generally except in 1929 when the percentage of infestation was higher than in 1928. In 1931 and 1932 the plats were located in higher yielding soils and likewise the infestation was higher. Therefore, the gains due to most of the treatments are greater and more significant. During the latter two years, the gains and net profits due to the treatment with calcium arsenate dust were consistently greater than for any of the other treatments. Sweet bait showed much smaller gains, a greater average percentage of infestation and an average net loss in 1931-1932. The gains in plats treated with sweet bait followed by calcium arsenate dust were greater than in plats treated with sweet bait alone in 1931.

Table III shows the percentage of weevils living through the winter in cages placed in various parts of the state for the years given.

TABLE III.—Boll weevil hibernation survival in cages in various parts of Oklahoma

Year	Number placed	Number survived	Percentage survival
1921-22	382	1	.26
1922-23	2000	37	1.85
1923-24	5500	1	0.018
1924-25	2500	0	0
1925-26	No record		
1926-27	4192	1	.023c
1927-28	3500	0	0
1928-29	3000	30	1.
1929-30	3000	0	0
1930-31	4700	154	3.27
1931-32	8623	44	0.51
1932-33	8267	88	1.06
1933-34	19690	17	0.085

III. CONTROL EXPERIMENTS BY U. S. D. A.

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Bureau of Entomology, U. S. Department of Agriculture

Field-plat tests of different methods of poisoning the boll weevil were conducted in Oklahoma during 1928, 1929, 1931, 1932, and 1933 by the Bureau of Entomology of the United States Department of Agriculture in cooperation with the Agricultural Experiment station and Extension Division of the Oklahoma A. & M. College. The purpose of these tests was to determine, under Oklahoma conditions, (1) the relative merits of calcium arsenate dust and molasses-calcium arsenate mixture (1-1-1) for control of the boll weevil; and (2) whether the calcium arsenate dusting method when properly applied would give satisfactory and profitable results, and, if so, under what conditions its use should be recommended to farmers.

EXPERIMENTAL PROCEDURE

During the five years tests were conducted in six localities in the southeastern part of the State and 114 plats were used. In 1928, 21 plats were utilized; 12 were located at Durant and nine at Wynnewood. In 1929 tests were started at Ada, Hugo, and Porum, but climatic conditions during July and August held the weevil infestation so low that it was unnecessary to apply poison on the plats located at Ada and Hugo, and the tests on only 10 plats at Porum were completed. In 1931, 38 plats were utilized, 13 being located at Hugo, 12 at Tishomingo, and 13 at Porum. Thirty-three plats were utilized in 1932, 16 being located at Hugo and 17 at Eufaula. Twelve plats located at Eufaula were utilized in 1933. No tests were conducted during the dry season of 1930, because climatic control held the weevil infestation well below the point where poison applications should be started.

The 12 plats at Durant, three at Tishomingo, and three of those at Eufaula utilized in 1932 were located on upland soil, while all the others were located on bottom land. With one exception, all the plats were located on soil sufficiently fertile to produce at least half a bale per acre if insect injury were eliminated. Each plat was at least 30 rows wide and 400 feet long and covered approximately one acre. In each field untreated plats were utilized as checks.

The calcium arsenate treatments were made according to recommendation of the Cotton Council of the Association of Southern Agricultural Workers and the U. S. Department of Agriculture (Leaflet No. 37, 1929), which reads as follows:

"For the boll weevil, one presquare poisoning may be applied if it appears that there are numerous overwintered weevils present. This should be given just as squares begin to form. Then apply the regular series of three or more dust applications of calcium arsenate at four- or five-day intervals, beginning when an average of approximately one-tenth of the squares show weevil punctures. Dusting should be continued as needed to keep this infestation low until a full crop is set and matured beyond the probability of further weevil injury."

All applications of calcium arsenate were made with hand guns, and from four to seven pounds of poison were used for the treatment of one acre at each application. Most applications of calcium arsenate were made between daybreak and 8:00 a. m., but a few were made in the afternoon just after sundown.

The molasses-calcium arsenate mixture was made by mixing thoroughly one pound of calcium arsenate, one gallon of water, and one gallon of molasses (a good grade of table syrup). The material was applied to the growing tips and terminal buds of the plants, by means of a home-made rag mop, within 24 hours after being mixed. The presquare treatments required about one gallon of the mixture per acre, but on larger cotton slightly more was used. Whenever the poison was washed off by a rain within 24 hours after being applied, the applications were repeated.

The cost of treatment included all materials and the labor required to make the applications. Calcium arsenate and molasses were figured at the current price each year and labor at the rate paid farm labor in this section. The cost of gain per 100 pounds of seed cotton is based on unpicked cotton in the field and the cost of picking the gain should be added when determining the profit from poisoning.

COMPARISON OF CALCIUM ARSENATE DUST AND WEEKLY APPLICATIONS OF MOLASSES MIXTURE

The average gain in seed cotton, the number of applications of poison, and the cost of treatment for the 18 tests in which calcium arsenate dusting was compared with weekly applications of the molasses mixture are shown in Table IV. In this series the plats treated with calcium arsenate dust received one presquare application of molasses mixture followed by cal-

TABLE IV.—Comparison of gains in yield of seed cotton resulting from treatment with calcium arsenate dust and with weekly applications of molasses mixture, and cost of treatment, on 18 experimental plats in Oklahoma, 1928-1932

Year	Number of plats	Check yield, pounds per acre	CALCIUM ARSENATE: Average number of applications per plat	CALCIUM ARSENATE: Average gain in yield, pounds per acre	CALCIUM ARSENATE: Cost of Treatment: Per acre	CALCIUM ARSENATE: Cost of Treatment: Per 100 pounds of gain	MOLASSES MIXTURE: Average number of applications per plat	MOLASSES MIXTURE: Average gain in yield, pounds per acre	MOLASSES MIXTURE: Cost of Treatment: Per acre	MOLASSES MIXTURE: Cost of Treatment: Per 100 pounds of gain
1928	7	796	8.4	266	$6.38	$2.40	8.9	136	$7.61	$5.60
1929	1	542	11.0	547	6.70	1.22	8.0	192	5.55	2.89
1931	6	843	8.0	405	4.23	1.04	8.2	102	4.94	4.84
1932	4	873	8.0	439	3.50	.80	7.8	123	2.81	2.28
Average		764	8.9	414	5.20	1.26	8.2	138	5.23	3.80

cium arsenate dust after the square infestation reached 10 percent. The plats treated with the molasses mixture received one pre-square application of this mixture followed by applications at weekly intervals throughout the season regardless of the square infestation.

In every test the calcium arsenate dust method gave the greatest gain in pounds of seed cotton and the most economical gain. The average production on the untreated plats during the 4-year period was 764 pounds of seed cotton per are. In the four seasons the calcium arsenate dust method produced an average gain of 414 pounds of seed cotton per acre and the average cost of treatment was $5.20 per acre, or $1.26 per 100 pounds of gain. The calcium arsenate plats received an average of 8.9 applications of poison. During the same period the molasses mixture showed an average gain of 138 pounds of seed cotton per acre and the average cost of treatment was $5.23 per acre, or $3.80 per 100 pounds of gain. The plats treated with molasses mixture received an average of 8.2 applications of poison. The cost of treatment per acre by the calcium arsenate dust method decreased from $6.38 in 1928 to $3.50 in 1932, and that of the molasses-mixture treatment decreased from $7.61 in 1928 to $2.81 in 1932.

Calcium arsenate dusting also gave larger profits per acre than the molasses mixture. In 1928 and 1929, when lint cotton was worth more than 15 cents per pound, the molasases mixture used alone showed a small profit, but with the low prices for cotton in 1931 and 1932 it did not increase the production enough to pay the cost of treatment. Calcium arsenate dusting therefore proved to be a better method of boll weevil control than applications of molasses mixture at weekly intervals throughout the season.

COMPARISON OF CALCIUM ARSENATE DUST AND EARLY APPLICATIONS OF MOLASSES MIXTURE

Five tests were conducted during 1929, 1931, and 1932 to ascertain the value of two to four early applications of molasses mixture as compared with the calcium arsenate dusting. These molasses-mixture treatments were started at the presquare stage and continued at weekly intervals until two to four applications had been made, regardless of the square infestation. The average number of applications was 3.3. The plats treated with calcium arsenate received one presquare application of molasses mixture followed by calcium arsenate dust after the square infestation reached 10 percent. The average number of applications of calcium arsenate dust was 7.7. The average number of overwintered weevils, just before treatments were started, on the areas where these five tests were conducted was 84 per acre. The average production of seed cotton on the untreated plats was 638 pounds per acre. The calcium arsenate dust method showed an average gain of 462 pounds per acre, and the average cost of treatment was $4.87 per acre, or $1.05 per 100 pounds of gain. The early applications of molasses mixture gave an average gain of 85 pounds per acre, and the average cost of treatment was $1.71 per acre, or $2.01 per 100 pounds of gain.

EFFECT OF FREQUENCY OF APPLICATION ON EFFECTIVENESS OF MOLASSES MIXTURE

In 1932, two tests were conducted to determine if the molasses mixture would give better control when applications were made every three or four days rather than at weekly intervals. In both instances the applications were started at the presquare stage of plant growth and continued throughout the fruiting season regardless of the square infestation. The plats treated at weekly intervals received an average of 8.5 applications of poison; the average gain was 129 pounds of seed cotton per acre; and the average cost of treatment was $3.02 per acre, or $2.34 per 100 pounds of gain. The plats treated at intervals of three or four days received an average of 13.5 applications of poison; the average gain was 252 pounds of seed cotton per acre; and the average cost of treatment was $5.06 per acre, or $2.01 per 100 pounds of gain.

The more frequent and greater number of applications of molasses mixture produced a greater gain in pounds of seed cotton, but this greater gain was largely offset by the increased cost of treatment.

These molasses-mixture treatments were also compared with calcium arsenate dusting. The calcium arsenate plats received one presquare application of molasses mixture followed by calcium arsenate dust after the square infestation reached 10 percent, the number of applications of calcium arsenate being 10.5. The average gain was 619 pounds of seed cotton per acre; and the average cost of treatment was $5.25 per acre, or $0.85 per 100 pounds of gain. The average production of the untreated plats in this series was 804 pounds of seed cotton per acre, and the average number of overwintered weevils, just before treatments were started, on the areas where these tests were conducted was 345 per acre.

VALUE OF ONE PRESQUARE APPLICATION OF MOLASSES MIXTURE WITH CALCIUM ARSENATE DUSTING

In 1932, four tests were conducted to determine the value of a presquare application of molasses mixture when followed by calcium arsenate dust after 10 percent infestation was reached. The average population of overwintered weevils on the areas where these tests were conducted, when the plants were at the presquare stage, was 322 per acre. The average production on the untreated plats in this series was 584 pounds of seed cotton per acre. The plats treated with one presquare application of molasses mixture followed by calcium arsenate dust when the infestation reached 10 percent received an average of nine applications of calcium arsenate dust; the average gain was 708 pounds of seed cotton per acre; and the average cost of treatment was $4.35 per acre, or $0.61 per 100 pounds of gain. Four comparable plats treated only with calcium arsenate dust after 10 percent infestation received an average of nine applications of poison; the average gain was 651 pounds per acre; and the average cost of treatment was $4.05 per acre, or $0.62 per 100 pounds of gain. The plats that received a presquare treatment showed an excess gain of only 57 pounds per acre. In 1932, when there was an unusually large number of overwintered boll weevils, 322 per acre of these plats, a presquare treatment did not reduce the number of calcium arsenate dust applications required during the season.

EFFECT OF CALCIUM ARSENATE DUSTING UNDER VARYING CONDITIONS

The average gain in seed cotton, the number of applications of poison, and the cost of treatment for the 48 plats treated by the calcium arsenate dust method during the five years are shown in Table V. Twenty-three of these plats received a presquare treatment of molasses mixture and 25 did not. In all instances calcium arsenate dusting was not started until the square infestation had reached at least 10 perent and applications were made at four- or five-day intervals as long as was necessary to keep the infestation low until the crop was set and matured beyond susceptibility to weevil injury. If the infestation fell below 10 percent, poison applications were discontinued until it again exceeded that figure.

The average production on the untreated plats was 826 pounds of seed cotton per acre. During the five years the plats dusted with calcium arsenate showed an average gain of 348 pounds of seed cotton per acre, or an increase of 42.1 percent over the yield from the untreated plats. The plats received an average of 7.6 applications of poison and the average cost of treatment was $4.35 per acre. The increased production of 348 pounds cost $1.25 per 100 pounds in the field, or unpicked. These tests have covered a wide range of conditions and varying degrees of weevil infestation. In 1932, a year when the boll weevils were abundant, the average gain was 569 pounds per acre. In 1933, when boll weevil infestation was very light, the average gain was only 129 pounds. The purpose of the poison applications in 1933 was to protect the bolls from weevil injury, as the weevil infestation was light until after most of the fields had set a good crop of bolls.

TABLE V.—Gains in yield of seed cotton resulting from treatment with calcium arsenate and cost of treatment of 48 experimental plats in Oklahoma, 1928-1933

Year	Number of plats	Check yield, pounds per acre	Average number of applications per plat	Average gain in treated plats, pounds per acre	COST OF TREATMENT	
					Per acre	Per 100 pounds of gain
1928	7	796	8.4	266	$6.38	$2.40
1929	4	721	7.8	322	4.96	1.54
1931	15	751	8.8	453	4.81	1.06
1932	15	683	8.5	569	3.74	.66
1933	7	1,180	4.3	129	1.88	1.46
Average		826	7.6	348	4.35	1.25

CONCLUSIONS

The experiments conducted in Oklahoma show that molasses mixture used alone did not control the boll weevil satisfactorily or give profitable gains in yield of cotton. Presquare applications of molasses mixture followed by calcium arsenate dusting did not appreciably increase the gains obtained with calcium arsenate dust and did not decrease the number of dust applications required. Calcium arsenate dusting after 10 percent infestation was reached produced profitable gains on fertile soil in years of heavy weevil infestation.

The gains obtained from poisoning in these experiments should not be interpreted as representing the average loss due to the boll weevil throughout southeastern Oklahoma for any of the years specified, because these tests were purposely located in fields subject to heavy weevil infestation.

IV. CONTROL DEMONSTRATIONS IN OKLAHOMA

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Boll weevil control demonstrations with cotton farmers in Oklahoma have been carried on for a number of years. In May of 1928 a cooperative boll weevil control program was started with the Oklahoma Experiment Station, the U. S. Bureau of Entomology and the Extension Division as cooperating agencies. It was planned to rather definitely assist county agents in applying experimental results, research information and successful farm practices in the various boll weevil infested counties of Oklahoma through the demonstration method. Extension specialists assisted in carefully locating cotton fields on productive cotton land where boll weevils were present in sufficient numbers and where the owners of such cotton fields were willing to follow specific instructions in conducting result control demonstrations.

In 1928 a survey was started in southeastern Oklahoma to determine the degree of boll weevil infestation. The first year it covered the counties of Garvin, Murray, Carter, Bryan, Pittsburg, Muskogee, Okfuskee and Pontotoc. In 1929, 1930 and 1931, it covered from twelve to fourteen counties. Okfuskee and Pottawatomie were dropped and Marshall, Choctaw, Atoka, McIntosh and Okmulgee were added. From one to three fields were examined weekly in each county for weevil infestation. The infestation counts were made as described elsewhere in this bulletin. This information was tabulated at the end of each week and released to the press by the Extension Division the following Monday. Many farmers were eager to get this information as they could readily tell the general trend of weevil infestation and could make their poisoning plans accordingly.

Other timely information on boll weevil outbreaks was released from time to time and farmers were instructed when and how to poison. They were also discouraged in using any poisoning methods which required expensive machinery and material where the degree of infestation and the productiveness of the land did not justify such a procedure. Use of various patented boll weevil remedies was discouraged. The fact was also kept before the farmers that the use of poison against the boll weevil under certain condtions has given good results but farmers should not depend too much upon it and neglect the cultural practices that are absolutely essential in any system of weevil control.

In addition to cultural control methods, demonstrations that pertained to the presquare treatment with 1-1-1 molasses mixture were put on by farmers assisted by extension agents. This mixture consisted of one pound of calcium arsenate, one gallon of water and one gallon of molasses. Demonstrations with dry calcium arsenate dust were conducted on productive cotton fields where the weevil infestation reached 10 percent at the time that the cotton plant was setting its fruit.

In 1927 conditions were especially favorable for boll weevils in Oklahoma, but due to frequent rains requiring repeated applications of calcium arsenate, the dusting method was not generally successful. One outstanding record of that year was in Love county where 2 applications of calcium arsenate were used at the rate of 8 pounds per acre on a 20-acre plat, the results showing that eight bales of cotton were realized on the treated area as compared to one-half bale on the 20-acre check which was planted and cultivated in the same manner as the poisoned area.

During late 1927 an extensive winter clean-up campaign was conducted and the results in 1928 were very favorable where the work was community-wide.

In 1928 when the cooperative plan with the various agencies was started, the Extension workers visited a larger number of cotton farmers than in previous years and assisted them in making infestation counts and in applying the poison. That year, more than 40 demonstrations were held throughout southeast Oklahoma. The 1-1-1 mixture and calcium arsenate dust were both used. In some fields only one was used, while in others a combination of the two was used. Only the farmers that had increased yields kept records, and for this reason the yields for that year are higher than in the following years where records were obtained from all cooperating.

The average yield of lint cotton per acre for Oklahoma in 1928 was 136 pounds and the estimated yield of seed cotton was 408 pounds per acre. The largest gains from poisoning were secured where the calcium arsenate dust method was used on fertile bottom land. The gains secured from the calcium arsenate method ranged from 85 to 750 pounds per acre and the average was 412 pounds. The average gain secured from the molasses mixture was 159 pounds.

The general infestation of weevils throughout southeast

Oklahoma in 1929 and the high price of cotton at this time (which on June 15, 1929, was 18 cents per pound) caused considerable interest in weevil control. Due to the lateness of the crop caused by a wet spring and poor germination, weevils became very destructive and much damage was done in some localities; however, the dry conditions during July and August were very effective in holding the weevils in check over the majority of the state.

A cooperative plan of procedure was again carried on with the farmers and a large group of demonstrations, under the supervision of County Agents and Extension Specialists, were started. Complete records were secured from 47 demonstrations during this year. The average gain secured from 1-1-1 molasses mixture was 105 pounds of seed cotton per acre. Where calcium arsenate dust was applied after 10 percent square infestation the average gain was 157 pounds per acre.

The average state yield of 1929 was approximately 372 pounds of seed cotton per acre. At the close of the calendar year farmers were receiving, on the average, 16 cents per pound for their lint cotton.

Fig. 7.—Dusting Cotton for Boll Weevil.

The winter of 1929-1930 was one of the most severe on record. The emergence of over-wintered weevils was exceedingly low and climatic conditions throughout the fruiting season held the weevil infestation well in check over the entire state. A number of farmers were contacted by the Extension Specialists and a few fields were actually staked out for boll weevil control demonstrations. However, the weevil infestation did not increase above the danger point, which we consider as 10 percent in Oklahoma. The farmers were advised not to poison, thus saving them considerable money.

A few farmers that were not contacted until late had actually started poisoning. Infestation records made in these fields failed to show over a 2 percent infestation, so the poisoning was discontinued. The average state yield for 1930 was only 301 pounds of seed cotton per acre. This low yield was caused by the extreme dry weather and not by the boll weevil.

The winter of 1930-1931 was very mild and weekly boll weevil infestation reports in 1931 showed that weevils were present in sufficient numbers to warrant control measures. Farmers were contacted in the heavy weevil infested areas, and a large number of control demonstrations were started. Soon after the demonstrations were started the price of cotton declined very rapidly, and by August 15 was only 6.3 cents per pound. In spite of this fact, more than 20 farmers continued their demonstrations and gave a complete report at the end of the season. Four demonstrations with the molasses arsenate mixture gave a gain of 161 pounds, or an average gain of 40 pounds each. Twenty calcium arsenate dust demonstrations gave a total gain of 6,124 pounds, or an average gain of 306 pounds each. One demonstration on rich bottom land gave a gain of 1,204 pounds per acre, where five applications of calcium arsenate dust were applied. The average yield for Oklahoma in 1931 was 519 pounds of seed cotton per acre.

Due to the extremely low price of cotton in 1932, and lack of equipment and material with which to work, farmers were not easily induced to carry on control demonstrations. Because of unusually heavy infestation of weevils, and prospects for a better cotton price, demonstrations were finally started in 14 infested counties. Due to the lack of interest early in the season, very few 1-1-1 molasses arsenate mixture demonstrations were conducted.

Demonstrations with calcium arsenate dust were started in nearly every county when cotton began to fruit rapidly. A sudden drop in cotton prices, and dry weather conditions which brought about considerable shedding, caused a large number of demonstrations to be discontinued. Others that were not carefully supervised were poorly conducted. In spite of these facts, some encouraging results were obtained.

The average gain of all molasses arsenate demonstrations was 83 pounds per acre. Twenty-five calcium arsenate dust demonstrations gave a gain of 9,291 pounds, or an average gain of 372 pounds each.

The largest gain was 890 pounds, which was from the same field that gave a gain of 1,204 pounds in 1931.

Another outstanding demonstration in 1932 was conducted by Clifford Earls, a 4-H club boy of Shawnee, Okla. His field was dusted eight times with calcium arsenate dust, using 3⅛ pounds at each dusting. The cost of the dust was $1.75. The dusted acre yielded 1,485 pounds of seed cotton and the adjoining acre yielded 595 pounds. The cotton all sold in the seed at 2¼ cents per pound, leaving Clifford a net profit of $20 for his cotton.

The average yield for Oklahoma in 1932 was approximately 477 pounds of seed cotton per acre.

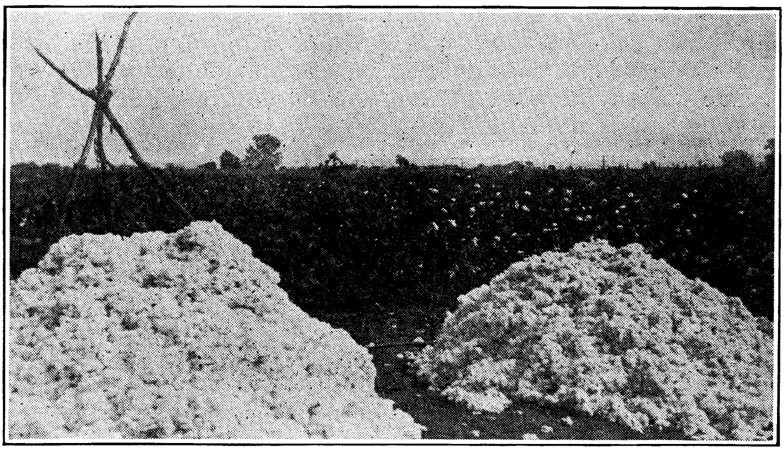

Fig. 8.—Cotton on the left, from a field treated for boll weevil, yielded 1,390 pounds of seed cotton per acre; that on the right, untreated, yielded 1,042 pounds of seed cotton per acre; Lincoln county, Okla.

The winter of 1932-1933 was much colder than either of the two previous winters; however, spring came much earlier. Weevils emerged earlier, but in fewer numbers than in past years. Due to the unusual climatic conditions during June and July the weevil infestation did not reach the danger point and a fair crop of cotton was set before the weevils could increase in damaging numbers after the rains came later in the season.

Due to the extremely low price of cotton, the cotton plow-up campaign, and the scarcity of weevils until late in the season, there was very little interest shown by cotton farmers towards any control measures. However, during the latter part of July and the first of August requests for assistance and poisoning came in and a few calcium arsenate dust demonstrations were started on late cotton. The early planted cotton had already set a good crop of bolls and it was not necessary to use any control measures on it.

The average net gain of the late calcium arsenate dust demonstrations was 74 pounds per acre. The average yield for Oklahoma in 1933 was approximately 630 pounds per acre, which shows the weevil damage was not an important factor in cotton production in 1933.

More than 250 boll weevil control demonstrations were started by the Extension Division during the past six years and the data obtained from farmers that completed their demonstrations show that under favorable conditions and with carefully supervised work it is profitable to poison on fertile land when the price of lint cotton is 10 cents or more, and the price of calcium arsenate does not exceed 7 cents per pound. As the price of cotton increases, there will be a larger return from poisoning. It is impossible to show a gain from poisoning on low yielding land.

V. RECOMMENDATIONS FOR CONTROL

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INDIRECT CONTROL

When cotton picking is completed before frost, the plants should be immediately destroyed by grazing, cutting, or plowing under. This will deprive the boll weevils of food and force them to feed elsewhere or enter hibernation earlier than normally. Experiments conducted at various places throughout the Cotton Belt, including Oklahoma, have shown that the earlier the boll weevils are forced into hibernation the fewer will live over the winter. In order to gain the full benefits from early destruction of the stalks, this should be done from two to four weeks before frost. It is realized that in some portions of the state picking is not completed before frost, but the farmer should destroy the stalks before frost whenever it is possible.

If fence rows, turn rows, and borders of fields have been allowed to grow up in weeds, grass, and other growth, they should be cleaned up during the fall and winter. This will destroy the boll weevils, as well as many other insects, that hibernate in such places. The best farm practice is to prevent weeds from growing along fences and borders, as there are several species of insects, such as the cotton flea hopper and the red spider, that develop on weeds and then move into the cotton fields to attack the cotton plants. Fall or early winter plowing should be practiced except on blow sands and steep slopes, and all crop residues should be completely turned under.

In the weevil-infested portion of this state, cotton production is a race between the setting and maturing of a crop of bolls and the increase in weevil population. Farmers should adopt every practice that will hasten the setting and maturing of a crop. On many farms boll weevil damage can be lessened by planting cotton in fields removed from timber and other hibernation quarters. Each farmer should study the conditions on his farm and plant his cotton as far away from hibernation quarters as is practical and on well-drained land where the plants will grow off fast. In the southeastern part of the state it is usually advisable to plant on a bed or ridge. These ridges should be prepared several weeks before planting so that the seed bed will be firm, as cotton grows off faster when planted on a well-settled bed. Weeds and grass should be destroyed by cultivating, disking, or harrowing just before planting.

Early varieties of cotton that set and mature bolls rapidly are essential under boll-weevil conditions. On the fertile bottom lands, where plants make heavy growth, varieties with light foliage are more desirable than those with heavy foliage. Many farmers object to the early maturing varieties because they usually have smaller bolls than those maturing later. However, there are varieties that produce good lint and a fair-sized boll which are adapted to the weevil-infested portion of the state. Your county agent will advise you in regard to a variety adapted to your locality. Pure-bred seed produced near you is preferable to that obtained from distant places.

Early planting is essential in weevil-infested areas. It should be done as soon as possible after all danger of frost is over and the ground has warmed up. Sufficient seed to produce a full stand should be planted at this time in order to avoid replanting. The rows should be only wide enough to permit proper cultivation, generally about 3½ feet.

The use of commercial fertilizer on certain types of soils in eastern Oklahoma stimulates the plants to mature early as well as increasing the yield.

Cotton should be chopped preferably when there are from four to six leaves on each plant. Chopping too early often means the loss of a stand and late chopping delays the setting of fruit. The plants should be left in hills 10 to 12 inches apart in the drill, and from two to three plants should be left in each hill.

Early cultivation is also essential, and the field should be kept free of grass and weeds. This can be done by shallow cultivation following rains, which sprout the weed seed and destroy the dust cover which helps to keep down the number of weevils. Heat will kill more weevil grubs in fallen squares when the soil is finely mulched. Deep cultivation close to the plants cuts the side roots and causes the shedding of squares and bolls, and should therefore be avoided after the cotton begins to fruit.

CONTROL BY POISONING

Successful cotton production in the boll-weevil section of Oklahoma depends almost entirely upon the use of purebred seed and proper cultural practices. If these practices are not followed, no method of poisoning can be expected to be profitable. Poisoning will not produce cotton; it merely protects the fruit that the cultural methods produce. If the cultural methods herein outlined are followed, the necessity for the use of poison will be reduced to a minimum. Poison should not be used unless the boll weevil is seriously damaging the crop after the cultural practices have been followed.

The molasses-mixture method of weevil control used alone, has not given profitable results in Oklahoma. The calcium arsenate dust method has given greater gains in pounds of cotton, as well as more economical gains, than the molasses mixture.

The calcium arsenate dust method has given profitable results in Oklahoma under certain conditions. The amount of gain that can be expected from its use depends on the degree of weevil infestation, the fertility of the soil, and the method of application. A light infestation or poor soil usually means a small gain in yield from dusting and probably a money loss, whereas if the weevils are exceedingly numerous and the soil is fertile, there is likely to be a good gain in yield if the dust is properly applied. For proper application suitable machinery is necessary and applications should be begun when the square infestation has reached approximately 10 percent, and should be repeated at intervals of four or five days until the infestation drops below 10 percent or the crop is matured beyond the danger of further injury.

The higher the price of cotton, the greater will be the returns from proper poisoning. When the price of lint cotton is less than 10 cents a pound, large gains are necessary for a profit, and when it is less than 8 cents and calcium arsenate is 7 cents or more a pound, the possibility of a profit is so slight that poisoning is not recommended.

Poison should never be applied without first determining the degree of infestation. To make an infestation count, examine 100 squares at each of five or more points in a field. Four of these points should be several yards from the border near each corner and the fifth point should be near the center of the field. Examine all squares that are large enough to be punctured by a weevil on each plant in a row until 100 squares have been examined. Do not change rows or skip any plants in the row. Remove the punctured squares and keep them until the count at that point is finished. Record the number of squares punctured at each point. Divide the total number of punctured squares collected from the five points by five to obtain the average percentage of infestation for the field. This infestation count must be made every week if a poison program is to be carried out effectively. Do not guess in this matter, for the success or failure of poisoning depends largely on beginning applications at the proper time. If applications are made when the infestation is below 10 percent, the poison is wasted, and thus needless expense is incurred.

All persons who intend poisoning the boll weevil are urged to seek further detailed information in regard to their specific problem from their county agent or from the Oklahoma A. & M. College.

INEFFECTIVE METHODS OF CONTROL

Such contrivances as weevil-catching machines, the burning of lights, and the use of kerosene or other oils and other strong-smelling materials are absolutely worthless for weevil control. The common practice of dragging sacks and brushes on cultivators damages the cotton plants and does not control the weevil. Such practices as topping of the plants and deep, close cultivation to stop plant growth are never advisable under any conditions.

SANE FARMING

In weevil-infested areas it is especially important that the farmer follow a sane program of farming. He should produce on his farm all supplies that can possibly be raised in his locality. He should have sufficient hogs, poultry, and milk cows to supply his own household. The home garden and orchard should receive good care and be large enough to produce plenty for the family. Sufficient land should be planted to feed and forage crops to provide an ample supply for all livestock on the farm. These items should receive primary consideration. After having provided for all things that can be produced at home the farmer should plant to cotton only that acreage which can be cared for without sacrificing the other crops. A crop rotation in which legumes are used should be practiced on all cotton farms to maintain the fertility of the soil.