

service that can be recognized as such. Are we ready to give it? Are we willing to adjust our ways and manner of thought so that we can in the future give this service demanded of us?

PRESIDENT W. C. O'KANE: Is there any discussion on this paper? If not, we will go to the next paper, "Notes on Poisoning the Boll Weevil," by Wilmon Newell.

## NOTES ON POISONING THE BOLL WEEVIL

RESULTS OF AN INVESTIGATION TO DETERMINE WHETHER THE PRESENCE OF DEW OR RAIN WATER ON COTTON PLANTS IS NECESSARY TO THE EFFECTIVE USE OF ARSENATES

By WILMON NEWELL and ELI K. BYNUM

While it is not our object in the present paper to review the history of the various attempts made to poison the boll weevil it is, nevertheless, pertinent to call attention to the fact that since the publication by the senior author and Mr. Geo. D. Smith, in 1909,<sup>1</sup> of experimental results which showed conclusively that the boll weevil could be profitably poisoned with powdered lead arsenate, close attention has been given this problem by the Bureau of Entomology. Since 1909 experiments with lead arsenate, and later with calcium arsenate, have been made at the Tallulah (Louisiana) laboratory of the Bureau, by Mr. Geo. D. Smith and subsequently by Mr. B. R. Coad, under the direction of Dr. W. D. Hunter.

After eight years of investigation the Bureau of Entomology, in July, 1918, finally committed itself to the proposition that the boll weevil can be poisoned with profit and has recently undertaken to promote the general use of arsenates, particularly calcium arsenate, for practical control of the boll weevil by cotton planters.

According to Bulletin No. 731, United States Department of Agriculture, by Mr. Coad, issued July 19, 1918, successful poisoning of the boll weevil is based upon the supposed habit of the boll weevil in drinking dew or rain water which collects on the cotton plants, this water presumably becoming poisoned by the application of calcium arsenate in the form of a dust or cloud.

Experiments made by Mr. T. C. Barber and the senior author of the present paper, in 1906, 1907, and 1908, seemed to show quite conclusively that mortality among the weevils, following application of an arsenical poison, was due to ingestion of the poison with their food, particularly when the poison was applied in such a way as to penetrate between the tender leaves in the terminal buds of the cotton plant or

<sup>1</sup> Circ. 33, Louisiana Crop Pest Commission, Dec. 1, 1909.

to cover the cotton square (bud) itself.<sup>1</sup> It was upon these results that the field work of 1909, by Mr. Geo. D. Smith and the senior author, was based and which showed an increased yield of cotton averaging 71 per cent in the poisoned plats of thirteen field experiments.

The question of whether the boll weevil is killed through ingestion of poison with its food or through drinking dew or rain water containing the poison is an important one, as bearing upon practical work in controlling the insect. If mortality is due to ingestion of the poison while the weevil is feeding manifestly that method of application will be most successful which places the poison directly upon those portions of the plant where the weevil is most likely to feed. On the other hand, if mortality is due to the weevil being poisoned by imbibing dew or rain water on the treated plants, any method of wholesale distribution of the poison throughout the cotton field will accomplish the desired purpose. The machinery used in these two methods of application will vary greatly and a correct understanding of the manner in which the weevil is poisoned by the use of lead or calcium arsenate will, therefore, prevent needless expenditure by the cotton planter in machinery which is not adapted to the purpose and also tend to increase the efficiency of the poisoning operations.

For the purpose of determining the point mentioned very careful experiments were conducted at Madison, Fla., during the summer of 1919, the work being immediately in charge of the junior author, assisted by Messrs. A. C. Brown, K. E. Bragdon, J. C. Goodwin and Walter F. Eberhardt, of the Florida State Plant Board. The work was inspected at frequent intervals by the senior author. Office and laboratory facilities at Madison were generously made available for us by Dr. W. D. Hunter of the Bureau of Entomology.

The powdered arsenate of lead used in these experiments was represented by the manufacturer to contain "not less than 30 per cent" of arsenic oxide and "less than 1 per cent" of water soluble arsenic.

The powdered calcium arsenate used was represented to contain "total arsenic oxide 40 per cent" and water soluble arsenic " $\frac{3}{4}$  per cent" and met the specifications laid down by Mr. B. R. Coad for calcium arsenate suitable for boll weevil poisoning.

Experiments were made under field conditions and also in the laboratory. The former will be first discussed.

#### FIELD CAGE EXPERIMENTS

The field experiments were conducted in cages 3 x 3 feet,  $4\frac{1}{2}$  feet in height, of 16-mesh galvanized wire-cloth, made as nearly insect-tight as possible. Cotton plants in the field were treated with calcium

<sup>1</sup> Circ. No. 23, Louisiana Crop Pest Commission, July, 1908.

arsenate and others with lead arsenate, using approximately ten pounds of the poison per acre. Cages were then placed over individual treated plants (see fig. 1), each cage floored with paper as tightly as possible and fly paper placed around the outside lower edges of the cage to exclude ants and a counted number of field-collected boll weevils introduced into each cage. Certain cages were covered at night and during showers with a heavy oilcloth cover, extending to within 12 inches of the ground (see fig. 2) so that the plants were protected against all deposition of visible moisture. Other cages, paired with these in the experiments, were not supplied with covers and the plants in them received the same precipitation of dew and rain as plants under normal field conditions, except that covers were placed on them when severe storms occurred in order to prevent excessive washing off of the poison or possible drowning of the weevils.

Corresponding cages, both "covered" and "uncovered," were placed over non-poisoned plants to serve as checks. Observations were made twice daily in all cages to determine the mortality among the weevils. The following table, showing the results obtained in two series of experiments, using lead arsenate and calcium arsenate on both covered and uncovered plants, is typical of the observations made on the total of 2,250 weevils used in the field experiments.

TABLE I. MORTALITY AMONG BOLL WEEVILS ON PLANTS PROTECTED FROM DEW AND RAIN ("COVERED") AND ON PLANTS EXPOSED TO DEW AND RAIN ("EXPOSED"). FIFTY WEEVILS PER PLANT, ONE PLANT PER CAGE. SIX CAGES. POISON APPLIED 7 P. M., SEPTEMBER 16, BY DIRECT APPLICATION WITH DUST SPRAYER ("BLAST METHOD") AT ABOUT 10 POUNDS PER ACRE.

Date	Number weevils dead each day				Check ("natural mortality")	
	Treated with lead arsenate		Treated with calcium arsenate		Covered* (Ser. 1) (50 weevils)	Exposed† (Ser. 11) (50 weevils)
Sept.	Covered* (Ser. 1) (50 weevils)	Exposed† (Ser. 11) (50 weevils)	Covered* (Ser. 1) (50 weevils)	Exposed† (Ser. 11) (50 weevils)		
17.....	3	2	3	0	0	0
18.....	4	5	4	6	0	0
19.....	13	11	17	9	1	0
20.....	11	11	8	6	0	0
21.....	4	3	2	2	0	0
22.....	6	3	4	3	0	0
23.....	4	4	4	3	1	0
24.....	2	2	0	3	0	0
25.....	1	2	2	0	1	4
Totals.....	48	43	44	32	3	4
Weevils alive at end of exp.....	2	2	1	4	28	38
Missing.....	0	5	5	14	19	8

\* No visible moisture on plants at any time during experiment.

† Heavy dew on plants on Sept. 17, 24 and 25; medium dew on 19th, 20th, 21st, 22nd and 23rd and light dew on 18th.

In all, nine series of experiments, such as described above, were made. Each "series" consisted of one cage-covered cotton plant treated with lead arsenate, one with calcium arsenate and one check cage, the latter containing the same number of weevils used in each of the other cages, in order to determine the "natural" mortality.

Observations were made twice daily on 750 weevils confined on plants treated with lead arsenate, 750 on plants treated with calcium arsenate and 750 confined on non-treated cotton plants but which were otherwise under the same conditions as those on the treated plants.

The following table shows the daily mortality, in percentages, among the weevils on plants treated with lead arsenate when protected from dew and rain, namely, kept entirely dry during the course of the experiments, and on plants similarly treated which were exposed to normal deposition of dew and light rains, being protected only from severe storms.

The deposition of dew on the exposed plants was of almost daily occurrence, heavy dew occurring on 20 mornings, medium dew on 17 mornings, light dew on 9 mornings and no dew on 10 mornings during the 60 "experiment-days" that these investigations were under way. Light rain fell on one morning. During the course of the experiments only one storm occurred which required the covering of the cages which were under "normal" conditions as to precipitation of dew and rain.

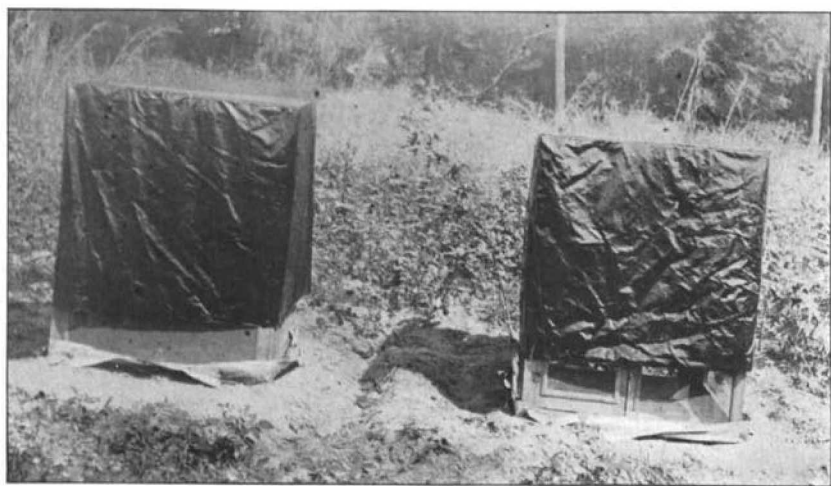
Of the nine plants treated with lead arsenate, three received the poison by the direct application or "blast" method and six by the "cloud" method as advocated by Coad. Of the three receiving treatment by the former method one was protected from all dew and rain and two were exposed to normal precipitation. Of the six treated by the cloud method two were protected from dew and rain and four exposed to normal precipitation.<sup>1</sup>

Poison used	Method of application	Number of weevils	Mortality during 10 days, per cent
Lead arsenate.....	Blast	150	88.6
Lead arsenate.....	Cloud	600	74.7
Calcium arsenate.....	Blast	150	79.3
Calcium arsenate.....	Cloud	600	74.2
Check.....	None	750	16.1

<sup>1</sup> Although the primary object of these investigations was to determine *how* the weevil obtains sufficient poison to produce death, the experiments were, nevertheless, so arranged as to give data on other questions. The data have been tabulated, for example, to show the mortality resulting from application of lead arsenate by the blast or direct method and by the cloud or settling method; also to show the comparative mortality when calcium arsenate was applied by both these methods. This information is summarized in the following table which shows the mortality among the boll weevils during the first 10 days following the applications:



Type of cages used over treated cotton plants in the field to determine mortality among boll weevils under varying conditions. (Original.)



Type of oilcloth covers used to prevent deposition of dew on certain of the treated plants.

TABLE II. PER CENT MORTALITY AMONG BOLL WEEVILS ON LEAD-ARSENATE TREATED PLANTS: (A) PROTECTED FROM DEW AND RAIN, AND (B) EXPOSED TO DEW AND LIGHT RAINS, DURING FIRST 10 DAYS AFTER TREATMENT

24-hour period after application	A		B	
	Protected from dew and rain		Exposed to dew and light rains	
	Treated (250 weevils in 3 cages) per cent	Check (250 weevils in 3 cages) per cent	Treated (500 weevils in 6 cages) per cent	Check (500 weevils in 6 cages) per cent
1st.....	7.2	0	9.0	1.4
2nd.....	8.8	0	11.4	1.4
3rd.....	18.4	2.8	12.	1.2
4th.....	15.2	0	10.	1.4
5th.....	9.6	0.4	7.	1.4
6th.....	9.2	2.4	6.8	2.0
7th.....	7.6	.4	5.	0.4
8th.....	3.6	2.8	5.6	1.8
9th.....	2.4	2.4	3.2	3.2
10th.....	3.6	2.8	3.8	3.0
Total mortality.....	85.6	14.0	73.8	17.2

Comparison of the data in the above table is easily made by means of the following chart, in which the daily percentage of mortality is shown in the case of both the covered plants and those exposed to normal deposition of dew and rain.

PER CENT.

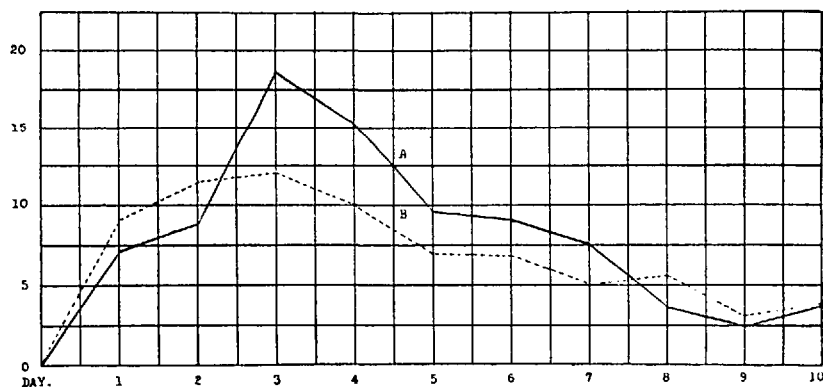


Chart 1.—Daily mortality, in percentages, among weevils on cotton plants treated with lead arsenate: heavy line (A), among 250 weevils on plants protected from all dew and rain; broken line (B), among 500 weevils on plants exposed to normal deposition of dew and rain.

The same information is also contained in the following chart, in which "A" shows the total mortality, during the first ten days after

application, on plants entirely protected from dew and rain and "B" the total mortality on plants exposed to light rains and normal deposition of dew.  $A_1$  and  $B_1$  show, respectively, the total natural mortality among weevils confined under identical conditions but on non-treated plants.

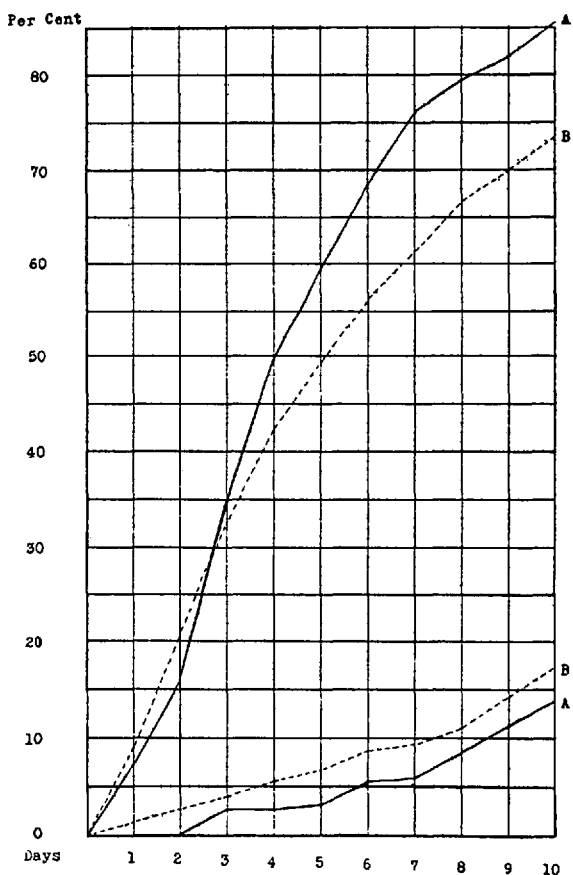


Chart 2.—Diagram showing total percentage of mortality among boll weevils on cotton plants treated with lead arsenate: A, on plants protected from all dew and rain; B, on plants exposed to normal precipitation. Also natural mortality among weevils on non-treated plants:  $A_1$ , on plants protected from all dew and rain;  $B_1$ , on plants exposed to normal precipitation.

Identical experiments were made using calcium arsenate, instead of lead arsenate, as the poison and using the same check cages. The following table shows the results obtained when using calcium arsenate, instead of lead arsenate, the arrangement of cages, method of applications, etc., being the same.



TABLE III. PER CENT MORTALITY AMONG BOLL WEEVILS ON CALCIUM-ARSENATE TREATED PLANTS: (A) PROTECTED FROM DEW AND RAIN, AND (B) EXPOSED TO DEW AND LIGHT RAINS, DURING FIRST 10 DAYS AFTER TREATMENT

24-hour period after application	A		B	
	Protected from dew and rain		Exposed to dew and light rains	
	Treated (250 weevils in 3 cages) per cent	Check (250 weevils in 3 cages) per cent	Treated (500 weevils in 6 cages) per cent	Check (500 weevils in 6 cages) per cent
1st.....	8.8	0	13.6	1.4
2nd.....	14.0	0	15.4	1.4
3rd.....	19.2	2.8	11.6	1.2
4th.....	10.8	0	8.6	1.4
5th.....	4.8	0.4	5.8	1.4
6th.....	6.0	2.4	4.0	2.0
7th.....	6.4	0.4	4.6	.4
8th.....	3.2	2.8	4.8	1.8
9th.....	3.2	2.4	3.0	3.2
10th.....	2.4	2.8	2.4	3.0
Totals.....	78.8	14.0	73.8	17.2

The following chart shows the above information in graphic form, i. e., the daily mortality on treated plants protected from dew and rain and on treated plants exposed to normal precipitation.

PER CENT

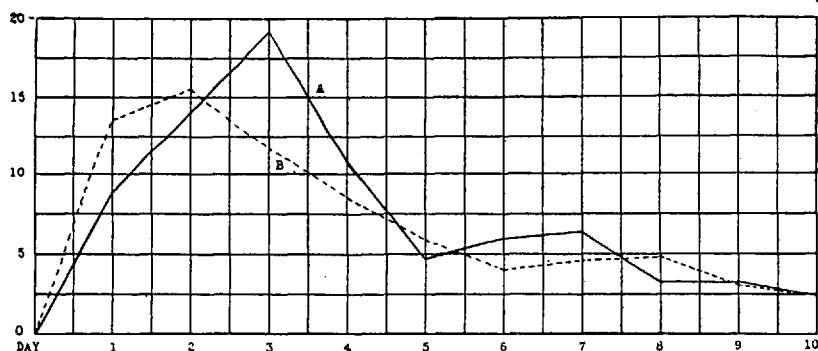


Chart 3.—Daily mortality, in percentages, among weevils on cotton plants treated with calcium arsenate: heavy line (A), among 250 weevils on plants protected from dew and rain; broken line (B), among 500 weevils on plants exposed to normal deposition of dew and rain.

Chart 4 shows in graphic form the total percentage of mortality as given in Table III and Chart 3.



The increased mortality among the weevils on treated plants protected from dew and rain, as compared to the mortality on treated plants exposed to deposition of dew and rain is very marked.

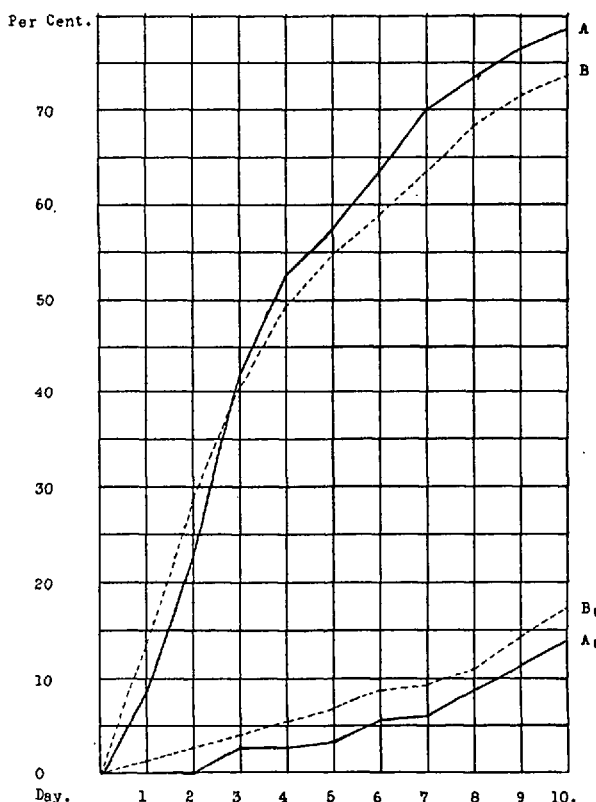


Chart 4.—Diagram showing total percentage of mortality among boll weevils on cotton plants treated with calcium arsenate: A, on plants protected from all dew and rain; B, on plants exposed to normal precipitation. Also natural mortality among weevils on non-treated plants: A<sub>1</sub>, on plants protected from all dew and rain; B<sub>1</sub>, on plants exposed to normal precipitation.

Reference to Table II shows that, using lead arsenate, the mortality on protected plants was 85.6 per cent during 10 days and on exposed plants was 73.8 per cent. During the same period the natural mortality, as shown by the weevils on non-treated plants, was 14 per cent on plants protected from dew and 17.2 per cent on plants exposed to dew. The mortality creditable to the lead arsenate was therefore 71.6 per cent in the case of the weevils on plants kept dry and 56.6 per cent on plants exposed to dew, or a mortality greater by 15 per cent on plants kept dry than that on plants receiving dew.

When calcium arsenate was used (Table III) the mortality on protected plants was 78.8 per cent and on "exposed" plants 73.8 per cent, the checks being as given above, giving a mortality, due to the poison of 64.8 per cent on dry plants and 56.6 per cent on plants exposed to dew, a gain of 8.2 per cent when the plants remained dry.<sup>1</sup>

The foregoing results seem to show conclusively that, as the mortality on dry plants was perceptibly higher than on those exposed to the deposition of rain and dew, the presence of visible moisture is in no way necessary to the effectiveness of either lead or calcium arsenate. This forces us to the conclusion that the weevil is killed by ingestion of the poison in feeding and not when drinking dew or rain water as claimed by Mr. Coad.

The investigation was, however, pursued along other lines, largely under laboratory conditions.

### THE TOXICITY OF DEW FROM POISONED PLANTS

Investigations were also made to determine the amount of arsenic contained in dew which was deposited on cotton plants which had been treated with both lead arsenate and calcium arsenate. Upland cotton plants in the field were treated by dusting them with lead arsenate in the usual manner, at the rate of about 8 pounds per acre. Other plants were treated in like manner with calcium arsenate. The dew was collected from these plants, early in the morning, by the use of shell or specimen vials. It was found that by carefully touching the lip of the vial to the dew drops suspended from the edges and tips of leaves that the dew could be, though rather tediously, drawn off into the vial and a sufficient quantity thus accumulated for laboratory experiments. Dew was collected only from leaves well covered with poison.

Dew collected in this manner was submitted to Mr. S. E. Collison, chemist of the University of Florida Experiment Station, for quantita-

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<sup>1</sup>The data secured in these experiments affords an interesting comparison between the effectiveness of lead arsenate and of calcium arsenate.

On plants protected from moisture the mortality ascribable to lead arsenate (Table II) was 71.6 per cent and to calcium arsenate (Table III) 64.8 per cent, a difference in favor of the lead arsenate of 6.8 per cent, but the mortality ascribable to lead arsenate on "exposed" plants (Table II) was 56.6 per cent and to calcium arsenate (Table III) also 56.6 per cent.

In the case of application by the blast method, all experiments, lead arsenate gave a mortality of 88.6 per cent during ten days and calcium arsenate a mortality of 79.3 per cent, a margin of 9.3 per cent in favor of lead arsenate. Applications by the cloud method, all experiments, gave a mortality with lead arsenate of 74.7 per cent and with calcium arsenate a mortality of 74.2 per cent. The mortality in the check was 16.1 per cent (see footnote, p. 9).

tive analysis. The following table shows the number of parts of arsenic per million in the dew as determined by Mr. Collison. Each sample of dew analyzed was collected from leaves well covered with poison from several dozen plants in different parts of the treated plat and the arsenic content may, therefore, be considered as decidedly above the average arsenic content of dew on treated plants.

From plants treated with	Dew collected	Parts arsenic per million
Lead arsenate	First morning after application	6.7
Lead arsenate	Second morning after application	6.7
Calcium arsenate	First morning after application	43.5
Calcium arsenate	Second morning after application	10.00

From the foregoing it is seen that the actual amount of arsenic in the dew from treated plants is remarkably small, even when collected from leaves heavily coated with the arsenate, and presumably a weevil would have to consume very considerable amounts of it in order for it to prove fatal. Experiments were accordingly made to determine whether such dew would prove fatal to boll weevils when all other sources of moisture were eliminated.

Large battery jars were prepared, each jar having a layer of dry sand in the bottom and the top covered with cheesecloth to permit circulation of air. A counted number of field-collected weevils was introduced into each jar and thereafter supplied with dew, collected from the treated plants the morning following the application of poison, by placing the dew in shallow tin trays. No other water was supplied and the weevils had no food. Corresponding lots of field-collected weevils were kept in similar jars, but supplied with clear water instead of dew and the daily mortality noted. Under these conditions the weevils went rather frequently to the dew in the trays and remained with their beaks inserted in the dew for periods varying from  $1\frac{1}{2}$  to 5 minutes,  $2\frac{1}{4}$  minutes being about the average. It is assumed that they were drinking during these periods.

The mortality, during 10 days, among 80 weevils supplied only with dew from lead-arsenate treated plants was 80 per cent, among 80 with dew from calcium-arsenate treated plants was 68.7 per cent and among 80 with clear water was 43.7 per cent; all of which is shown in the following chart:

In the course of these experiments one weevil lived for 12 days on an exclusive diet of dew from calcium-arsenate treated plants and

two lived for 13 days and one for 19 days on dew from lead-arsenate treated plants.

From the foregoing chart it is seen that the mortality was not appreciable until the weevils had been drinking the poisoned dew for more

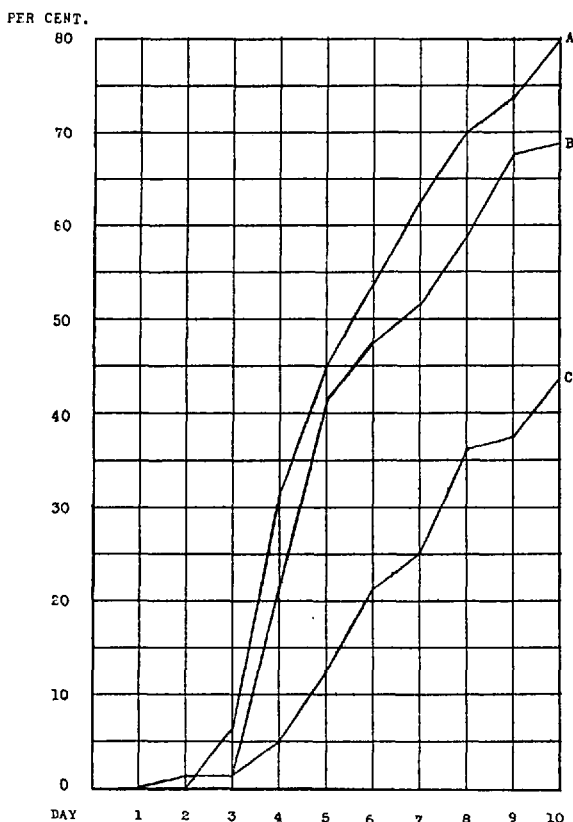


Chart 5.—Total percentage of mortality among weevils deprived of all food and furnished only with: A, dew from plants treated with lead arsenate; B, dew from plants treated with calcium arsenate; C, clear water.

than three days. Therefore, under normal field conditions the mortality caused by drinking dew containing poison is so small that no practical degree of control through this cause can be expected. Besides, a careful study of the weevil's habits indicates no tendency to drink dew in such quantities as would be necessary for successful poisoning if the weevil secures the poison mainly or entirely in this way.

The following experiments approximated field conditions in that weevils were furnished with both dew from treated plants and with fresh cotton squares as food.

# MORTALITY AMONG WEEVILS SUPPLIED WITH FOOD AND WITH DEW FROM TREATED PLANTS

Field-collected weevils were confined in battery jars as described in the preceding experiments, furnished with dew from treated plants in the same manner and in addition given fresh cotton squares each morning. They, therefore, had cotton squares as a source of both food and moisture, as is the case in the field, and in addition had dew constantly available for drinking purposes. The mortality, during 10 days, among 80 weevils confined with dew from lead-arsenate treated plants, 80 confined with dew from calcium-arsenate treated plants and 80 confined with clear water is shown in the following table.

TABLE IV. DAILY MORTALITY AMONG BOLL WEEVILS SUPPLIED WITH FOOD AND WITH DEW FROM POISONED COTTON PLANTS

Liquid	Number weevils confined	Daily mortality										Total dead during 10 days	Per cent mortality during 10 days
		1	2	3	4	5	6	7	8	9	10		
Dew from lead-arsenate treated plants.....	80	0	0	0	0	0	1	2	0	2	1	6	7.5
Dew from calcium-arsenate treated plants.....	80	1	0	0	0	0	1	0	1	1	1	5	6.2
Water ("check").....	80	0	0	0	0	1	0	1	1	5	0	8	10.0

As the mortality among the weevils having access to water was fully as great as that among those having access to the poisoned dew it is at once evident that either the weevils did not partake of the dew or they did not drink enough of it to cause any mortality. It is to be remembered, in this connection, that the dew to which these weevils had access was collected the first morning following the application of arsenates and only from leaves which showed a relatively heavy coating of the poison.

## SUMMARY

1. The mortality among boll weevils on cotton plants treated with lead and calcium arsenates and kept protected from all rain and dew was appreciably higher than the mortality on plants similarly treated but exposed to dew and normal precipitation. As the presence of dew or rain water on the cotton plants does not increase the effectiveness of either lead or calcium arsenate as a boll weevil poison it is evident that mortality from the use of either of these poisons is brought about by ingestion of the poison with the weevil's food and not by drinking the so-called "poisoned dew."

2. Dew collected from cotton plants treated with lead arsenate at the rate of approximately 8 pounds per acre was found, upon analysis, to contain 6.7 parts of arsenic per million. Dew from plants treated

with calcium arsenate at the same rate was found to contain from 10 to 43.5 parts of arsenic per million. The dew was collected only from cotton leaves that showed a distinct, thorough white coating of the arsenates.

3. Boll weevils deprived of all food and having dew from treated plants as the only source of moisture suffered a greater mortality than boll weevils confined on clear water, showing that the dew contained sufficient arsenic to produce death when the weevils were *compelled* to take the dew and no other food or water over a period of several days. However, such a condition does not occur in cotton fields.

4. When boll weevils had access to food in the form of non-poisoned cotton squares and, at the same time, to dew from treated plants, no mortality resulted, showing that the weevil can be poisoned under normal conditions only by poisoning its food.

### CONCLUSIONS

1. As the boll weevil is poisoned largely or entirely through taking poison with its food, machinery for applying poison to the cotton plants should be so designed as to apply the poison primarily to the squares, bolls and terminal buds, rather than to the foliage.

2. The greatest mortality among the boll weevils occurred on the third day following application of the arsenates and fell off rapidly after the seventh day indicating that, other things being equal, applications should be at intervals of a week, or less, apart.

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PRESIDENT W. C. O'KANE: Do you wish to discuss this paper? '

MR. E. G. KELLY: Did calcium arsenate burn the tender foliage?

MR. WILMON NEWELL: I am not able to answer this question positively. In our experiments, it did not.

MR. W. D. PIERCE: I would call attention to the fact that in all of Mr. Newell's experiments, lead arsenate proved more effective than calcium arsenate. I would like to ask him as to the method of application that he found the most successful.

MR. WILMON NEWELL: In the case of both lead and calcium the highest efficiency was the method of application that forced the poison directly on the plants, as compared with distributing it in the form of dust clouds and allowing them to settle.

MR. R. N. CHAPMAN: I would like to ask how large numbers those percentages of mortality are based on.

MR. WILMON NEWELL: In the first table, in the protected cages, there were 250 weevils, and in the cages exposed to the rain and dew, there were 500 weevils.

MR. R. N. CHAPMAN: Do you think there would be any advan-

tage in applying the poison in a blast or cloud and putting it on the plants when they are wet?

MR. WILMON NEWELL: We have also tabulated the data so as to get information on that point. The mortality when the poison is applied to the wet plants is a little higher during the first 48 hours than when applied to plants that are dry. During the first four days, the mortality was practically the same in both cases.

MR. F. L. THOMAS: I am glad to hear this paper, as it shed new light to those who are carrying on similar experiments. In Alabama, in 1918, we carried out one test, the details of which I cannot recall, but in the cages that were treated, the one that was not exposed to dew had a greater mortality than the one that was.

PRESIDENT W. C. O'KANE: The next paper is entitled "Miscellaneous Soil Insecticide Tests," by J. J. Davis.

### MISCELLANEOUS SOIL INSECTICIDE TESTS

By JOHN J. DAVIS, *Riverton, N. J.*

(Summary; Complete Paper to be Published Elsewhere)

Of the several materials tested against soil-infesting grubs, only emulsifiable creosote compounds, kerosene emulsion and sodium cyanide have given appreciable results.

Emulsifiable creosote compounds diluted 1 to 125 ("Carco" and "Barrett's Disinfectant" were used) and 10 per cent kerosene emulsion gave about 80 per cent kill for grubs of *Cotinix nitida* and 30 to 70 per cent kill for *Popillia* and other grubs which do not have a definite open burrow. Sodium cyanide, however, gave the best kill and when applied at 110 to 165 pounds per 12,000 gallons of water per acre a 90 to 100 per cent kill was obtained under favorable conditions. It is cheaper than either of the other two materials and is easier to prepare than the emulsion. Sodium cyanide was tested against the grubs of *Popillia japonica*, *Cyclocephala immaculata*, *Macrodactylus subspinosus* and *Lachnosterna* spp., the first mentioned species apparently being more resistant to the action of the insecticide than the others.

MR. Z. P. METCALF: I would like to ask Mr. Davis to give us some idea as to how deep the insecticide penetrated the soil.

MR. J. J. DAVIS: We had a very good kill—from 80 to 95 per cent killed—when the grubs were not deeper than two inches. When they were below that we got a very unsatisfactory kill. This was with an application of 165 pounds of granular sodium cyanide, dissolved in 12,000 gallons of water to the acre.

MR. GLENN W. HERRICK: I would like to ask Mr. Davis what effect that material had upon sod land, and upon the future crops?