1

THESIS

THE CONTROL OF THE SQUASH BUG
(ANASA TRISTIS DEGEER)

Submitted by
Herbert Osthoff

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State College
of
Agriculture and Mechanic Arts
Fort Collins, Colorado
November, 1940

COLORADO STATE COLLEGE

OF

AGRICULTURE AND MECHANIC ARTS

November 25, 1940

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Herbert Osthoff

ENTITLED THE CONTROL OF THE SQUASH BUG (ANASA TRISTIS DEGEER)

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF Science

MAJORING IN Entomology

CREDITS 10

Chas R Jones
In Charge of Thesis

APPROVED Chas R Jones
Head of Department

Recommendation concurred in

Committee on Final Examination

Chas R Jones
Geo. M. List
Maurice T. James

Committee on Graduate Work

Alvin Kezer
L. W. Durrell

ACKNOWLEDGMENTS

The author wishes to thank Mr. John L. Hoerner, Associate Professor of the Entomology and Zoology Department, for his aid in procuring experimental fields and materials, and for his patient and untiring efforts in suggesting suitable methods of experimental technique and collection of data; and Dr. C. R. Jones, Head of the Entomology and Zoology Department, for his friendly criticism and suggestions concerning the gathering of data and the writing of this thesis; and also Mr. V. L. Forsberg for the use of a squash field which he so generously contributed for experimental purposes.

CONTENTS

LIST OF TABLES AND FIGURES.

Page

INTRODUCTION

Background of the problem.

The production of squash and pumpkins has been an important phase of home and market gardening for many years. The well known Hubbard Squash, especially, is considered a delicacy by many people and consequently brings a comparatively high price on the market.

As is the case of other farm crops, the squash plant has many insect enemies. Chief among these is the common squash bug, *Anasa tristis* De Geer.* This insect, according to Elliott (8:224), was first described by DeGeer in 1773, and has since been found over the entire United States, and South to Central America. Hoerner (15:1) lists the squash bug as a serious pest in Colorado since 1892. So serious have the attacks become, that many gardeners do not attempt to grow certain types of squash in the area near the mountains in Northern Colorado. Hixson (14:257) states, "The squash bug, *Anasa tristis* DeG., was the limiting factor to squash and pumpkin production in this state [Oklahoma]...."

The injury by the squash bug is of two types. One; the sucking of juices, thereby weakening the plant. Two; an evident indirect injury, much more severe, which quite often causes the death of the plant in a few hours.

---

* Hereafter referred to, in this paper as the squash bug.

The cause of this is not definitely known, and several theories have been advanced regarding it. These will be discussed in later paragraphs.

A suitable control of the squash bug would curtail and possibly eliminate much of the destruction due to the insect injury now so prevalent. This would aid materially in the profitable production of squash and pumpkins in this and other sections of Colorado and the United States as a whole.

Previous studies.

Since the squash bug was first described in 1773, it has been found to be a very serious pest to Cucurbitaceous plants, especially the squash and pumpkin members of this family. Because it has been such a pest, this insect has been the object of a considerable amount of study. Countless attempts have been made by many workers over widespread districts to find a suitable control.

Damage to plants. - The damage to plants, previously mentioned, is due, it is thought, to two causes: First, the direct damage to the plant caused by the insect sucking the plant juices, thereby weakening the plant; Second, the indirect damage, due to a cause which is not yet definitely determined. Chittenden (4:8) states that in addition to the direct injury,

> Still another form of injury is due to the insect's acting, though not to a very great extent, as a transmitter of the insidious bacterial disease....

Haseman (13:11) contends that Anasa tristis damages the plant by injecting salivary secretions into it while sucking the sap. Granovsky (12:14) lists the squash bug as an example of an insect which causes mechanical injury only, to the plant which it attacks. Britton (3:45) states that,

> In addition to their punctures and withdrawal of sap from the plant, it is thought that some poisonous substance is injected into the wound. A few punctures are sufficient to kill a small plant.

Hoerner (15:4) asserts that one or two bugs may cause seedling squash plants to wilt in 24 hours. Garman (11:30) states,

> This bug introduces something into the wound made by its beak which causes the leaves to wilt and hang limply immediately after being attacked ....

Rand (18:419) believes that squash bugs do not transmit bacterial wilt, while Chittenden (4:2) states,

> ...injury by this squash bug is sometimes exaggerated in reported cases, the damage observed being often due to other insects which are less apt to be noticed....

as cucumber beetles, squash vine borers and the melon louse.

Natural enemies. - A few natural enemies of the squash bug are known. Perhaps the most important of these is *Trichopoda pennipes* Fabr. Worthley (21:77-79) describes the work of this insect in New England where it acts as a curb upon the squash bug under favorable conditions. In Colorado the natural enemies do not appear at all effective in curbing or controlling this insect.

Mechanical control. - For years the major methods of control have been of a mechanical nature. Elliott (8:228-29) advocates four ways of controlling the squash bug mechanically. He lists (A) Handpicking of the adults from the plants, (B) Trap boards laid out near the plants so that the insects will crowd under them at night and be subject to destruction by crushing while they are yet in an inactive condition the following morning, (C) Trap crops of early squash may be planted among the later varieties which are less attractive to the insects and thus save the main crop from serious damage by the squash bug, (D) Clean farming, such as plowing under the old vines or burning them in the fall as soon as the crop is harvested thus destroying many of the nymphs and making hibernating quarters more difficult for the bugs to find. In addition, Wadley (20:422) advocates crop rotation and thorough tillage of the land as an aid. A diagram by Wadley, adapted and reproduced in the appendix as Chart A, shows that only the adults live overwinter in Kansas and Iowa. It is apparent that any method which would aid in decreasing the number of hibernating insects during the fall would be of material value in control.

Chart A, appendix, shows that after the eggs hatch in the spring, all stages of the insect are present for the remainder of the summer and through early fall. Although there is only one generation per year in Northern Colorado, according to Hoerner (15:3), all stages of the insect are present throughout most of the summer. Worthley (21:74-75) reports that the same situation is true in Massachusetts.

Chemical control. - More positive, practical and economical control methods have been sought by many workers. Some of the more important methods are reviewed.

Early experiments were conducted using nicotine and soap sprays and nicotine dusts. Cook (5:248), reporting in 1891, asserted that he had obtained very poor results using kerosene emulsion or pyrethro-kerosene emulsion. Merrill (17:24), in 1918 reported good results using Black Leaf 40 (Nicotine sulphate) in the proportions of 1:400 parts of water with four pounds of soap per 100 gallons. This spray killed all the insects in the first four instars, and two applications at intervals of one week controlled a severe infestation. Dudley (7:69-70), in 1928 found that nicotine sulfate dust, containing 4-7% nicotine, killed nymphs of the first three instars, but had no permanent effect upon the last three instars or upon the eggs. Wadley (20:423-24), in 1920 reported very good results in Kansas by the use of fishoil soap in concentrations of 0.4-0.5 pounds of soap per gallon of water. This solution gave a mortality rate of 75% of adults in the laboratory, and 70% in the field. When Black Leaf 40 was added at the rate of 1:250, a 100% mortality rate was recorded in the laboratory, and 83.5% killed in the field. Sulfur, added to the soap solution only, at the rate of 1-2 ounces per gallon, gave better than a 91% kill of adults in the field. The sulfur caused some trouble by clogging the nozzle. He concluded that sulfur,

> ...increased the effectiveness of the soap against the nymphs as well as the adults; that strong soap

> solutions will not affect the eggs; and that squash plants suffer little or no injury from fishoil soap solutions in the strengths used [0.2-0.5 pounds per gallon of water]. ...

Little (16:575), in 1927 found that nicotine dusts containing 2-4% nicotine were not effective in controlling the pest. Worthley (21:76-77), in 1922 found that nicotine dusts, and sprays of Black Leaf 40, were of little value. He found that fishoil soap solutions gave good results if warm and the bugs dipped into the solution. As high as 90% of the adult insects were killed when dipped into warm fishoil soap solutions, but only a small percent was killed if dipped into the cold liquid, or sprayed with the warm or cold solutions. In addition, he reported that the soap sprays caused severe foliage burn when applied to the plants.

In 1927, Little (16), experimenting with Cyanogas "A" dust (calcium cyanide) under field conditions, reported excellent results. In his experiments, he brushed the insects onto the ground if they were found upon the leaves. He then dusted the bugs which were on the ground and those which were on the stems, with the undiluted dust. The insects were stupified in from 20 seconds to one minute after being dusted. Many of them recovered, but all those that lived, recovered before 24 hours had elapsed. Some showed signs of life after a period of 48 hours, but none of these recovered. Of the nymphs treated, from 84-90% were killed, while the check plots, untreated, showed a mortality rate of from 0.5-8.0%. Of the treated adults, 42-77% were killed, compared to no deaths in the untreated check groups. The plants dusted in this manner showed no evident signs of injury unless the dust was applied directly to the leaves. It is claimed by Little, that because most of the insects are found on the stems, there is no need to dust the leaves. However, Beard (1:237), in 1935 found that the application of Cyanogas to the plant caused severe burning of the foliage, and that only bugs of the first and second instars were killed. Insects of later instars were stupified, but most of them recovered. Elliott (8:229), found in 1925 that Cyanogas was the most effective of several dusts tested, either when used alone or mixed with nicotine dust or gypsum. He concluded, however, that it was of little value in the control of the adults.

The more common insecticides, effective against many types of insects, have in general been of little value in the control of the squash bug. New materials devised or discovered from time to time have often been used against the squash bug. Darley (6:115), in 1927 used "Penetrol," a "versatile standardized preparation consisting of sulfonated oxidized petroleum hydrocarbons...." as a carrier and spreader in combination with Rotenone, Pyrethrum, and Nicotine as separate sprays.

The nymphs of the squash bug, while in test cages, were sprayed with solutions of these compounds in varying concentrations. Only the Pyrethrum mixtures, in fairly strong concentrations, were of appreciable effectiveness. Rotenone and Nicotine compounds were of little value in controlling the insects. Elliott (8:229), in 1935 found that Pyrethrum dust was only moderately effective against the nymphs in varying degrees, and the results were disappointing. Nicotine sprays gave little indication of control. Pyrethrum extracted in kerosene gave the most promising results when mixed with soap and water. Beard (1:337-39), reported in 1935 that kerosene extract of Pyrethrum, 1-800, mixed with soap solution, 1-400, gave fair results in the field. If the emulsion is not properly prepared, the kerosene separates out and a gummy residue is left in the bottom of the container. Lethane 420, used with a Carbon Disulfide spreader, gave as much promise of control, with one application, as did the kerosene emulsion with four applications. However, the Lethane was applied in the laboratory, while the emulsion was used in field tests.

<u>Summary</u>. - No effective and practical control for the squash bug has yet been found by any of these investigators. Substances which apparently show good results for one worker often fail entirely when used by other experimenters in different localities. In addition,

materials which sometimes show promise of control, may be found to have a detrimental effect upon the squash plants.

The problem and its objectives.

This study was undertaken to develop, if possible, a positive and economical control for the squash bug in Colorado. It was thought that this might be done in one or more of the following ways or a combination of them: The application of chemicals in order to repel or destroy the insects; the discovery of varieties which would not be harmed by the insect, or the finding of varieties which would be least attractive to them; the discovery of attrahent materials which might be used to attract the insects so that they could be trapped and destroyed; the use of traps of a chemical or mechanical nature to ensnare the insects so that they could be destroyed.

This study was conducted at Fort Collins, Colorado, in collaboration with Mr. John L. Hoerner of the Colorado State College Entomology Department, in the summer of 1938.

PROCEDURE AND METHODS.

In this study there were four distinct parts, each of which required its own techniques and materials. These are explained below.

Comparison of the effect of contact insecticides upon the squash bug.

This part of the experiment may readily be subdivided into laboratory and the field studies.

Laboratory studies. - The laboratory work was an attempt to develop contact insecticides, which would be toxic or repellant to the squash bug. This part of the experiment was conducted in the college Insectory. The temperature and humidity very nearly duplicated those existing out of doors. The Insectory was shaded from the sun, and was somewhat protected from the wind.

Temperature and humidity were uncontrolled. Such controlled conditions, while desirable, were precluded because of the lack of apparatus and space necessary for such experiments. Work involving controlled conditions is entirely beyond the contemplated scope of this experiment.

Adult insects were kept in large supply cages made of wire screen over a wooden framework. These cages were approximately 2 1/2 feet high and three feet square. The insects were fed with squash leaves, stems, potted seedling squash plants, and a few small squash fruits occasionally. Each cage contained several hundred bugs, the number varying from time to time.

Insects were taken from the cages as desired for experimental work. Each test consisted of one or more cages of treated insects, usually 10 in number, and an untreated cage, designated in the tables as "check."

The insects undergoing treatment were placed in a small screen cage and sprayed or dusted thoroughly with the chemicals being tested. They were then removed from the spraying or dusting cage and placed in a clean dry screen cage made by inverting a household tea strainer with dimensions of approximately three inches high by six inches in diameter, inverted into an ordinary pie tin covered with a sheet of paper toweling. The food consisted of moistened squash seed placed in a small metal plate resting on the floor of each cage. Each plate contained a small quantity of water for the purpose of keeping the squash seed moist and palatable.

The materials used in this phase of the study, together with their active ingredients, are listed in Chart C, Appendix.

The insects were observed at the end of one day (24 hours), and again at the end of two days, then in most cases the observations were continued for a period of four days. The number of insects found dead in each case was recorded.

Field studies. - The field tests were conducted under relatively uncontrolled conditions. They included only the chemicals which had shown the most promising and practical results in the laboratory. Adult insects and all instars were present upon the plants, and were thereby subjected to the treatments. In the laboratory the attempts to control the insect were directed mainly toward the adults, but in the field all stages were treated. In both studies the primary object was to determine a method of control for the adult insects, because the nymphs are less resistant to chemical applications, as shown by investigators noted in previous paragraphs of this work. The materials which would control the adults would also act as an even more effective weapon against the nymphs.

The plants, containing an unknown number of insects, were sprayed or dusted thoroughly, and observations made to detect whether or not any insects attempted to leave the treated plants. The plants, in blocks of five to ten hills each, were treated with the desired materials and compared to untreated check plots. At the end of specified times, the plants and the ground under them were inspected and the number of insects present was noted. All insects found, whether alive or dead, were counted and the results recorded. Obviously, since the plants were unscreened and unseparated from each other by any artificial means, unknown numbers of insects may have left the treated area or may have migrated into it. This introduced a possible error which might be quite large, but which was unavoidable under the conditions which existed at the experimental sites. Efforts to reduce this error to a minimum were made. These efforts consisted of observing the insects to determine whether any of them left the treated area, and of keeping the squash plants separated by at least two feet. Any insects observed leaving the plants following the application of chemicals, were gathered in containers and observed along with the ones found on the plants. They were included in the findings and recorded as being on the plant.

Only one treatment was given the plants here listed, although in other parts of the fields several applications were made in an effort to save the plants and to observe the effect of the materials upon them. Two fields were used. One, the College field, and the other, a field owned by Mr. V. L. Forsberg, located about two miles west of Fort Collins, Colorado.

Feeding habits in relation to varieties.

It was desired to determine whether or not squash bugs show a preference for certain varieties of squash. The following procedure was used: Short rows of squash were grown in a small field. There were different varieties in each row so that the chance of infestation was nearly equal for all varieties. No other plants known to harbor the squash bugs were near the field. In some cases there were twice as many plants of one variety as of others. It was necessary, therefore, to add an additional column in the tables, in which the number of insects upon the squash plants could be shown as based upon equal numbers of plants.

The incoming adults were handpicked at definite intervals of time. Usually this was done each odd day, although several deviations from this are recorded. Picking of the insects was started at the time the first insects were noticed, and continued until the vines became so large and the insects so scarce and hard to find that it was not considered practical to continue the picking of the insects. It was felt that there was a strong possibility of losing or missing many of the insects and of possibly introducing large errors into the data. The number of bugs obtained from each variety was recorded. The insects gathered by this method were taken into the laboratory for further study.

Tests of possible attractants.

A group of 61 different organic chemicals and extracts of squash bugs were tested as possible attractants. It was hoped that some material might be found which would act as a powerful lure for the insects. The chemicals were commercial compounds, and the squash bug extracts were made by boiling dead adult squash bugs in water, or by macerating them and extracting possible attractive secretions, using alcohol or ether as a solvent. These materials were placed in separate small tin containers, circular in shape, about 1/2 an inch deep and two inches wide. These containers were filled about half full of water and moist cotton, in order to allow easy access to the liquid. To this cotton and water mixture were added two drops of the material undergoing the test.

These tin containers were placed five inches apart, in a cage containing approximately 300 adult bugs, and in competition with a small potted squash plant and a receptacle containing only water and untreated squash seeds. The number of insects found feeding upon each of the materials was recorded at the end of each hour, for a period of five hours. The results were tabulated and used for an index to determine the comparative attractant powers of the materials. Those which gave the best results were retested under laboratory conditions, and the materials which gave the best average results were reserved for later field tests.

<u>Baits and traps.</u>

Various baits and traps were used in the field in an effort to develop a method of poisoning or trapping the insects.

Stomach poisons used with baits. - Sodium arsenite was dissolved in water and used to moisten squash seed utilized as food by the insects. Several attractants were used by adding them to the food, in an effort to induce the insects to consume the poisoned food. The same procedure was followed both in the field and in the laboratory. The chief difference was that in the field the insects were not confined, and the bait was in competition to the live squash plants adjacent to the containers. In the laboratory no other food than the poison bait was avilable to the insects.

The use of traps, chemical and mechanical. - Small wire screen traps similar in design to a common inverted-funnel-fly-trap, about four inches square and six inches high, were used in an effort to trap the insects in the field. Several of these traps were baited with attractants and moist cotton and were placed in vertical and horizontal positions adjacent to infested squash plants. Other traps, similar in design, but unbaited, were placed in various positions near the plants in an effort to catch the insects during the cool part of the night when they might huddle together under rubbish and boards in their search for shelter. All insects caught by these methods were noted and the results recorded.

RESULTS OF THE APPLICATION OF INSECTICIDES

Laboratory study

Various substances known to be harmful to many insects, or indicated by other investigators, to be useful in the control of the squash bug, were applied to the insects in the College Insectory, under laboratory conditions which very closely approximated those existing in the field. The results obtained are tabulated and discussed in this part of the chapter.

Table I indicates the effect of lime-sulfur sprays upon the squash bug.

Table I. - The Effect of Aqueous Lime-Sulfur Sprays Applied to the Squash Bug.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
1	7-6	Lime-sulfur	1:40					
		& Aresket	1:200	10	2	2	4	6
3	7-6	Lime-sulfur	1:50	10	0	2	6	10
4	7-6	Lime-sulfur	1:35	10	0	1	3	7
5	7-6	Lime-sulfur	1:40					
		&Verdol	1:200	10	0	2	4	9
6	7-6	Lime-sulfur	1:40	10	-	0	7	9
7	7-6	CHECK		10	1	1	1	5

This table indicates that lime-sulfur, an excellent control for some insects, had very little effect upon squash bugs for at least two days after the material was applied, and that there was marked increase in the mortality rate the third and fourth days. This rate was also evident in the control group. Apparently from this chart, the lime-sulfur is of little value as a control material.

Table II indicates the results obtained by spraying the insects with aqueous Cubor.

Table II. - The Effect of Applying Aqueous Cubor Sprays Upon the Adult Squash Bug.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
2	7-6	Cubor	1:200	10	0	0	2	9
7	7-6	"	1:100	10	1	2	3	9
8	7-6	"	1:50	10	4	7	7	8
16	7-6	CHECK		10	1	1	1	5

This table appears to indicate that aqueous solutions of Cubor are not effective in killing the squash bug. The evident concentrations needed to obtain the desired results is quite high. A solution of Cubor in the ratio of one part to fifty of water is shown to kill 70% of the insects the second day after application. Again in this table, as in the previous one, such a large number of the insects in the control group died, that the few additional deaths shown in the groups where Cubor is used, are not significant and do not imply that Cubor is at all effective as a contact insecticide.

Red Arrow insecticide was used as an aqueous spray in various concentrations. The results of this experiment are shown in Table III.

Table III. - The Effect of Aqueous Red Arrow Sprays Upon Adult Squash Bugs.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
11	7-6	Red Arrow	1:200	10	5	8	9	10
10	7-6	"	1:100	10	8	10	10	10
9	7-6	"	1:50	10	9	10	10	10
16	7-6	CHECK		10	1	1	1	5

Red Arrow is here indicated to be quite effective against the squash bug. A solution of 1:200 killed all bugs in four days. It may be noted, however, that the concentrations used here are of quite strong soap (Red Arrow) content. This material is too expensive to be used extensively in spraying if these concentrations are to be needed to kill the insects.

Mixtures of Ethyl Alcohol, Black Leaf 40 and water, were applied to adult squash bugs. The results are shown in Table IV.

This table indicates that mixtures of Ethyl Alcohol, water and Black Leaf 40, are of no value in the control of the insect when used in the concentrations here noted. In these tests the materials may be considered as of no importance in killing squash bugs.

Table IV. - The Effect of Aqueous Sprays of Ethyl Alcohol and Black Leaf 40 Upon Adult Squash Bugs.

Expt. No.	Date Applied	Spray Materials	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days
17	7-7	Ethyl Alcohol	1:50	10	3	3	5
18	7-7	Ethyl & Black Leaf 40	1:1:50	10	4	5	5
19	7-7	" "	2:1:150	10	2	2	4
20	7-7	" "	4:1:200	10	3	4	4
21	7-7	" "	2:3:300	10	2	4	6
22	7-7	CHECK		10	2	3	6

Table V indicates the effect of Loro and Penetrol when applied to the adult squash bugs.

Table V. - The Effect of Applying Aqueous Penetrol Sprays to the Adult Squash Bugs.

Expt. No.	Date Applied	Spray Materials	Conc.	No. Bugs	No. dead at end of 1 day	2 days	2 days	4 days
31	7-9	Penetrol	1:50	10	4	8	8	8
32	7-9	"	1:100	10	0	8	8	8
33	7-9	"	1:200	10	0	8	8	10
34	7-9	" & Loro	1:1:50	10	10	10	10	10
35	7-9	"	1:1:100	10	6	10	10	10
36	7-9	"	2:1:200	10	9	10	10	10
37	7-9	"	4:1:400	10	4	10	10	10
38	7-9	"		10	2	4	6	6

Table V indicates that a mixture of Penetrol and Loro is fairly effective against the insect under laboratory conditions. This appears to be a fairly effective spray, although the control insects showed a large loss also.

Table VI shows the results of the application of Nicotine Oleate sprays to the adult insects.

Table VI. - The Effect of Aqueous Nicotine Oleate Sprays Upon the Adult Squash Bug.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
44	7-11	Nicotine Oleate	1:50	10	3	7	8	9
45	7-11	" "	1:100	10	2	6	6	9
46	7-11	" "	1:200	10	0	3	5	9
47	7-11	" "	1:300	10	0	5	5	6
48	7-11	" "	1:400	10	1	3	3	4
62	7-11	CHECK		10	0	0	0	1

Nicotine Oleate appears to be effective in the more concentrated solutions, but the weaker solutions do not appear to be sufficiently toxic to the insect to be considered a means of control.

New Evergreen was mixed with water and the insects sprayed with various concentrations of this compound. Table VII is a tabulation of the effect obtained by this application of spray materials.

New Evergreen is here indicated as being quite toxic to the insects. The addition of Penetrol appears to increase the effectiveness of the spray quite materially. This is the most effective spray material, of the commercial preparations, used in this study.

Table VII. - The Effect of Spraying Squash Bugs (Adults) with Aqueous Solutions of New Evergreen.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
49	7-11	New Evergreen	1:50	10	6	6	10	10
50	7-11	" "	1:100	10	3	7	7	10
51	7-11	" "	1:200	10	0	4	5	10
52	7-11	" "	1:400	10	1	5	10	10
53	7-11	New Evergreen & Penetrol	1:1:200	10	9	10	10	10
54	7-11	" "	1:1:400	10	9	10	10	10
62	7-11	CHECK		10	0	0	0	1

The effect of Aresket upon the adult squash bugs is shown in Table VIII.

Table VIII.- The Effect of Aqueous Aresket Solutions Applied to the Adult Squash Bug.

Expt. No.	Date Applied	Spray Material	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
55	7-11	Aresket	1:50	10	2	4	5	10
56	7-11	"	1:100	10	3	4	7	8
57	7-11	"	1:200	10	5	5	6	6
62	7-11	CHECK		10	0	0	0	1

Table VIII indicates that very concentrated solutions of Aresket are needed to be effective against this insect. On the whole, only fair results were shown by the use of this material.

Fishoil soap was applied in the form of aqueous sprays. The results are shown in Table IX.

Table IX.- The Effect of Applying Aqueous Fishoil Soap and Other Materials to the Adult Squash Bug.

Expt. No.	Date	Materials Used	Conc. in oz. per gal. water	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
58	7-11	Fishoil soap	4	10	8	8	9	10
59	7-11	" "	3	10	3	4	9	9
60	7-11	" "	2	10	7	7	8	8
61	7-11	" "	1	10	0	4	7	8
79	7-11	Fishoil soap & B.L.40(1)	4:1 1/2	10	2	8	10	10
63	7-11	" "	4:1	10	2	8	9	9
64	7-11	" "	4: 3/4	10	2	8	9	10
65	7-11	" "	4: 1/3	10	6	7	9	9
66	7-11	" "	3:1 1/2	10	8	8	10	10
67	7-11	" "	3:1	10	5	7	10	10
68	7-11	" "	3: 3/4	10	8	8	10	10
69	7-11	" "	3: 1/3	10	8	8	9	9
70	7-11	" "	1: 3/4	10	7	9	9	9
71	7-11	Fishoil soap & sulfur	2: 3/4:1	10	9	10	10	10
72	7-11	Fishoil soap sulfur & B.L.40.	2:1/3:1	10	8	8	8	8
73	7-11	" "	2: 3/4:2	10	8	10	10	10
74	7-11	" "	1: 1/3:2	10	6	8	8	8
75	7-11	" "	1: 1/3:1	10	1	3	3	3
76	7-11	" "	1: 3/4:1	10	9	10	10	10
77	7-11	" "	2: 1/2:2	10	6	10	10	10
78	7-11	" "	1: 3/4:2	10	5	7	7	8
62	7-11	CHECK		10	0	0	0	1
80	7-11	"		10	0	1	1	2

(1) Black Leaf 40

The fishoil soap used in this experiment was procured and used in the form of paste. Shephard(19:181) estimates this soap to contain 70% soap and 30% water. The quantities of soap shown in Table IX are in the paste form. This material gave fairly good results in all concentrations used, but the addition of Black Leaf 40 did not appear to appreciably intensify the action of the soap.

The addition of small amounts of sulfur to the mixture of fishoil soap and Black Leaf 40 gave outstanding results. The spray which proved so effective in the laboratory in killing the squash bugs contained; fishoil soap, two ounces; Black Leaf 40, 3/4 ounces; sulfur, one ounce. This material was mixed with one gallon of water and the insects sprayed thoroughly with the insecticide.

Another soap, Potassium Oleate, was applied to the insects as an aqueous spray. The results of this application are shown in Table X. The table indicates that this material may be effective as a control of the squash bug under laboratory conditions. In concentrations of three ounces per gallon of water there was a 100% kill in two days. The addition of small amounts of sulfur appears to render the spray much more deadly to the insects. As in the case of other soap sprays, it is feared that this material will not be applicable in the field where hard water may cause it to be ineffective, and the plants may be injured if it is applied in the quantities which appear to kill the squash bug.

Table X. - Results of the application of Aqueous Potassium Oleate to the Adult Squash Bug.

Expt. No.	Date	Materials Used	Conc. in oz. per gal. water	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
81	7-16	Potassium oleate	1/2	10	2	2	3	3
82	7-16	" "	1	10	7	8	8	8
83	7-16	" "	2	10	5	6	7	7
84	7-16	" "	3	10	9	10	10	10
85	7-16	" " & sulfur	1:1	10	7	10	10	10
86	7-16	CHECK		10	0	1	1	2

Various dusts were applied to the insects in an effort to find one which would control the squash bug. Table XI summarizes the results obtained with the use of Barteldes Squash Bug Special Dust upon the adult insects.

Table XI. - The Effect of Applying Barteldes Squash Bug Special Dust to the Adult Squash Bug.

Expt. No.	Date	Material Used	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
15	7-6	Barteldes Squash Bug Special Dust	Undiluted	10	5	10	10	10
27	7-6	" "	"	10	0	10	10	10
16	7-6	CHECK		10	1	1	5	5
30	706	"		10	0	1	2	2

Table XI appears to indicate that Barteldes Squash Bug Special Dust is an effective control when used upon the insects in the laboratory. The use of undiluted dust is recommended for the control of the adult squash bug in the laboratory.

Adult squash bugs were also treated with various mixtures of Pyrocide dust. Table XII indicates the results obtained by this application.

Table XII. - The Effects of Pyrocide Dust upon Adult Squash Bugs.

Expt. No.	Date Applied	Materials Used	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
12	7-6	Pyrocide & Celite	1:9	10	2	3	5	9
13	7-6	" "	1:5	10	5	8	9	10
14	7-6	Pyrocide & lime	1:5	10	9	9	9	9
16	7-6	CHECK(NONE)		10	1	1	1	5
23	7-8	Pyrocide & gas sulfur	1:5	10	0	7	7	8
24	7-8	Pyrocide & Celite	1:5	10	0	10	10	10
25	7-8	Pyrocide & lime	1:5	10	0	7	7	8
26	7-8	Pyrocide & gypsum	1:15	10	0	9	10	10
30	7-8	CHECK		10	0	1	1	2
87	7-18	Pyrocide & sulfur	1:5	10	10	10	10	10
88	7-18	Pyrocide & gypsum	1:5	10	10	10	10	10
89	7-18	Pyrocide & Portland cement	1:5	10	7	10	10	10
90	7-18	CHECK		10	0	1	1	1

Pyrocide dust was used in various dilutions with different compounds in these tests. The results shown in Table XII indicate that Pyrocide may be very effective as a means of killing squash bugs. In experiment 89, above, the insects collapsed about 30 minutes after the dust was applied. They seemed to be partially paralysed and lay on their backs, kicking their legs slowly. The same effect was noticed in experiment number 87, where a mixture of Pyrocide and sulfur was used. The most effective dust tried, from observation of the insects, was a mixture of Pyrocide and gypsum, listed in experiment 88, above. This dust paralysed the insects in less than five minutes, and they all died in less than an hour after the dust was applied.

Pyrocide dust mixed with gypsum is indicated as being the most effective material applied to the insects in the laboratory.

Miscellaneous dusts, applied to the squash bugs gave the results shown in Table XIII.

Table XIII. - The Effect of the Application of Miscellaneous Dusts to the Adult Squash Bug.

Expt. No.	Date	Materials Used	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
29	7-8	Sodium Fluoride	pure	10	0	7	7	8
26	7-8	Gypsum	"	10	0	1	1	2
30	7-8	CHECK		10	0	1	1	1
91	7-20	Lethane	"	10	0	2	6	7
92	7-20	Sulfur	"	10	1	3	7	7
93	7-20	Cubor Sulfur	"	10	0	1	4	6
94	7-20	Serrid(3% Derris)	"	10	0	1	6	6
95	7-20	CHECK		10	1	3	3	3

The results shown by Table XIII appear to indicate that the materials used varied appreciably in their insecticidal powers when applied to adult squash bugs. Comparatively little effect upon the insects was noted for a period of at least two days after the application of the dusts. Sodium Fluoride gave fair results after a period of two days. Lethane, sulfur, and Serrid each gave fair results after a period of three days. In general these materials do not appear to be very promising as a means of control of the squash bug.

The dusts which appeared to be the most effective when applied to the adult insects, were utilized as dusts to be tested for control of the nymphs. Table XIV shows the results of this test.

Table XIV. - The Effect of Applying Various Dusts to the Squash Bug Nymphs.

Expt. No.	Date	Materials Used	Conc.	No. Bugs	No. dead at end of 1 day	2 days	3 days	4 days
39	7-11	Pyrocide & gypsum	1:5	39	27	39	not recorded because all treated insects were killed	
40	7-11	Pyrocide & Celite	1:5	492	241	492	"	"
41	7-11	Pyrocide & gas sulfur	1:5	116	58	116	"	"
42	7-11	Barteldes Squash Bug Special	pure	93	33	93	"	"
43	7-11	CHECK		142	5	9	"	"

In Table XIV these further observations were noted: Number 39, all the nymphs were knocked down instantly, with little or no motion of their legs or antennae. In number 40 most of the nymphs were knocked over immediately, but showed that they were still alive by movements of legs and antennae. In numbers 41 and 42 most of the nymphs were downed immediately, but they still manifested a high degree of motility when disturbed.

It may be noted, by a comparison of Tables XI, XII, showing adults, and XIV, showing nymphs, that the results were apparently affected less by the dusts than were the nymphs. These findings coincide with the results reported by other workers, some of whom are listed in the Introduction of this paper. It is to be expected, therefore, that spray or dust materials which will control a large percentage of adults will have even more value in the control of the nymphs.

Field studies

Unpublished data, obtained from experiments conducted by the author in 1934, concerning the use of sprays, indicate that soap solutions applied in the concentrations here proposed may seriously retard the growth of the plants. Potassium Oleate used in strengths of 1-3 ounces per gallon of water, gave a moderate burning of the leaf edges; five ounces resulted in the plant wilting to a marked degree. Fishoil soap, 1/2 to 2 ounces per gallon of water, combined with Black Leaf 40

1-200, gave a moderate wilting of the leaves; while four ounces killed large portions of the leaves.

Further, soap solutions, when utilized in the areas where the water contains alkali minerals, will immediately be flocculated, and be of little value in the control of insects. Use of the large amounts of soap needed to overcome this flocculation would entail considerable expense. It would be impossible to recommend a definite soap solution because the water in many areas of Colorado is of indefinite hardness, the degree depending upon the location and the time of the year, in addition to other factors.

A third factor must be considered as of major importance in the consideration of soap sprays. This is the effect of rapid drying of the soap solutions upon the bodies of the insects. Apparently the effectiveness of soap sprays is due largely to the ability of the soap film to spread over the body of the insect, and to penetrate the trachea and other external openings. As soon as the film dries the toxic value is apparently lost and no further harm seems to accrue to the insect. In experiments with soap solutions used as insect sprays, Fulton (9:630) found that soap sprays must remain on the body of the insect for several minutes if the insect is to be killed. Under conditions of rapid evaporation the solution may dry before it can produce lethal effects. he contends that better effects may be obtained if the soap sprays are applied during cloudy humid days instead of bright ones, especially if the wind is blowing. In the dry atmosphere of our western states, the evaporating power of the bright sunlight and the low humidity causes an almost immediate drying of the solutions upon the body of the insect before the bug has been materially injured by the spray. Due to these factors the use of soap sprays as a control for the squash bug is largely precluded.

In the laboratory experiments with dusts and sprays, the only materials apparently effective as a squash bug control were those sprays containing soap as a spreader, and various dusts. Inasmuch as soap sprays are of doubtful value in the field, in this section of the country, and since other workers, listed in the Introduction, have explored the possibilities of many soaps without finding a suitable control for the squash bug, it was deemed expedient to conduct the field tests with dusts which had shown promising results in the laboratory. Table XV shows the results of the application of some dusts upon the plants and insects in the field. Both adults and nymphs are listed, and evident damage to plants are here recorded.

In the field tests, 14 different mixtures of dusts were used in attempts to control squash bugs. The materials used, with one or two minor exceptions, were those which gave the best results in the laboratory.

Table XV.—The Results of Applying Various Dusts to the Squash Bug Under Field Conditions.

Field Plot No.	Date Applied	Dust Material Used	Conc.	No. of Hills	Adults: No. of Bugs	Adults: No. dead at end of 1 Day	2 Days	3 Days	4 Days	Nymphs: No. of Bugs	Nymphs: No. dead at end of 1 Day	2 Days	3 Days	4 Days
COLLEGE FIELD														
A	7-8	Pyrocide & lime---	1:5	10	11	2	2	2	2	10	5	5	5	5
B	" "	Pyrocide & gypsum-	1:5	5	4	0	3	4	4	9	7	9	9	9
C	" "	Serrid------------	pure	5	7	0	0	0	0	17	0	0	0	4
D	" "	Pyrocide & Celite-	1:5	5	6	1	1	2	2	30	15	18	21	21
E	" "	Pyrocide----------	pure	5	2	0	1	1	1	26	18	18	22	24
F	" "	Derris------------	pure	5	2	0	0	0	0	21	14	14	17	17
G	" "	Lethane-----------	pure	5	2	0	0	0	0	16	3	5	5	5
H	" "	Sulfur------------	pure	5	14	1	3	3	3	28	9	9	12	12
I	" "	Cubor Sulfur------	pure	10	12	0	0	0	0	35	7	7	7	7
J	" "	Barteldes Special-	pure	10	6	2	2	3	3	13	6	6	6	6
K	" "	CHECK (not dusted)	----	5	17	0	0	0	0	29	0	0	0	0
FORSBERGS FIELD														
L	7-10	Pyrocide & gypsum-	1:5	20	37	32	32	34	34	68	57	68	68	68
M	" "	Pyrocide & Celite-	1:5	20	29	6	9	9	14	73	36	42	51	51
N	" "	Pyrocide, gypsum & Tobacco Dust--	1:5:5	20	28	0	0	0	3	97	30	30	39	39
O	" "	Tobacco Dust------	pure	20	32	0	0	0	0	81	0	0	0	0
P	" "	CHECK (not dusted)	----	20	18	0	0	0	0	93	0	0	0	0

Observations concerning the plants dusted disclosed that Derris, 5% Rotenone Dust resulted in a moderate burning of the leaves. Lethane, Sulfur, and Cubor Sulfur apparently retarded the growth of the plants considerably. Tobacco Dust caused wilting of the plants. None of the other materials appear to cause any injury or checking of the plant growth.

Table XV. indicates that contrary to the belief of many gardeners, tobacco dust has no apparent harmful effect upon the adult or nymph squash bugs. In fact, it even seems to cause some injury and wilting of the plant to which it is applied. However, the wilting here noted may have been due to other factors unknown to the author.

It is noted that Lethane, Cubor Sulfur, Derris (5% Rotenone), Serrid (3% Derris), Sulfur, and tobacco dust do evidently exert some slight varying toxic effect upon the nymphs and in some cases upon the adults. However, since these materials showed such low mortality rates for the nymphs and extremely low ones for the adults, they may be considered as being of little value in the control of the squash bug.

The most promising material used in the field was Pyrocide in its various mixtures. The dry Pyrocide was applied both in the diluted and the undiluted state. Excellent results were obtained where both types were used. The best control was obtained by an application of a mixture one part of Pyrocide to five parts of gypsum. A 92.7% mortality rate among the adults was obtained, and 100% of the nymphs were killed.

An additional factor in favor of the Pyrocide dusts appears to be that there is no harmful effect upon the plant. At least none was noted in the limited number of cases which were observed. Pyrocide mixtures apparently have a slightly repellant effect, as the insects seemed to avoid the plants dusted with this material, for a period of from one to two days. In most cases where these Pyrocide mixtures were applied to the insects, they seemed to be immediately knocked over, and appeared practically helpless as they lay on their backs kicking their legs slowly. Quite often this happened within one or two minutes after the dust was applied.

None of the other compounds, with the exception of tobacco dust, showed any repellant property at all. The tobacco dust appeared to repel part of the nymphal groups for a period of one to two days, but at the end of that time there was no apparent repellant effect at all. Several of the compounds used, especially Derris, Lethane, Sulfur, and Cubor Sulfur, appear to burn the leaves and otherwise retard the growth of the plants.

Since these data were gathered, Beard (2:248) tested Dry Pyrocide Dust and found that in dilutions of

1:9 parts of talc, 69.5% of all stages of the insect were killed in field tests. He recommended talc as a diluent instead of gypsum. He tested a Pyrethrum spray in combination with wetting materials, and obtained an 82.9% kill. Fulton and Howard (10:408) in later tests, reported very good results using a spray of Derris-acetone extract (0.015% Rotenone) either alone or with spreaders of vegetable oils. They concluded that freshly prepared Derris-acetone extracts were very effective, and that the addition of vegetable oils rendered the sprays more effective than the addition of mineral oils or no oils at all.

RESULTS OF OTHER PHASES OF THE STUDY OF THE SQUASH BUG.

Variety tests.

Tests were conducted in the field to determine whether or not the insects were especially attracted by certain squash varieties. A search for various stages of the insect was made upon other plants than squash and pumpkin. The results of these tests are given in this part of the paper. Table XV is a tabulated record of the tests made upon squash varieties in an effort to determine relative attractability of the various kinds in the field.

These data appear to indicate that the variety known as Golden Delicious Squash harbored the most insects. Boston Morrow and Banquet followed closely in the number of adult insects collected. It is readily apparent, in this field test, in which 1540 insects were picked, that these three varieties appear to be more attractive to the insects than are the other varieties grown.

The varieties which seem to have the least attraction for the insects, judging by this same table, are Curshaw, Table Queen, Gills Queen and Banana Squash.

Experiments started July 9, 1936, and ending July 30, 1936, on a small plot west of Fort Collins, gave the following results: Acorn squash in a field adjacent to one containing Hubbard squash and an undetermined variety of pie pumpkin were not infested with the insects in appreciable numbers even though the Hubbards harbored large numbers of the bugs. During the latter part of July, these heavily infested squash plants died. Only then did the insects migrate to the acorn squash, and this occurred only on a limited scale.

In another field, the eggs of the squash bug were found on the following non-cucurbitaceous plants: common pigweed, ground tomato, fireweed, lambs quarter and round leafed mallow. Nymphs of the first instar were found upon the common pigweed, but they did not appear to feed upon it, and they migrated to squash plants soon after hatching.

This part of the study indicates that certain varieties of squash and pumpkin are more attractive to the insects than are others. Further study in this field is recommended, especially in the growing of non-attractive or less attractive varieties in conjunction with those which are attractive to the insects to an appreciable degree. It is felt that by this procedure, a large crop of squashes will be possible, in contrast to little or no crops produced where only one variety is planted in the field.

Table XVI.—Numbers of Adult Squash Bugs Handpicked From Certain Varieties of Squash Plants in the Field.

Squash Variety Tested. In Order of No. of Bugs Found.	Number of Hills Tested	Number of Insects Obtained Each Day														Total Number of Insects Collected	
		6-15	6-17	6-19	6-23	6-25	6-27	6-29	7-1	7-3	7-6	7-8	7-10	7-13	7-15	Actual	Computed on A Basis of 18 Hills.
Golden Delicious-	18	0	0	0	27	35	23	12	4	36	5	12	5	7	5	171	171
Boston Morrow----	18	0	0	5	15	17	39	9	7	28	10	7	7	5	10	159	159
Banquet----------	9	0	0	0	2	17	20	12	4	7	0	10	0	0	3	75	150
Warted Hubbard---	18	0	0	0	17	29	19	7	6	21	10	10	2	5	9	135	135
Delicious--------	18	0	0	2	6	20	35	12	5	2	24	7	10	1	4	128	128*
Baby Hubbard-----	18	0	0	2	4	23	23	20	12	18	10	6	2	3	6	128	128*
Buttercup--------	27	0	0	1	9	32	35	32	11	13	20	13	16	0	8	190	127-
Blue Hubbard-----	18	0	0	0	19	25	20	6	2	14	8	9	10	4	3	120	120
Golden Hubbard---	18	0	0	2	17	21	19	10	3	3	12	6	5	4	7	109	109
True Hubbard-----	18	0	0	2	12	24	16	5	1	8	8	5	5	2	4	92	92
Arikara----------	18	0	0	0	2	26	18	2	2	5	15	3	8	0	7	88	88
Banana-----------	18	0	0	0	11	17	13	6	0	8	5	6	4	2	4	76	76
Gills Queen------	18	0	0	3	3	15	15	8	7	3	5	3	3	1	3	69	69
Table Queen------	18	0	0	0	0	9	10	4	1	6	3	3	1	4	3	44	44
Curshaw----------	9	0	0	0	0	1	6	5	1	0	0	1	2	0	0	16	32
Total------------		0	0	17	144	311	311	150	66	172	135	100	80	38	76	1540	

* These two varieties each yielded the same number of insects.

Attractant tests.

The squash bugs in the Supply Cages were subjected to tests in which organic materials and squash bug concentrates were used to attract the insects. The summarized results of these tests are shown in Table XVII.

Table XVII. - The Number of Insects Feeding on Attractants in Competition to Squash Plants and Seeds. (Extract of Chart B, Appendix).

Experiment Number	Materials Used	Total number of insects found feeding on materials
3-a	citronellol dextro	4
CHECK	seed (average)	3-
CHECK	plants (average)	49-
25-a	phenyl acetaldehyde	6
58-a	courmarin	4
38-a	citral	3
63-a	phenyl acetaldehyde (test repeated)	3

All other materials tested, attracted fewer than three insects.

Table XVII indicates that none of the materials tested were of appreciable value in attracting squash bugs when in competition with squash plants. Those showing the most attractant power, limited though it was, were : Coumarin , Phenyl Acetaldehyde, and Citronellol Dextro. Squash seed showed no outstanding attractant value when in competition with squash plants. The plants themselves showed a much greater attraction for the insects than did any of the materials tested. Further search for attrahents is recommended.

Baits and traps.

Even though no materials were discovered in the previous part of this study, which seemed to attract the insects, attempts were made to trap and to poison these insects.

Stomach poisons mixed with baits.

In the laboratory and in the field, various stomach insecticides were used in conjunction with baits in an effort to entice the insects to imbibe injurious chemicals which might cause their death. Sodium arsenite, dissolved in water used to moisten squash seed as food, did not attract the insects. When the bugs were placed in captivity with only this material available as food, they were sometimes forced to imbibe this substance. When this consumption occurred, death usually resulted in from 12-24 hours.

Several poisons were tested separately in the field, mixed with Phenyl Acet Aldehyde, the most promising attrahent discovered in the search for attractants, in an effort to poison the squash bugs. These poisons were: Lead arsenate, Paris green, sodium arsenite, and sodium fluoride. Two containers of each of these materials were placed near the base of squash plants harboring the insects. Observations were made for a period of five days (July 16-21). Not an insect was found feeding upon the baits, and none were observed near the containers in which the baits were kept. Apparently no squash bugs were killed by this method.

<u>Trapping squash bugs</u>.

<u>Traps with chemical attractants</u>. - Attempts made in the laboratory to discover attrahent chemicals were without favorable results, as shown by Table XVII and accompanying discussion. Nevertheless, field experiments upon this phase of the problem were conducted in the hope that some positive results might be obtained. The results of this phase of the work are here given.

Some of the attrahent material, Phenyl Acet Aldehyde, was placed in a small screen trap, and the trap placed at the base of a plant which harbored squash bugs. No squash bugs were caught by this method. The only insects trapped were a grasshopper and a Harpulus beetle. The tests were run for five days.

<u>Mechanical traps</u>. - In addition to the tests carried on with chemical traps, there were attempts made to trap the squash bugs by using mechanical traps in the field. The results of these experiments are discussed here.

Small square screen traps of the inverted funnel type were placed at the base of squash plants in an effort to entice the insects into an escape proof box. It was hoped that the insects would gather in the traps with chemical attractants or very near them during the cold part of the night. Should they do this, it was hoped that part of them would crawl into the traps and be unable to get out. The insects often prefer to seek shelter under small boards or bits of rubbish on the ground. Several of these small boards and bits of rubbish were placed so that the insects could crowd under them. These boards were arranged in such a manner that the bugs could naturally follow them into the traps, if they were to move about to any great extent. These experiments were disappointing and were entirely without favorable results. No squash bugs were caught by this method in a period of five days.

CONCLUSIONS

As a result of the study of squash bug control, the following conclusions, based upon the data presented in this paper, are given.

1. Of 23 materials tested as contact insecticides upon adult squash bugs in the laboratory, the following gave promising results: Barteldes Squash Bug Special, Fishoil soap, New Evergreen, Pyrocide Dusts, Potassium Oleate, and Red Arrow.

2. Materials in dust form showed the greatest promise of practical control of the insects.

3. Barteldes Squash Bug Special dust was very effective in the laboratory, but was of limited value in the field.

4. Dry Pyrocide, mixed with five times its weight of gypsum, gave excellent control of the bugs both in the laboratory and in the field.

5. The nymphs are less resistant to contact insecticides than are the adults.

6. There is apparently a wide variation in the attractibility of the squash for the bugs. Varieties tested which were specially attractive were: Golden Delicious, Boston Morrow, Banquet, and Warted Hubbard. Those showing the least attraction were: Curshaw, Table Queen and Gills Queen.

7. The results indicate that trap crops may

be of value.

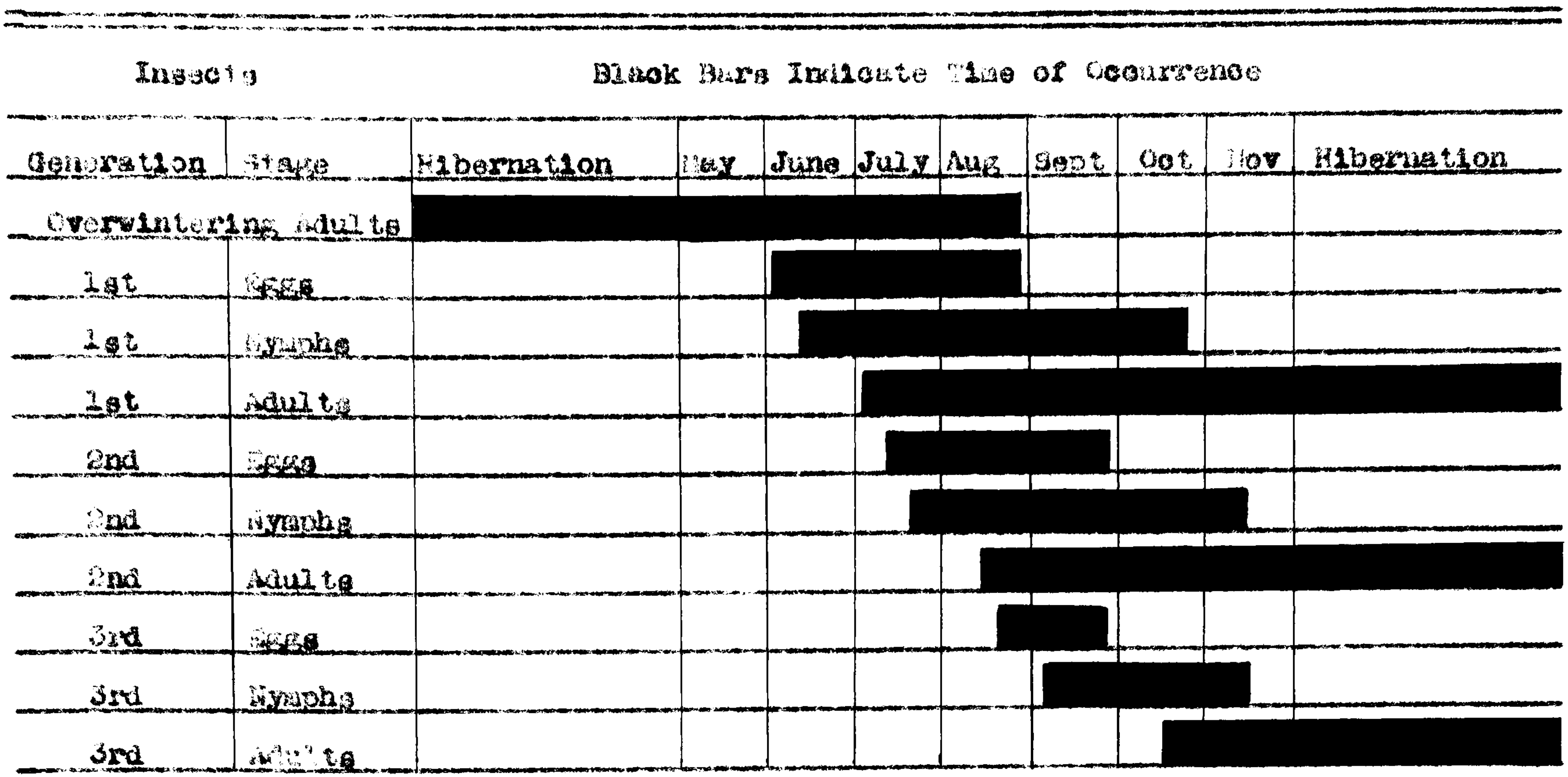
8. Preparations made from squash bug bodies failed to attract squash insects.

9. No effective chemical attractants for the squash bug were found.

10. Attempts to poison the insects in the field with arsenical baits gave negative results.

11. No squash bugs were captured in the field by the use of mechanical traps.

Chart A.—Diagram Showing Stages of Squash Bugs Present in the Field at Certain Times in Kansas and Iowa.*



* Data From Wadley (20) page 421.

Chart B.—Numbers of Adult Squash Bugs Found Feeding Upon Various Attractant Materials.

Expt. No.	Date	Materials Tested	Numbers of Insects Found Feeding on Materials at end of Time shown.					
			1 Hr	2 Hrs	3 Hrs	4 Hrs	5 Hrs	Total
1a	7-16	Terpineol----------	0	0	0	0	0	0
2a	"	Isobutyl butyrate--	0	0	0	0	1	1
3a	"	Citronellal dextro-	3	0	1	0	0	4
4a	"	Amyl valerate------	0	0	0	2	0	2
5a	"	Terpinyl formate---	0	0	0	0	0	0
6a	"	Geraniol-----------	0	1	0	0	1	2
7a	"	Isobutyl phenyl acetate	0	0	0	1	0	1
8a	"	Amyl Oenanthate----	0	0	0	1	0	1
9a	"	Diphenyl oxide-----	0	0	0	0	1	1
10a	"	Bromestyrol--------	0	0	0	0	2	2
11a	"	Benzyl benzoate----	0	0	0	0	2	2
12a	"	Ethyl salicylate---	0	0	0	0	0	0
13a	"	Isobutyl cinnamate-	0	0	0	0	0	0
14a	"	Octyl alcohol------	0	0	0	0	1	1
15a	"	Ethyl cinnamate----	0	0	0	0	1	1
16a	"	Methyl acetophenone	0	0	0	0	0	0
17a	"	Cinnamic aldehyde--	0	0	1	0	0	1
18a	"	Rhodinol-----------	0	0	0	0	0	0
19a	"	Benzyl butyrate----	0	0	0	0	0	0
20a	"	Benzyl acetate-----	0	0	1	0	0	1
21a	"	Acetophenone-------	1	0	0	0	0	1
	"	CHECK (seed only)--	0	0	0	1	2	3
		CHECK (plants only)	6	6	11	15	17	55
22a	7-17	Isobutyl benzoate--	2	0	0	0	0	2
23a	"	Ethyl valerate-----	0	0	0	1	0	1
24a	"	Methyl octyl carbonate-	0	0	0	1	1	2
25a	"	Phenyl acetaldehyde	1	0	0	0	5	6
26a	"	Ethyl propionate---	0	0	0	0	0	0
27a	"	Nonyl anthranilate-	1	0	0	0	0	1
28a	"	Geranyl acetate----	0	0	0	0	0	0

Chart B (Continued).—Numbers of Adult Squash Bugs Found Feeding Upon Various Attractant Materials.

Expt. No.	Date	Materials Tested	Numbers of Insects Found Feeding on Materials at end of Time shown. 1 Hr	2 Hrs	3 Hrs	4 Hrs	5 Hrs	Total
29a	7-17	Citronellal----------	0	0	0	0	0	0
30a	"	Benzyl propionate---	0	0	0	0	0	0
31a	"	Safrol--------------	0	0	0	0	1	1
32a	"	Terpinyl acetate----	0	0	0	0	0	0
33a	"	Linalyl formate-----	0	0	0	0	0	0
34a	"	Ethyl citrate-------	0	0	1	0	0	1
35a	"	Methyl benzoate-----	0	0	0	0	2	2
36a	"	Isoeugenol----------	0	0	0	0	0	0
37a	"	Phenyl ethyl alcohol	0	0	2	0	0	2
38a	"	Citral--------------	0	1	0	1	1	3
39a	"	Anethol-------------	0	0	0	0	0	0
40a	"	Eugenol-------------	0	0	1	0	0	1
	"	CHECK (seed only)---	2	1	0	0	0	3
	"	CHECK (plants only)-	10	18	13	10	14	65
41a	7-18	Citronellyl formate-	0	0	1	0	0	1
42a	"	Ethyl benzoate------	0	0	0	1	0	1
43a	"	Isobutyl acetate----	0	0	0	1	0	1
44a	"	Isoamyl acetate-----	0	0	0	0	0	0
45a	"	Diethyl phthalate---	0	0	0	1	0	1
46a	"	Benzyl cinnamate----	0	0	0	0	0	0
47a	"	Methyl salicylate---	0	0	0	0	0	0
48a	"	Benzyl phenylacetate	0	0	0	0	0	0
49a	"	Geraniol*-----------	0	0	0	0	0	0
50a	"	Linalool------------	0	0	0	0	0	0
51a	"	Geraniol*-----------	0	0	0	0	0	0
52a	"	Methyl cinnamate----	0	0	0	0	0	0
53a	"	Amyl salicylate-----	0	0	0	0	0	0
54a	"	Oenanthic ether-----	0	0	0	0	0	0
55a	"	Benzaldehyde--------	1	0	0	1	0	2
56a	"	Piperonal-----------	0	0	0	0	0	0
57a	"	Methyl anthranilate-	0	0	0	0	0	0
58a	"	Coumarin------------	0	1	1	2	0	4
59a	"	Vanillin------------	0	0	0	0	0	0
60a	"	Benzophenone--------	0	0	1	0	0	1

Chart B (Continued).—Numbers of Adult Squash Bugs Found Feeding Upon Various Attractant Materials.

Expt. No.	Date	Materials Tested	Numbers of Insects Found Feeding on Materials at end of Time shown.					
			1 Hr	2 Hrs	3 Hrs	4 Hrs	5 Hrs	Total
61a	7-18	Oil of apple (alcoholic sol.)	1	0	0	0	0	1
62a	"	Amyl acetate---------*	0	1	1	0	0	2
63a	"	Phenyl acetaldehyde-	0	1	1	1	0	3
64a	"	Alcoholic squash bug solution-	0	0	0	0	0	0
65a	"	Alcoholic-ether squash bug solution	0	0	0	0	0	0
66a	"	Hot water squash bug solution-	0	0	0	0	0	0
	"	CHECK (seed only)---	0	1	1	0	0	2
	"	CHECK (plants only)-	2	7	10	9	0	28

* Indicates that these are being repeated here and have been listed previously in this chart.

Chart C. - Commercial Materials Used as Contact Insecticides.

Material	Active Ingredients	Approximate percent of ingredients present
Aresket	Spreader	not available
Barteldes Squash Bug Special	Pyrethrum & Rotenone	unknown
Celite	Diatomaceous earth	100%
Cubor	Rotenone	3/4-1%
Cubor Sulfur	Rotenone	3/4-1%
Lethance	Alkyl thiocyanate	25%
Loro	Lauryl thiocyanate	25%
New Evergreen	Pyrethrine & spreader	1.8%
Nicotine Sulfate (Black Leaf 40)	Nicotine	40%
Penetrol	Sulfonated oxidized oil	100%
Pyrocide	Pyrethrine in stablized carrier	2%
Red Arrow	Pyrethrum & spreader	1.5%
Serrid	Rotenone	3/4-1%
Verdol	Refined oil (spreader)	90-95%

SELECTED BIBLIOGRAPHY

There are hundreds of publications which mention the squash bug. Many of these are merely popular articles appearing in farm periodicals, or notations concerning the appearance of this insect in a new locality. The publications to which reference is made in this thesis are here presented.

(1) Beard, R. L.
1935. Further observations on the squash bug in Connecticut. Conn. Agr. Expt. Sta. (New Haven) Bull. 383, pp. 333-39, illus.

(2) ____________
1938. Control of the squash bug. Conn. Agr. Expt. Sta. (New Haven) Bull. 408, pp. 243-48, illus.

(3) Britton, W. E.
1919. Insects attacking squash, cucumber, and allied plants in Connecticut. Conn. Agr. Expt. Sta. (New Haven) Bull. 216, pp. 34-51, illus.

(4) Chittenden, F. H.
1899. The common squash bug (Anasa tristis DeG.) U.S. Dept. Agr., Div. Entom. 2nd ser. Circ. 39, 5 pp., illus.

(5) Cook, A. J.
1891. Kerosene emulsion and its uses. Mich. Agr. Expt. Sta. Bull. 76, 16 pp.

(6) Darley, M. M.
1927. Some comparative tests with Rotenone, Nicotine and Pyrethrum. Jour. Entm. 24:111-15, illus.

(7) Effect of nicotine dusts on crop insects. 1923 . Wis. Agr. Expt. Sta. Bull. 352, pp. 65-74, illus.

(8) Elliott, D. G.
1935. The squash bug in Connecticut (Anasa tristis DeGeer). Conn. Agr. Expt. Sta. Bull. 368, pp. 224-31, illus.

(9) Fulton, B. B.
1930. The relation of evaporation to killing efficiency of soap solutions on the Harlequin Bug and other insects. Jour. Econ, Entom. 23:625-30.

(10) Fulton, R. A. and Howard, N. F.
1938. Effect of addition of oil on the toxicity to plant bugs of derris and other insecticides. Jour. Econ. Entom. 31:405-9.

(11) Garman, H.
1901. Ememies of cucumbers and related plants. Ky. Agr.Expt. Sta. Bull. 91, pp. 3-56, illus.

(12) Granovsky, A. A.
1938. Insects in relation to diseases of truck crops. Jour. Econ. Entom. 31:11-18.

(13) Haseman, L.
1937. Controlling insect pests of melons, cucumbers, and related crops. Mo. Agr. Expt. Sta. Bull. 391, 19 pp., illus.

(14) Hixson, E.
1934. The more important pests during 1932-34. Okla. Agr. Expt. Sta. Rpt. 1932-34: 256-59.

(15) Hoerner, J. L.
1938. Controlling the squash bug. Colo. Agr. Expt. Sta. Press Bull. 93, 8 pp., illus.

(16) Little, V. A.
1927. Calcium Cyanide for the control of the squash bug, Anasa tristis DeGeer. Jour. Econ. Entom. 20:575-77, illus.

(17) N. Mex. Agr. Expt. Sta.
Twentyninth Annual report. 1917-1918. 73 pp.

(18) Rand, F. V., and Enlows, E. M. A.
1916. Transmission and control of Bacterial Wilt of Cucurbits. Jour. Agr. Research 6:417-35, illus.

(19) Shephard, H. H.
1939. The chemistry and toxicology of insecticides. 383 pp. Burgess Publishing Co., Minneapolis, Minn.

(20) Wadley, F. M.
1920. The squash bug. Jour. Econ. Entom. 13: 416-25, illus.

(21) Worthley, H. N.
1923. The squash bug in Massachusetts. Jour. Econ. Entom. 16:73-79, illus.