LABORATORY COMPARISONS OF THE EFFECTS OF WHEAT PROTECTANTS ON STORED GRAIN INSECTS

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LABORATORY COMPARISONS OF THE EFFECTS OF WHEAT PROTECTANTS ON STORED GRAIN INSECTS

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TABLE OF CONTENTS

I. INTRODUCTION

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Insect pests have been important in stored grain and similar products ever since man learned to keep grain for food or seed. In many instances the human race has carried these insects along in its movements over the globe. As a result we find that many of our common grain insects have become cosmopolitan in distribution.

The sources of insect infestation vary with crop and region. In the South infestation usually starts in the field.

Besides field infestation, infestation in stored grain can begin in storage facilities, or anywhere there is an accumulation of old grain, feed, or other infested food products. (Cotton and Ashby 1952). This occurs more often in the North.

In the United States today the demand for grain that is free from insects and insect fragments is increasing. With the encouragement of the Food and Drug Administration, more stress is being placed on the control of insects before they get into the grain.

The Food and Drug Administration has begun to restrict the movement of infested grain and intends to insure that grain will not be shipped for use as food if it contains excessive insect infestation . (Kennedy 1953).

Experts have estimated the total annual loss of stored grain due to weevils in this country to be about 50 million dollars; the estimated total annual insect damage in the United States is considered to be around two billion dollars.

Cotton (1950) stated that as a result of their feeding activities, their presence in grain and cereal products and the cost of methods employed to destroy them, this group of insects exacts a yearly toll of at least $300,000,000 in the United States alone.

Due to the extensive damage caused by grain insects a great deal of research has been conducted along the lines of prevention of infestation through the use of clean bins, protectant dusts and fumigation.

This paper is devoted chiefly to the use of protectant materials as preventatives against infestation by insects. The insects used in these tests were the confused flour beetle, Tribolium confusum, Duv., the granary weevil, Sitophilus granarius (L.) and the rice weevil, Sitophilus oryza (L.).

Tests were conducted in an attempt to determine which protectant provided the most satisfactory control. An attempt was also made to see how these protectant dusts would act against the confused flour beetle on whole wheat flour.

These tests were conducted at different temperatures and a constant humidity to determine if temperature would affect the toxicity of the material.

The confused flour beetle was used because it is easy to raise. However, with regard to stored grain, it is a mistake to base results of protectant tests on this. It is more reliable to use as test insects the primary insects of stored grain, namely the rice weevil and the granary weevil.

These tests were conducted with Pyrenone Wheat Protectant which has a pyrethrum base and a piperonyl butoxide synergist and with two other materials containing allethrin as the base and piperonyl butoxide as the synergist.

II. REVIEW OF LITERATURE

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The use of a protective covering of dust, wood ashes or similar finely divided material, or the mixing of the material with grain to prevent insect damage was first practiced many years ago and has never been entirely abandoned (Cotton, 1950).

Experiments have shown that chemically inert dusts cause the dessication of insects by getting between the surfaces of the cuticle that rub against each other, destroying its impermeability by abrading the waxy coating and thus causing a great increase in transpiration through the cuticle (Cotton and Frankenfeld, 1947). These inert dusts, although economical to use will not give reliable results and therefore have not achieved the desired protection.

Chemically active dusts have been employed for the protection of seed for many years, but usually the materials used are not suitable for grain destined for feed or food, because of their toxicity to warm-blooded animals (White 1952).

Among the various dusts employed in the past for the control of insects we find that pyrethrum is one of the most effective. The exact nature of the action of pyrethrum on insects is not known but destruction of nerve tissue is considered a primary factor in causing death. With most insects death from pyrethrum is accompanied by violent and occasionally prolonged struggles.

Beckley (1948) in preliminary tests with pyrethrum powders used alone or diluted with diatomaceous earth reported approximately eight months protection of bagged maize and wheat exposed to natural infestation. Watts and Berlin (1950) stated that any large-scale development program based on the use of such a dust would be seriously impaired by the limited supply of pyrethrum that could be obtained for this purpose.

McAlister, Jones, and Moore (1947) stated that despite the fact that pyrethrum insecticides on a unit-weight basis are the most toxic to insects and at the same time the least toxic to warm-blooded animals, their utilization has been necessarily restricted by their relatively high cost.

Attempts therefore have been made to develop synergists, activators or synthetic materials which would permit the use of pyrethrum at an economical cost. The development and use of piperonyl butoxide (Wachs, 1947) as an extender for this purpose aroused considerable interest and various tests were conducted to determine the degree of synergism obtained by the addition of piperonyl butoxide to reduced amounts of pyrethrins. Wachs and Berlin (1950) stated that the use of piperonyl butoxide alone was almost ineffective against the rice weevil. Pyrethrins alone gave from moderate to good control. Combinations of the two materials however, gave from good to complete control over a 30-day test period.

These various tests led to the development of Pyrenone which is a registered trade-mark of U. S. Industrial Chemicals, Inc., and pertains to various combinations of pyrethrins and piperonyl butoxide, with ground wheat as the carrier in the wheat protectants (Dove, 1952). As a result of laboratory tests it was found that the material had no effect on the germination of seed wheat and the odor was not noticeable in eggs when treated wheat was fed to laying hens (Wilbur, 1952).

The other material used in this thesis work was a combination of allethrin and piperonyl butoxide. In March 1949 the Bureau of Entomology and Plant Quarantine announced that their chemists Schechter, Green, and La Forge had discovered a method of synthesizing esters closely related to natural cinerin I which is an ester of pyrethrolone with chrysanthemum monocarboxylic acid and is one of the four esters found in pyrethrum flowers. The dl-2-allyl, 1-4-hydroxy-3-methyl-2-cyclopenten-1-one esterified with cis and trans di-chrysanthemum monocarboxylic acids was shown to be the most practical ester from the standpoint of economical preparation and insecticidal action and was the one selected for technical production. This completely synthetic ester, the allyl homolog of cinerinI, is now known as allethrin.

In the Pyrenones piperonyl butoxide acts as the synergist and in the allethrin mixtures the piperonyl butoxide has been shown to exhibit synergism with allethrin. In all of these formulations piperonyl butoxide appears to be the synergist in that it has the effect of extending the toxicity of pyrethrum in one instance and allethrin in another, so that very much less pyrethrum or allethrin is needed to achieve the usual kill of insects.

Tests of the residual effectiveness of natural pyrethrins as compared with the allyl homolog of cinerin 1 (allethrin) were conducted by E. W. Laake and associates on the stable fly. These materials were used at a concentration of 0.1% alone, and in combination with 1% of piperonyl butoxide, as dips on screen-wire cages, and stable flies were introduced one day later and then exposed for 24 hours. The natural pyrethrins, alone and in combination, gave a 100% knock-down and kill, whereas the synthetic ester alone gave 60% and 40% and in combination with piperonyl butoxide 87% and 72%, respectively. In another test without the synergist the natural pyrethrins gave a 100% knock-down and kill as compared with 92% knock-down and 85% kill for the synthetic ester. The natural material with piperonyl butoxide gave 100% knock-down and kill as compared with a 82% knock-down and a 70% kill for the synthetic product.

Dennis and Cotton in tests against the confused flour beetle by their glass plate method compared a number of different synergists and various rates of application. They found that the mortality of adults after 12 days was essentially the same for the natural product and the synthetic material without the synergist, but one commercial synergist greatly increased the kill with the synthetic ester. This work was reported by Bishopp (1950).

Allethrin has been shown to be as toxic as natural pyrethrins to Musca, but is inferior in toxicity to Periplaneta, Tribolium, Oncopeltus and a number of field crop insects.

Bishopp (1950) stated that the allyl homolog of cinerin I (allethrin) was superior to natural pyrethrins against several species of insects, about as toxic to many others, and decidedly inferior against certain pests of field crops. In some cases the allethrin was less effective than the natural pyrethrins at low concentrations whereas the reverse was true at high concentrations. Wide differences in toxicity to insects also resulted when different synergists were added to the sprays.

The great advantages of pyrenone and allethrin are derived from the fact that they are non-toxic to mammals while extremely toxic to insects. Pyrethrins, which are components in the Pyrenone material have long been known for their safety. Piperonyl butoxide which acts as the synergist is even safer than pyrethrins. Allethrin, which is similar in its action to pyrethrins is considered to be a safe material with regard to humans.

These protectant materials are designed to prevent infestation, but are not necessarily a "cure all". They are not effective when attempting to control an already heavy infestation. Neither of these materials will improve upon natural practices of drying and preserving stored grain, but they aid the natural means of protection. These two compounds will help in good methods of storing grains by preventing insects from becoming established in the treated grain. They will kill the insects if in moderate numbers, and will insure protection for a comparatively long period of time. Their main value will be in long time storage where protection for a season or longer is desired (Winburn, 1952).

III. METHODOLOGY AND MATERIALS

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Procedure in Rearing the Insects

In any type of experiment where live insects are required it is necessary to build up and maintain a constant supply. Grain insects are no exception, therefore it was necessary to build up a colony of confused flour beetles, granary weevils, and rice weevils for use in this work. After trying different temperatures with varying success it was found that the optimum temperature for development was between 85° and 90°F. At this temperature range the confused flour beetles completed their life cycle in 27 days.

The confused flour beetles were raised in whole wheat flour in wide-mouth pint jars. The eggs of this insect are so minute that they are barely distinguishable with the unaided eye in the flour. When first laid they are covered with a fluid which causes the small particles of flour to adhere to them. The eggs are laid singly and are scattered around in the flour. The female beetle may live approximately one year and lay one or two eggs each day during the year.

If the temperature is maintained at about 90 F the eggs will hatch in about 4 days. The larvae mature in about 17 days and the pupal stage lasts about 6 days. This seems to be the optimum temperature for rearing these insects.

The rice and granary weevils were reared at the same temperature as the confused flour beetle. The rice weevil is a small reddish brown beetle, about 1/8 of an inch long and can be distinguished from the granary weevil by the two vague yellowish spots on each wing, the well developed wings, and the fine rounded punctures on the thorax. The rice weevil is considered by Cotton (1945) to be the most destructive insect pest of stored grain. The rice weevil is more important in the South. It flies from infested granaries to the fields of corn, wheat, and rice and starts the infestations that are so damaging after the grain is harvested. The granary weevil on the other hand has become a very specialized insect and seems to have lost the power of flight. It differs from the rice weevil in that it never breeds in the field and is found only in stored grain.

The adult rice weevil lives an average of 4-5 months, during which time the female lays around 300 to 400 eggs. The granary weevil will live about 7 or 8 months. These weevils are similar in their work in that they both bore a hole in the grain into which the egg is inserted. After this is accomplished the female turns around and seals the hole with gelatinous fluid. The small white legless grubs hatch from the egg but remain inside the kernels. When they are fully grown they transform to the pupal stage and then to the adult weevil which bores out of the grain. At a temperature of 90° F. these insects can complete their life cycle in 27-30 days.

The insects were reared in two small cabinets at an average temperature of 85° F, originally. However, they were later transferred to one large cabinet which contained a fan to insure more circulation of air. The relative humidity was maintained between 65 and 70%. This was insured through the use of a saturated solution of Diamond Crystal Salt, which is composed of 99.5% choloride and 0.5% tri-calcium phosphate. The salt solution was mixed in two large enamel pans and placed in the cabinet. The fan in the cabinet circulated the air and appeared to keep the relative humidity constant. In the smaller cabinets which lacked a fan the water in the salt solution had to be replaced more often than in the large cabinet with the fan.

The confused flour beetles were reared in whole wheat flour while the rice weevils and granary weevils were raised in whole wheat.

A thermograph and a thermometer were used to register the correct temperature.

Materials Tested

Common Name	Composition	Percent	Company
Pyrenone Wheat Protectant	Piperonyl Butoxide Pyrethrins Inert Materials	1.10 0.08 98.82 100.00	U. S. Industrial Chemicals
Grain Protectant Dust	Allethrin Piperonyl Butoxide Wheat Dust Diluent	0.14 1.60 98.26 100.00	Carbide and Carbon Chemical Division of Union Carbide and Carbon Corp.
Grain Protectant Dust	Allethrin Piperonyl Butoxide Wheat Dust Diluent	0.07 1.60 98.33 100.00	Carbide and Carbon Chemical Division of Union Carbide and Carbon Corp.

Tests Against the Confused Flour Beetle

The insecticides and wheat flour were weighed out in grams in the following amounts:

Insecticide	Wheat Flour	Equivalent to:
0.05 gram	40 grams	75 lbs. per 60,000 pounds
0.05 gram	30 grams	75 lbs. per 45,000 pounds
0.1 gram	40 grams	75 lbs. per 30,000 pounds
0.1 gram	20 grams	75 lbs. per 15,000 pounds
1 gram	40 grams	75 lbs. per 3,000 pounds

After the wheat flour was weighed out the insecticide was weighed out and added to the flour. The flour and insecticide were thoroughly mixed together in small jars. After leaving this mixture in the test cabinet for a period of twenty-four hours at a temperature of 85° F. and a humidity of 65%, fifty confused flour beetles were placed in each jar. The insects were maintained at the above temperature and humidity for periods of one month, two weeks, and one week. In all instances four replicates were made of each material as well as of the control.

The insects were prevented from crawling out by a rim of vaseline along the top of the jar.

Tables I, II, III, IV and V illustrate the results of these tests.

Tests Against the Granary Weevil, *Sitophilus granarius* and the Rice Weevil, *Sitophilus oryza*

In the tests conducted against these two insects the insecticides were mixed with whole wheat instead of flour because the weevils work only in the whole wheat. They puncture the bran on the wheat and lay their eggs next to the starch. The eggs hatch in the kernel and the insect completes its development inside before emerging.

The procedure followed in the case of *Tribolium confusum* was applied here also with a few exceptions. The granary and rice weevils were prevented from crawling out, (or flying out in the case of the rice weevil), by the use of 40-mesh screen covers.

The insecticide and wheat were weighed out in the amounts listed below:

Insecticide	Wheat	Equivalent to:
0.05 gram	40 grams	75 lbs. per 1000 bushels
0.1 gram	40 grams	75 lbs. per 500 bushels

Comparative tests were run between the granary weevil and rice weevil at a temperature of 80° F. and concentrations of 0.05 grams of insecticide per 40 grams of wheat and 0.1 gram of insecticide per 40 grams of wheat for one month.

After this, a test was run at 71.6° F. and a concentration of 0.05 grams of insecticide to 40 grams of wheat against the granary and rice weevils.

Because the granary weevil is the more important insect in the northern states it was decided to run comparative tests against this insect at the two concentrations listed in the table at temperatures of 64.4° F., 70° F. and 82.4° F. at a constant humidity of 65% for a period of approximately one month in each case. Both of these species will lay a few eggs at 64° F. and they will complete their development from egg to adult but at a much slower rate than at 70 or 82 F. It was decided to compare the effectiveness of the materials at the three temperatures listed above because temperature is the most important factor in determining insect development. According to Cotton (1950) the rice weevil is affected more by lower temperatures than the granary weevil. The rice weevil will become dormant at 45° F. and the granary weevil at 35° F. Unlike the cadelle they usually do not hibernate so their development is not effectively retarded by low temperatures to enable the food reserves of their bodies to carry them through long periods of dormancy (Cotton, 1950). Therefore they usually die of starvation at low temperature.

Hanson (1951) stated that stored-grain pests will not work in grain having a moisture content of less than eight per cent. The wheat used in all the tests had a moisture content of fourteen per cent so this would not effect the comparative results. However, in comparing the three temperatures the results obtained at 64° F. may be influenced not only by the insecticides, but also by the lower temperature.

IV. PRESENTATION AND ANALYSIS OF DATA

PRESENTATION AND ANALYSIS OF DATA

Discussion of Results of Tests Against *Tribolium confusum*

As can be seen from Tables I to V none of the materials showed very much promise for use in the control of the confused flour beetle in flour. Even at the rate of one gram of insecticide to forty grams of wheat flour, which is equivalent to 75 pounds to 3000 pounds of wheat flour there was no evidence of any notable toxicity to this insect.

Although the insects were maintained for only a week at the above concentration the materials should have shown some effect in this period of time.

In the test where one-tenth of a gram of insecticide was used with twenty grams of flour for a period of one month there was very little development of larvae.

Although the materials used have not been recommended for use in flour it seemed logical to test the materials against the confused flour beetle because of the damage it can cause wherever flour is stored. According to Hinton (1942) the confused flour beetle, *Tribolium confusum* Duv. and the rust-red flour beetle, *Tribolium castaneum* Herbst, are the most abundant and destructive insects infesting flour and other stored products. Therefore, for this reason alone it seemed worth-while to observe the effects, if any, upon this insect.

TABLE I

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST Tribolium confusum AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHOLE WHEAT FLOUR (EQUIVALENT TO 75 LBS. PER 60,000 POUNDS)*

Insecticide	Alive	Dead	Percent Mortality
Pyrenone	48	2	4
	48	2	4
	48	2	4
	47	3	6
Average	47.75	2.25	4.5
Grain Protectant (0.07% Allethrin)	48	2	4
	50	0	0
	46	4	8
	48	2	4
Average	48	2	4
Grain Protectant (0.14% Allethrin)	49	1	2
	50	0	0
	50	0	0
	50	0	0
Average	49.75	.25	2
Check	50	0	0
	49	1	2
	50	0	0
	50	0	0
Average	49.75	.25	2

* Results were noted after exposure of two weeks.

TABLE II

RESULTS OF TESTS COMPARING EFFECTIVENESS OF PROTECTANT DUSTS AGAINST Tribolium confusum AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 30 GRAMS OF WHOLE WHEAT FLOUR (EQUIVALENT TO 75 LBS.PER 45000 POUNDS OF WHOLE WHEAT)*

Insecticide	Alive	Dead	Percent Mortality
Pyrenone	50	0	0
	48	2	4
	46	4	8
	48	2	4
Average	48	2	4
Grain Protectant (0.07% Allethrin)	50	0	0
	47	3	6
	44	6	12
	47	3	6
Average	47	3	6
Grain Protectant (0.14% Allethrin)	45	5	10
	40	10	20
	42	8	16
	43	7	14
Average	42.5	7.5	15
Check	48	2	4
	50	0	0
	50	0	0
	48	2	4
Average	49	1	2

* Results were noted after exposure for one month.

TABLE III

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Tribolium confusum* AT A CONCENTRATION OF 0.1 GRAMS OF INSECTICIDE TO 40 GRAMS OF WHOLE WHEAT FLOUR (EQUIVALENT TO 75 LBS.PER 30000 POUNDS OF WHOLE WHEAT)*

Insecticide	Alive	Dead	Percent Mortality
Pyrenone	46	4	8
	49	1	2
	49	1	2
	48	2	4
Average	48	2	4
Grain Protectant (0.07% Allethrin)	48	2	4
	50	0	0
	49	1	2
	50	0	0
Average	49.2	0.75	1.5
Grain Protectant (0.14% Allethrin	46	4	8
	49	1	2
	50	0	0
	49	1	2
Average	48.5	1.7	3
Check	50	0	0
	50	0	0
	49	1	2
	50	0	0
Average	49.7	0.25	0.5

* Results were noted after exposure for one month.

TABLE IV

RESULTS OF TESTS COMPARING EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Tribolium confusum* AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 20 GRAMS OF WHOLE WHEAT FLOUR (EQUIVALENT TO 75 LBS. PER 15,000 POUNDS)*

Insecticide	Alive	Dead	Percent Mortality
Pyrenone	44	6	12
	46	4	8
	45	5	10
	46	4	8
Average	45.2	4.7	9.5
Grain Protectant (0.07% Allethrin)	47	3	6
	46	4	8
	48	2	4
	47	3	6
Average	47	3	6
Grain Protectant (0.14% Allethrin)	49	1	2
	42	8	16
	46	4	8
	45	5	10
Average	45.5	4.5	9
Check	47	3	6
	47	3	6
	48	2	4
	49	1	2
Average	47.7	2.2	4.5

* Results were noted after exposure for one month.

TABLE V

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Tribolium confusum* AT A CONCENTRATION OF 1 GRAM TO 40 GRAMS OF WHOLE WHEAT FLOUR (EQUIVALENT TO 75 LBS. PER 3000 POUNDS OF WHOLE WHEAT)*

Insecticide		Alive	Dead	Percent Mortality
Pyrenone		49	1	2
		48	2	4
		49	1	2
		49	1	2
	Average	48.7	1.2	2.5
Grain Protectant (0.07% Allethrin)		48	2	4
		49	1	2
		49	1	2
		49	1	2
	Average	48.7	1.2	2.5
Grain Protectant (0.14% Allethrin)		47	3	6
		49	1	2
		49	1	2
		49	1	2
	Average	48.5	1.5	3
Check		50	0	0
		50	0	0
		50	0	0
		50	0	0
	Average	50	0	0

* Results were noted after exposure for one week.

Tribolium confusum is also one of the insects most commonly used in the laboratory for experimental purposes. This insect may be very resistant to certain types of insecticides and not to others and it seems debatable whether it is wise to use it in experiments where recommendations for control are involved.

In these experiments it is possible that the flour itself may have absorbed the insecticide in such a way that its effect on the insect would be negligible.

According to Linsley (1943) and Michelbacher the eggs which are laid directly in the flour are sticky and food particles adhere to them. It seems logical to assume that small amounts of the insecticide would adhere to the eggs and have an effect upon development. However, since numerous larvae developed in most of the tests it appeared that the insecticide had no effect upon the egg, larval, or adult atages. As mentioned before there was only one test over a thirty-day period that gave any control of the larvae. This was at a concentration of one tenth of a gram of insecticide to twenty grams of flour which is equivalent to 75 pounds of insecticide to 15,000 pounds of wheat flour. If the protectants were used at this rate, they would not be worth-while from a control or economical standpoint.

Discussion of Results of Tests Against *Sitophilus granarius* and *Sitophilus oryza*

As can be seen from the tables all the materials employed exhibited a higher degree of toxicity to the rice weevil and the granary weevil than to the confused flour beetle. This may seem to be a minor detail,

TABLE VI

RESULTS OF TESTS COMPARING EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus granarius* AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 71.6° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	20	30	60	
	14	36	72	
	18	32	64	
	0	50	100	
Average	13	37	74	69.4
Grain Protectant (0.07% Allethrin)	20	30	60	
	20	30	60	
	26	24	48	
	23	27	54	
Average	22.2	27.7	55.5	47.6
Grain Protectant (0.14% Allethrin)	17	43	86	
	19	31	62	
	13	37	74	
	24	26	52	
Average	18.2	34.2	68.5	57
Check	43	7	14	
	43	7	14	
	43	7	14	
	41	9	18	
Average	42.5	7.5	15	0

* Results were noted at the end of one month.

TABLE VII

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus oryza* AT A CONCENTRATION OF 0.05 GRAM INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS OF WHEAT) AT A TEMPERATURE OF 71.6°F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	1	49	98	
	2	48	96	
	3	47	94	
	16	34	68	
Average	5.5	44.5	89	85.1
Grain Protectant (0.07% Allethrin)	12	38	76	
	15	35	70	
	19	31	62	
	4	46	92	
Average	12.5	37.5	75	66.2
Grain Protectant (0.14% Allethrin	9	41	82	
	13	37	74	
	10	40	80	
	19	31	62	
Average	12.7	37.2	74.5	65.6
Check	34	16	32	
	39	11	22	
	36	14	28	
	39	11	22	
Average	37	13	26	0

* Results were noted after a period of one month.

TABLE VIII

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST THE GRANARY WEEVIL *Sitophilus granarius* AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 500 BUSHELS) AT A TEMPERATURE OF 80.6°F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	18	32	64	
	3	47	94	
	0	50	100	
	12	38	76	
Average	8.2	41.7	83.5	80
Grain Protectant (0.07% Allethrin)	7	43	86	
	17	33	66	
	0	50	100	
	5	45	90	
Average	7.2	42.7	85.4	80
Grain Protectant (0.14% Allethrin)	13	37	74	
	22	28	56	
	17	33	66	
	20	30	60	
Average	18	32	64	56
Check	42	8	16	
	40	10	20	
	41	9	18	
	41	9	18	
Average	41	9	18	0

* Results were noted after a period of one month.

TABLE IX

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST Silophilus oryza AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 500 BUSHELS) AT A TEMPERATURE OF 80.6° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	19	30	60	
	12	38	76	
	10	40	80	
	17	33	66	
Average	14.5	35.2	70.5	62
Grain Protectant (0.07% Allethrin	5	45	90	
	2	48	96	
	2	48	96	
	3	47	94	
Average	3	47	94	92
Grain Protectant (0.14% Allethrin	9	41	82	
	3	47	94	
	2	48	96	
	2	48	96	
Average	4	46	92	89.5
Check	35	15	30	
	36	14	28	
	40	10	20	
	42	8	16	
Average	38.2	11.7	24	0

* Results were noted after a period of one month.

TABLE X

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus granarius* AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 80.6° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	20	30	60	
	17	33	66	
	22	28	56	
	17	33	66	
Average	19	31	62	53.8
Grain Protectant (0.07% Allethrin	19	31	62	
	16	34	68	
	23	27	54	
	16	34	68	
Average	18.5	31.5	63	55
Grain Protectant (0.14% Allethrin)	19	31	62	
	24	26	52	
	19	31	62	
	19	31	62	
Average	20.2	29.7	59.5	50
Check	40	10	20	
	42	8	16	
	42	8	16	
	41	9	18	
Average	41.2	8.7	17	0

* Results were noted after a period of one month.

TABLE XI

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus oryza* AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 80.6° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	22	28	56	
	18	32	64	
	22	28	56	
	23	27	54	
Average	21.2	28.7	57.5	34.7
Grain Protectant (0.07% Allethrin)	27	23	46	
	24	15	30	
	21	29	58	
	19	31	62	
Average	22.7	24.5	49	30
Grain Protectant (0.14% Allethrin)	23	27	54	
	18	32	64	
	17	33	66	
	18	32	64	
Average	19	31	62	41.
Check	35	15	30	
	31	19	38	
	34	16	32	
	30	20	40	
Average	32.5	17.5	35	0

* Results were noted after a period of one month.

TABLE XII

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST <u>Sitophilus granarius</u> AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 500 BUSHELS) AT A TEMPERATURE OF 64° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	0	50	100	
	0	50	100	
	0	50	100	
	0	50	100	
Average	0	50	100	100
Grain Protectant (0.07% Allethrin)	1	49	98	
	10	40	80	
	5	45	86	
	0	50	100	
Average	4	46	91	89.2
Grain Protectant (0.14% Allethrin)	1	49	98	
	1	49	98	
	1	49	98	
	1	49	98	
Average	1	49	98	97.3
Check	39	11	22	
	28	22	44	
	42	8	16	
	40	10	20	
Average	37.2	12.7	25.5	0

* Results were noted at the end of one month.

TABLE XIII

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST Sitophilus granarius AT A CONCENTRATION OF 0.05 GRAMS OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 64. ° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	2	48	96	
	0	50	100	
	1	49	98	
	1	49	98	
Average	1	49	98	97.8
Grain Protectant (0.07% Allethrin)	5	45	90	
	1	49	98	
	3	47	94	
	1	49	98	
Average	2.5	47.5	95	94
Grain Protectant (0.14% Allethrin)	3	47	94	
	9	41	82	
	14	36	72	
	7	43	86	
Average	8.2	41.7	83.5	81
Check	39	11	22	
	49	1	2	
	48	2	4	
	43	7	14	
Average	44.7	5.2	15	0

* Results were noted at the end of one month.

TABLE XIV

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST Sitophilus granarius AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 500 BUSHELS) AT A TEMPERATURE OF 70° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	0	50	100	
	1	49	98	
	0	50	100	
	1	49	98	
Average	0.5	49.5	98.5	99
Grain Protectant (0.07% Allethrin)	2	48	96	
	0	50	100	
	4	46	92	
	2	48	96	
Average	2	48	96	95
Grain Protectant (0.14% Allethrin)	0	50	100	
	0	50	100	
	0	49	98	
	2	48	96	
Average	0.5	49	98.5	99
Check	46	4	8	
	42	8	16	
	46	4	8	
	46	4	8	
Average	45	5	10	0

* Results were noted at the end of one month.

TABLE XV

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus granarius* AT A CONCENTRATION OF 0.05 GRAMS OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 70° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	5	45	90	
	2	48	96	
	10	40	80	
	1	49	98	
Average	4.5	45.5	91	89.3
Grain Protectant (0.07% Allethrin)	27	23	46	
	16	34	68	
	10	40	80	
	7	43	86	
Average	15	35	70	64.3
Grain Protectant (0.14% Allethrin)	5	45	90	
	32	18	36	
	8	42	34	
	10	38	76	
Average	13.7	35	71.5	67
Check	50	0	0	
	45	5	10	
	34	16	32	
	41	9	18	
Average	42	7.5	15	0

* Results were noted at the end of one month.

TABLE XVI

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST *Sitophilus granarius* AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 500 BUSHELS) AT A TEMPERATURE OF 82.4° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	0	50	100	
	0	50	100	
	3	47	94	
	1	49	98	
Average	1	49	98	97.7
Grain Protectant (0.07% Allethrin)	15	35	70	
	21	29	58	
	22	28	56	
	21	21	42	
Average	19.7	28.2	56.5	56.2
Grain Protectant (0.14% Allethrin)	17	33	66	
	19	31	62	
	16	34	68	
	12	38	78	
Average	16	34	68.5	64.4
Check	47	3	6	
	44	6	12	
	43	7	14	
	46	4	8	
Average	45	5	10	0

* Results were noted after a period of one month.

TABLE XVII

RESULTS OF TESTS COMPARING THE EFFECTIVENESS OF PROTECTANT DUSTS AGAINST <u>Sitophilus</u> <u>granarius</u> AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT (EQUIVALENT TO 75 LBS. PER 1000 BUSHELS) AT A TEMPERATURE OF 82.4° F.*

Insecticide	Alive	Dead	Percent Mortality	Abbotts Percent Control
Pyrenone	1	49	98	
	0	50	100	
	0	50	100	
	0	50	100	
Average	0.25	49.7	99.5	99.4
Grain Protectant (0.07% Allethrin)	12	38	76	
	11	39	78	
	10	40	80	
	12	38	76	
Average	11.2	38.7	77	73.9
Grain Protectant (0.14% Allethrin)	5	45	90	
	7	43	86	
	8	42	84	
	9	41	82	
Average	7.2	42.7	85	83.2
Check	41	9	18	
	43	7	14	
	43	7	14	
	45	5	10	
Average	43	7	14	0

* Results were noted at the end of one month.

but in this case it is very important because the weevils are considered to be the primary insects in stored wheat, corn or other grains. If these insects can be prevented from making the initial attack on the grain it is very improbable that the secondary insects will be able to move in. The weevils have to work in the wheat before any of the so-called bran beetles can do their damage, because they cannot puncture the kernel.

The rice weevil is not as important in the northern states as the granary weevil but a limited comparison was made between the two.

If we observe the results in Tables VI and VII we can readily see that at a temperature of 71.6° F. there was a higher mortality of rice weevil than of the granary weevil. However, there was also a higher percentage of dead rice weevils in the control.

In both instances the Pyrenone Wheat Protectant gave the best control at the rate of 0.05 grams of protectant to 40 grams of wheat.

In Tables X and XI at the same concentration but at 80.6 F. there was very little difference in the effectiveness of the materials used with the exception of the 0.07% Allethrin Grain Protectant which was slightly more effective against the granary weevil than against the rice weevil.

At a temperature of 80.6° F. and a concentration of 0.1 gram of insecticide to 40 grams of wheat which is equivalent to 75 pounds of insecticide to 500 bushels the two Allethrin Grain Protectants gave very good control against the rice weevil.

These comparisons do not indicate that one material is much more effective than another. However, if we compare the concentrations used at a temperature of 80.6° F. it can be readily seen that if the protectants are used at the rate of 0.1 gram of insecticide to 40 grams of wheat the mortality rate with each material will be markedly higher than at a concentration of 0.05 grams of insecticide to 40 grams of wheat. (See Figure III)

In comparing the protectants at three temperatures and in two formulations it is interesting to note that the Pyrenone Wheat Protectant gave excellent control in all the tests against the granary weevil.

At 64° F. all the materials used gave similar results although the mortality rates given by the protectants containing allethrin were not quite as high as those given by Pyrenone.

The temperature factor in the tests conducted at 64° F. and involving both formulations may have affected the results. According to Brown (1951) the processes of recovery are retarded at low temperatures and the mortality will be higher than at high temperatures as far as post-treatment temperature is concerned. He also stated that pyrethrins are more toxic at lower temperatures. This may not be the case in these tests but it would be difficult to prove that the lower temperature did not have an effect on the mortality rate. In the tests at three varying temperatures the Pyrenone Wheat Protectant gave the best control. (See Figures I and II)

FIGURE 1

MORTALITY OF GRANARY WEEVILS, TREATED WITH THREE PROTECTANTS, AT THREE TEMPERATURES AT A CONCENTRATION OF 0.05 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT.

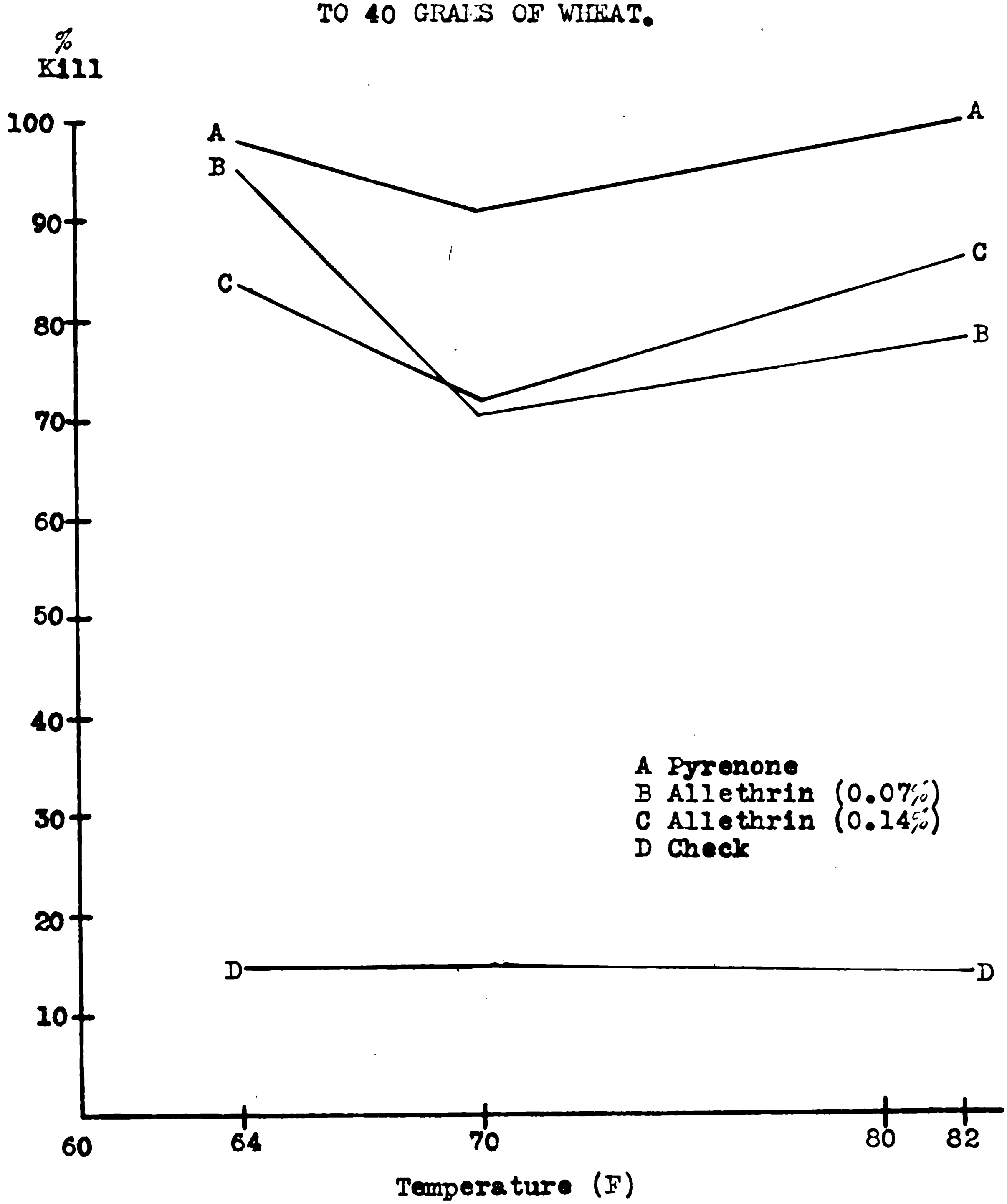


FIGURE 11

MORTALITY OF GRANARY WEEVILS, TREATED WITH THREE PROTECTANTS, AT THREE TEMPERATURES AT A CONCENTRATION OF 0.1 GRAM OF INSECTICIDE TO 40 GRAMS OF WHEAT.

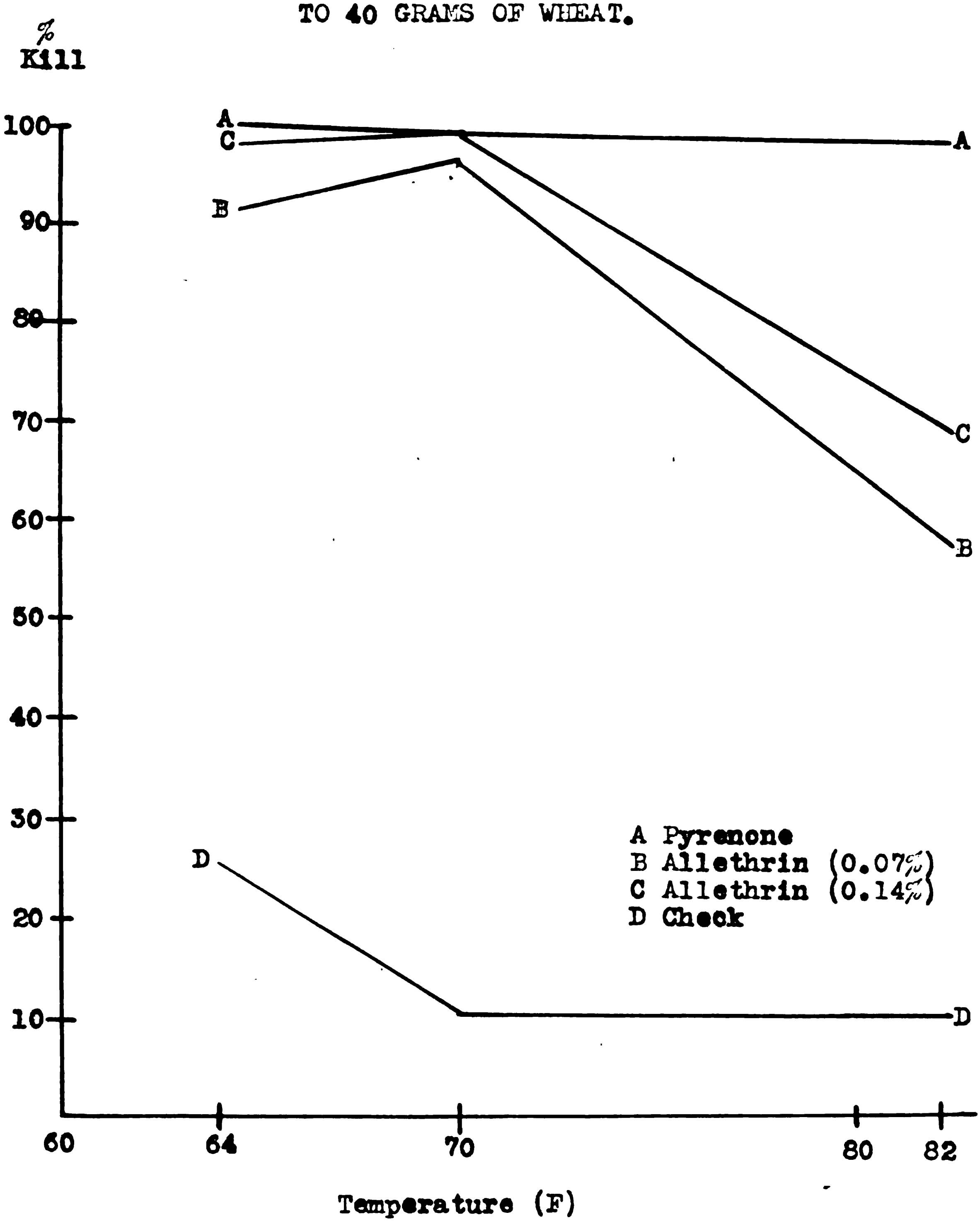
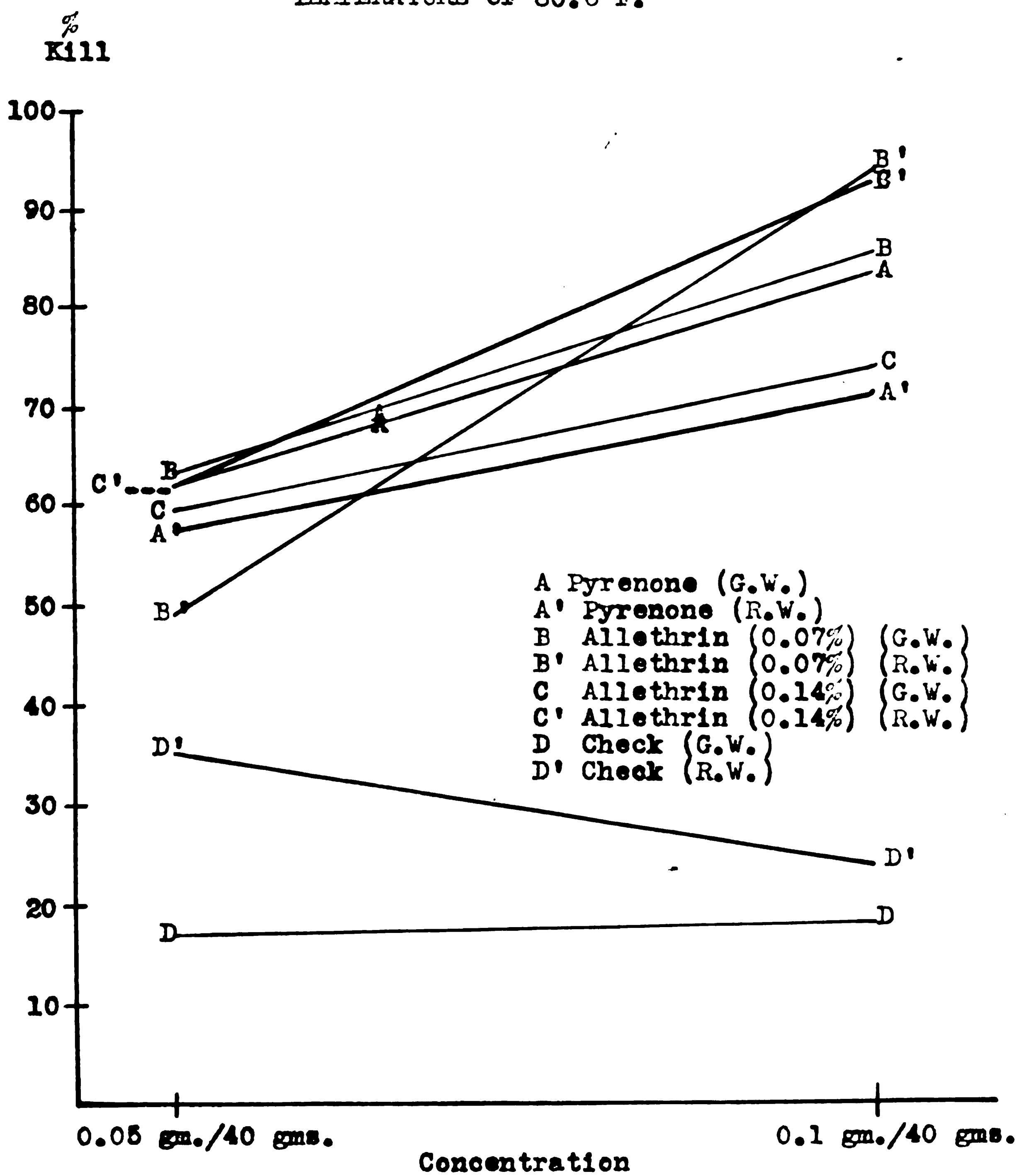


FIGURE 111

COMPARISON OF MORTALITY OF GRANARY AND RICE
WEEVILS TREATED WITH THREE PROTECTANTS
IN TWO CONCENTRATIONS AT A
TEMPERATURE OF 80.6 F.



V. SUMMARY

V. SUMMARY

Three different wheat protectant dusts were used against two insects of primary importance to stored grain, namely the granary weevil, Sitophilus granarius and the rice weevil, Sitophilus oryza. They were tested also against the confused flour beetle, Tribolium confusum, which is of secondary importance to stored grain.

From the results obtained it appears that the confused flour beetle is very resistant to all three materials. Even at very high concentrations there was no evidence that the protectants used had any toxic effect on adult confused flour beetles. In one case however, at a concentration of one tenth of a gram of insecticide to twenty grams flour (equivalent to 75 pounds of insecticide to 15,000 pounds of wheat flour) there was very little development of larva. At this concentration it would not be economical to attempt to control this insect in flour.

With regard to the granary weevil and the rice weevil the results were much more promising. In comparing the effects of the materials against each insect Table IX indicates that the grain protectants containing Allethrin at a concentration of 0.1 gram of insecticide to 40 grams of wheat gave good control against the rice weevil. However, the other tests conducted with this insect did not give consistently high results. The Pyrenone Wheat Protectant appeared to cause a higher mortality of the granary weevil.

The results in the Tables XII through XVII verify this assumption. In fact the Pyrenone material gave excellent results in all the tests although the two materials containing 0.07% Allethrin and 0.14% Allethrin respectively gave good control. The best control was attained at temperatures of 64° F. and 70° F. and at a concentration of 0.1 gram of insecticide to 40 grams of wheat (equivalent to 75 pounds to 500 bushels).

These grain protectants are useful to prevent infestation rather than to destroy an existing infestation. They have no fumigant effect, but kill by contact only. Their importance is in protecting grain over a long period of time.

VI. LITERATURE CITED

LITERATURE CITED

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