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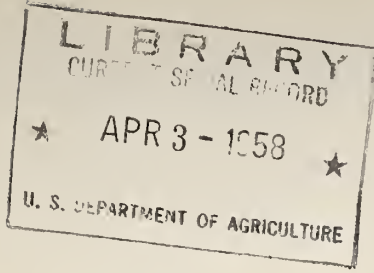


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# Evaluation of Synergized Pyrethrum for the Control of Indian-Meal Moth in Stored Shelled Corn



Marketing Research Division  
Agricultural Marketing Service  
U. S. DEPARTMENT OF AGRICULTURE

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March 1958

EVALUATION OF SYNERGIZED PYRETHRUM FOR THE CONTROL OF  
INDIAN-MEAL MOTH IN STORED SHELLED CORN

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SUMMARY

This report presents the results of the first year's tests with a synergized pyrethrum spray applied to the top surface of bulk shelled corn at different dosages and frequencies to control infestation by the Indian-meal moth (*Plodia interpunctella* Hbn.). The tests were conducted in 1956 in USDA 3,250-bushel circular metal bins.

The sprays were applied at 3 concentrations and 3 frequencies, with 3 replicates in the treated series and 5 in the untreated controls. The sprays were formulated in base oil at concentrations of 0.125 percent, 0.250 percent, and 0.375 percent of pyrethrins, the ratio of the synergist (piperonyl butoxide) to pyrethrins being 10:1. The schedule of application was semi-weekly, weekly, and biweekly, beginning July 9, 1956, and continuing until the last week of October 1956.

Samples for determination of population trends, moisture content, insecticidal residues, and commercial grade were taken at intervals after treatment.

The peak population was noted on August 20 and thereafter the population declined, possibly owing to parasitism by the parasite *Bracon hebetor* Say. None of the treatments gave complete control but statistically only the bi-weekly application of 0.125 percent pyrethrins showed significantly less control than the other treatment. The populations in all of the treatments were significantly lower than those in the untreated controls.

The residues of piperonyl butoxide found in composited samples drawn 3 and 6 months after the treatments were begun showed that even though massive amounts were applied, much of the piperonyl butoxide had disappeared by the time the samples were taken, about 75 percent at the end of 3 months, and nearly 90 percent at the end of 6 months.

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1/This laboratory is a field station of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

There were virtually no changes in the moisture content of the corn during the observation period.

There were no changes in commercial grade due to treatment, but 9 of the 32 bins observed were downgraded one grade because of increases in the grade factor "Total damage."

## INTRODUCTION

Changes in grain handling and grain storage practices in the past few years have resulted in the storage of grain for much longer periods of time, sometimes up to 5 years. The reserve stocks of grain, particularly of corn which is not otherwise commercially stored in large quantities as shelled corn, have required new and improved methods of protection from insect invasion.

The Indian-meal moth (Plodia interpunctella Hbn.) has been especially troublesome in shelled corn stored in wood or metal bins with capacities of 3,000 to 3,250 bushels. This species does not penetrate deeply into the grain bulk, confining its activities chiefly to the surface layer of grain where the larvae feed on the germ and spin unsightly webs on the surface.

In line with the demand for improved control measures for this species, studies were begun at the Watseka, Ill., experimental corn storage site, in the summer of 1956, to explore the possibility of applying an insecticide directly to the top surface of the shelled corn to prevent further development of an existing infestation.

This report presents the results of the first year's tests with a synergized pyrethrum spray applied to the surface of the grain at different dosages and at different frequencies. The study is still in progress, but due to the interest in this approach, the results through December 1956 are being presented now.

## TECHNIQUE AND MATERIALS

The tests were conducted in 32 USDA circular metal bins, 16 feet in height and 18 feet in diameter, with a capacity of 3,250 bushels. The bins were filled during March and April 1956 with shelled corn of the 1954 crop year from nearby Commodity Credit Corporation bin sites where it had been in storage since August 1955. The spray was applied as a fine mist by means of compressed air.

In order to insure an intense and increasing infestation in the bins, 50 moth larvae were introduced into the surface layer of corn in each of the bins on June 4, 14, and 22. By the end of the first week in July, a thriving population of all stages was present.

## Sampling Methods

Samples from the top inch of corn were taken at biweekly intervals from all of the bins. The samples were taken from 5 places with a 5-foot 11-celled grain trier laid horizontally in the surface layer--at the center and in the 4 cardinal directions about 3 feet from the wall. These samples were placed in plasticized kraft envelopes and taken to the laboratory for examination. Each sample was screened through a 12/64-inch grain sieve and the number of living and dead Indian-meal moths was recorded. The insects and screenings were then returned to the sample and the moisture content was determined with a dielectric type moisture tester. In October and January these samples were composited and submitted for chemical analyses of piperonyl butoxide present to the chemical unit of the Stored-Product Insects Section at Savannah, Ga. At the time of the biweekly sampling the number of adult moths present in the headspace in each bin was estimated.

At monthly intervals samples were also drawn from 8 places in the grain mass for determination of the moisture content, each sample amounting to about 500 grams of corn. The samples were taken vertically in the center of the bins from the top, middle, and bottom 5 feet, from the top 5 feet in each quadrant at a location about 3 feet from the wall, and horizontally from the top inch. Each sample was placed in a plasticized kraft bag and taken to the laboratory for determination of the moisture content.

The commercial grade of the corn was determined in April after the bins were filled and again in October after the treatment schedule had been completed. For commercial grade, the sampling pattern described in the preceding paragraph was extended to include vertical samples from the middle and bottom 5 feet in each quadrant. These were composited with the other samples from each bin after the moisture records were taken. The samples were cut to 1,500 grams with a grain divider and submitted to the Federal Grain Supervisor's Office in Indianapolis, Ind., for commercial grade determination.

## Statistical Analyses

The treated lots were compared with the controls and with each other on the basis of moth population, using the analysis of variance method.

## Composition of Sprays

The pyrethrum-piperonyl butoxide concentrate from which the diluted sprays were formulated was composed of:

Pyrethrins . . . . .	5.3 percent by weight
Piperonyl butoxide . . . . .	53.0 percent by weight
Inert and oil. . . . .	41.7 percent by weight

The pyrethrum concentrate was diluted with number 10 base oil having the following characteristics:

Specific gravity at 60° F. . . . .	0.7927
Flash point (tag closed cup) . . . . .	140° F.
Initial boiling point. . . . .	360° F.
End point. . . . .	49° F.
Unsulphonated residue . . . . .	99.3
Color. . . . .	water white
Odor, no kerosene, naphtha, or residual. .	neutral

The spray was made up in 3 concentrations:

1. 0.125 percent pyrethrins by weight, 1.25 percent piperonyl butoxide by weight
2. 0.250 percent pyrethrins by weight, 2.50 percent piperonyl butoxide by weight
3. 0.375 percent pyrethrins by weight, 3.75 percent piperonyl butoxide by weight

#### EXPERIMENTAL PATTERN

The sprays were applied at 3 concentrations and 3 frequencies, with 3 replicates in the treated series and 5 in the untreated controls, making a total of 32 bins.

There were 3 frequencies of application: semi-weekly, weekly, and bi-weekly.

The spray was applied with an oil spray-gun connected to a portable air compressor (figs. 1 and 2). The compressor delivered 1.5 cubic feet of air per minute. The air outlet was connected to the spray gun with 50 feet of 1/4-inch hose. This gun produced a fine aerosol-like mist having an estimated particle size of 100 microns.

One quart of spray was applied uniformly to the surface of the grain, the nozzle being held about 6 inches above the corn. An additional pint of spray was directed as a fine mist into the overspace from the outside.

The treatments were begun on July 9, 1956, and continued through October. Samples for analyses of residues were taken in October, 3 months after the first treatment, and again in January 1957, 6 months after the first treatment, to obtain information on the accumulation of pyrethrins and piperonyl butoxide in the surface layer of grain.



BN-5114

Figure 1.--The compressor sprayer in action.



BN-5115

Figure 2.--Compressor and sprayer unit.



Figure 3.--The surface of untreated corn illustrating the webbing left by moth larvae. BN-5116



Figure 4.--Indian-meal moth on the inside of the bin wall above the corn. BN-5117

## INSECT POPULATION TRENDS

The trends of the Indian-meal moth populations are given in tables 1 and 2. The peak population was recorded on August 20, and thereafter the population declined except in test No. 20 (table 2) on October 1 when an estimated 60,000 adults were noted. Table 1 shows that none of the treatments gave complete control, but with the exception of tests 19, 20, and 21, the populations were well below those in the untreated controls. The semi-weekly applications at all concentrations provided the best control of the adults (table 2); weekly applications of 0.250 and 0.375 percent concentrations (tests 13-18) were satisfactory; the biweekly application of 0.375 percent concentration required about 5 weeks to bring the infestation under control.

The following tabulation of the means of the several series of tests gives the comparative performance of the treatments, on August 20, the date of peak populations:

<u>Frequency of application</u>	<u>Concentration pyrethrins</u>	<u>Adults, larvae, pupae per 1,000 grams</u>	<u>Estimated adults in overspace</u>
	<u>Percent</u>	<u>Number</u>	<u>Number</u>
Semi-weekly	0.125	0.7	0
	.250	.1	0
	.375	.7	0
Weekly	.125	3.2	90
	.250	.4	0
	.375	.7	0
Biweekly	.125	25.0	16,667
	.250	1.9	368
	.375	1.9	10
Untreated controls	--	31.6	16,000

The surface layer of corn in the untreated controls was heavily webbed by the larvae (fig. 3) and at times large numbers of adults could be seen resting on the inside of the roof and the exposed side-walls (fig. 4).

The parasite, Bracon hebetor, was observed in numbers in the untreated control bins and also in some of the treated series. Samples of 1,000 grams each taken from the surface inch of corn were examined and the number of the parasites counted (table 3). Apparently, the insecticide reduced the parasite population to a very low point.

Table 1.--Indian-meal moth populations in shelled corn following application of pyrethrum-piperonyl butoxide sprays, July to October 1956

Frequency of treatment, concentration of pyrethrins, and test number	Living Indian-meal moth adults, larvae, and pupae found per 1,000 grams of shelled corn									
	July		August		September		October			
	9 1/2	23	6	20	4	17	1	15	29	
	Number	Number	Number	Number	Number	Number	Number	Number	Number	
<b>Semi-weekly</b>										
0.125 percent										
1	0.8	2.0	0.4	0.8	0	0	0	0.4	0	
2	0	1.6	0	0	.4	0	.8	.4	0	
3	.8	1.6	2.4	1.2	0	0	2.4	.4	.4	
Mean	.5	1.7	.9	.7	.1	0	1.1	.4	.1	
0.250 percent										
4	0	0	1.6	0	.4	0	0	0	.4	
5	0	.8	2.8	0	0	.8	.4	0	0	
6	0	0	0	.4	0	.8	.8	0	0	
Mean	0	.3	1.5	.1	.1	.5	.4	0	.1	
0.375 percent										
7	0	2.4	1.2	1.2	0	2.4	0	0	0	
8	0	1.2	.8	0	0	0	.4	0	.4	
9	.4	.4	.8	.8	0	0	0	0	0	
Mean	.1	1.3	.9	.7	0	.8	.1	0	.1	
<b>Weekly</b>										
0.125 percent										
10	0	0	.4	.8	2.0	.8	0	.8	1.2	
11	0	0	0	1.6	2.0	1.2	.8	.8	1.2	
12	.4	5.6	3.6	7.2	.8	.4	0	1.2	.4	
Mean	.1	1.9	1.3	3.2	1.6	.8	.3	.9	.9	
0.250 percent										
13	0	3.2	1.2	0	1.6	.8	1.2	.4	.4	
14	.4	1.2	1.2	.8	0	0	.4	2.0	.4	
15	0	0	.4	.4	1.2	.4	1.2	0	.4	
Mean	.1	1.5	.9	.4	.9	.4	.9	.8	.4	
0.375 percent										
16	0	1.2	1.2	0	0	.4	.8	0	.4	
17	0	.8	1.2	.8	.4	.4	0	0	.4	
18	0	.8	2.0	1.2	.8	1.2	1.8	0	0	
Mean	0	.9	1.5	.7	.4	.7	.9	0	.3	
<b>Biweekly</b>										
0.125 percent										
19	0.8	2.0	17.2	43.3	11.6	15.6	11.2	3.2	5.2	
20	.8	1.2	1.2	9.2	13.2	15.6	22.0	4.8	13.2	
21	.4	.4	9.2	22.4	12.0	9.2	7.2	3.6	4.4	
Mean	.7	1.2	9.2	25.0	12.3	13.5	13.5	3.9	7.6	
0.250 percent										
22	0	2.0	2.8	2.0	2.8	1.6	2.4	.8	1.2	
23	.4	.4	2.0	1.2	2.0	.4	1.2	.4	0	
24	0	1.2	.4	2.4	3.6	.8	.8	5.2	0	
Mean	.1	1.2	1.7	1.9	2.8	.9	1.5	2.1	0	
0.375 percent										
25	.4	1.2	.4	.4	2.4	3.6	.4	0	0	
26	0	3.2	2.8	4.8	.4	0	.4	.8	0	
27	0	1.2	3.4	.4	.4	.4	.4	0	.8	
Mean	.1	1.9	2.2	1.9	1.0	1.3	.4	.3	.3	
<b>No treatment--controls</b>										
28	.4	5.2	7.2	33.6	2.4	3.6	1.2	.8	0	
29	0	0	2.0	12.4	8.0	3.2	2.8	2.0	1.6	
30	0	.4	15.2	35.6	5.2	3.6	2.4	0	0	
31	0	3.2	7.2	44.0	4.8	1.2	2.0	0	.8	
32	0	4.0	25.6	32.4	9.2	6.4	3.6	1.6	.8	
Mean	.1	2.6	11.5	31.6	5.9	3.6	2.4	.9	.6	

1/ Before first treatment.

Table 2.--Adult Indian-meal moth populations in bins following application of pyrethrum-piperonyl butoxide sprays, July to October 1956

Frequency of treatment, concentration of pyrethrins, and test number	Estimated adult Indian-meal moths in overspace of bins								
	July		August		September		October		
	9 1/2	23	6	20	4	17	1	15	29
	Number	Number	Number	Number	Number	Number	Number	Number	Number
<b>Semi-weekly</b>									
<b>0.125 percent</b>									
1	25	50	3	0	0	0	0	0	0
2	20	0	0	0	0	0	0	0	0
3	25	0	20	0	0	0	0	0	0
Mean	23	17	8	0	0	0	0	0	0
<b>0.250 percent</b>									
4	25	0	0	0	0	0	0	0	0
5	10	0	15	0	0	0	0	0	0
6	10	10	5	0	0	0	0	0	0
Mean	15	3	7	0	0	0	0	0	0
<b>0.375 percent</b>									
7	25	0	0	0	0	0	0	0	0
8	50	0	15	0	0	0	0	0	0
9	25	0	15	0	0	0	0	0	0
Mean	33	0	10	0	0	0	0	0	0
<b>Weekly</b>									
<b>0.125 percent</b>									
10	50	100	125	20	1	2	0	0	0
11	25	3	50	0	0	10	0	0	0
12	50	350	1,500	250	20	20	0	0	0
Mean	42	151	558	90	7	11	0	0	0
<b>0.250 percent</b>									
13	50	0	0	0	0	0	0	0	0
14	25	10	0	0	0	0	0	0	0
15	25	4	3	0	0	0	0	0	0
Mean	33	5	1	0	0	0	0	0	0
<b>0.375 percent</b>									
16	25	10	0	0	0	0	0	0	0
17	50	3	4	0	0	0	0	0	0
18	25	10	0	0	0	0	0	0	0
Mean	33	8	1	0	0	0	0	0	0
<b>Biweekly</b>									
<b>0.125 percent</b>									
19	50	350	3,000	20,000	5,000	3,000	50	20	0
20	25	300	700	10,000	10,000	4,000	60,000	300	10
21	50	400	3,000	20,000	15,000	2,000	200	10	0
Mean	42	350	2,233	16,667	10,000	3,000	20,833	110	3
<b>0.250 percent</b>									
22	50	150	400	600	700	100	10	0	0
23	10	15	20	5	5	5	20	0	0
24	50	200	1,000	500	300	50	100	10	0
Mean	37	122	373	368	335	52	43	3	0
<b>0.375 percent</b>									
25	25	15	20	20	0	0	0	0	0
26	50	100	250	10	0	0	0	0	0
27	25	0	20	0	0	0	0	0	0
Mean	33	38	97	10	0	0	0	0	0
<b>No treatment--controls</b>									
28	50	400	3,000	15,000	5,000	300	200	20	0
29	5	150	1,000	10,000	6,000	5,000	300	200	100
30	0	200	5,000	20,000	15,000	5,000	200	30	5
31	25	300	3,000	30,000	2,000	600	200	20	0
32	50	400	5,000	5,000	600	1,000	2,000	100	10
Mean	26	290	3,100	16,000	5,720	2,380	580	74	23

1/ Before first treatment.

Table 3.--Adults of the Indian-meal moth parasite (Bracon hebetor Say) found in surface corn following treatment with pyrethrum sprays

Frequency of treatment, concentration of pyrethrins, and test number	Adult parasites per 1,000 grams of shelled corn 1/		
	September		October
	4	17	1
	<u>Number</u>	<u>Number</u>	<u>Number</u>
Semi-weekly			
0.125 percent . . . . .	0	0	0
0.250 percent . . . . .	0	0	0
0.375 percent . . . . .	0	0	0
Weekly			
0.125 percent . . . . .	.3	0	0
0.250 percent . . . . .	0	0	0
0.375 percent . . . . .	0	0	0
Biweekly			
0.125 percent . . . . .	.9	.3	0
0.250 percent . . . . .	0	.3	0
0.375 percent . . . . .	0	0	0
Untreated controls . . . . .	2.4	4.3	3.2

1/ Means of 3 bins.

#### STATISTICAL ANALYSES

Statistical analyses of the data on populations by the analysis of variance method showed that a difference between the means of each treated series that equaled or exceeded 8.97 was significant. Only the biweekly application of 0.125 percent showed significantly less control than the other treatments (table 1). Similarly, a difference between the means of the untreated controls and the treated series that equaled or exceeded 8.03 was significant. This difference occurred only on August 20, when the mean population in all of the treated series was significantly less than that in the untreated controls (table 1). After that date all series were on about the same level with regard to Indian-meal moth populations, which may have been due to parasitism.

## INSECTICIDAL RESIDUES

The residues of piperonyl butoxide found in composited samples of the surface inch of grain taken from each bin, 3 and 6 months after the treatments were begun, are given in table 4. Even though massive amounts were applied, much of the piperonyl butoxide had been dissipated by the time the samples were drawn in October and January.

The mean percent recoveries at the 3- and 6-month samplings are given in the tabulation below:

<u>Frequency of application and concentration of piperonyl butoxide</u>	Amount of piperonyl butoxide found:	
	<u>3 months after beginning of treatment schedule</u>	<u>6 months after beginning of treatment schedule</u>
	<u>Percent of total applied</u>	<u>Percent of total applied</u>
Semi-weekly		
1.25 percent	26	12
2.50 percent	25	12
3.75 percent	41	11
Weekly		
1.25 percent	27	11
2.50 percent	33	11
3.75 percent	30	13
Biweekly		
1.25 percent	27	12
2.50 percent	38	13
3.75 percent	31	12

From the above figures, it appears that the amount of piperonyl butoxide present in the samples was about the same regardless of amount applied. At the end of 3 months about three-fourths of the piperonyl butoxide had disappeared and at the end of 6 months, nearly 90 percent.

## MOISTURE CHANGES

The corn used in these tests was sufficiently dry to store well, and ranged from 11.7 to 13.1 percent moisture. The average moisture content of the several series was nearly the same. There was virtually no change in the moisture content between April and October.

Table 4.--Residues of piperonyl butoxide in the surface inch of shelled corn at intervals following periodic applications of three concentrations of pyrethrum-piperonyl butoxide spray, 1956

Frequency of treatment, concentration of piperonyl butoxide, and test number <sup>1/</sup>	Amount of piperonyl butoxide applied and recovered in shelled corn--			
	After 3 months <sup>2/</sup>		After 6 months <sup>3/</sup>	
	Amount applied July 9 to Sept. 27	Amount recovered	Amount applied July 9 to Oct. 25	Amount recovered
	P.p.m.	P.p.m.	P.p.m.	P.p.m.
<b>Semi-weekly</b>				
1.25 percent				
1 . . . . .	786	290	1,048	146
2 . . . . .	786	180	1,048	112
3 . . . . .	786	138	1,048	124
Mean . . . . .	786	203	1,048	127
2.50 percent				
4 . . . . .	1,572	450	2,096	228
5 . . . . .	1,572	370	2,096	360
6 . . . . .	1,572	338	2,096	152
Mean . . . . .	1,572	386	2,096	247
3.75 percent				
7 . . . . .	2,358	1,200	3,144	360
8 . . . . .	2,358	885	3,144	480
9 . . . . .	2,358	808	3,144	228
Mean . . . . .	2,358	964	3,144	356
<b>Weekly</b>				
1.25 percent				
10 . . . . .	393	132	524	58
11 . . . . .	393	134	524	54
12 . . . . .	393	56	524	56
Mean . . . . .	393	107	524	56
2.50 percent				
13 . . . . .	786	212	1,048	106
14 . . . . .	786	290	1,048	120
15 . . . . .	786	266	1,048	132
Mean . . . . .	786	256	1,048	119
3.75 percent				
16 . . . . .	1,179	310	1,572	218
17 . . . . .	1,179	380	1,572	232
18 . . . . .	1,179	388	1,572	168
Mean . . . . .	1,179	359	1,572	206
<b>Biweekly</b>				
1.25 percent				
19 . . . . .	197	54	262	32
20 . . . . .	197	56	262	17
21 . . . . .	197	52	262	44
Mean . . . . .	197	54	262	31
2.50 percent				
22 . . . . .	393	136	524	60
23 . . . . .	393	158	524	76
24 . . . . .	393	154	524	72
Mean . . . . .	393	149	524	69
3.75 percent				
25 . . . . .	590	192	786	82
26 . . . . .	590	174	786	98
27 . . . . .	590	180	786	106
Mean . . . . .	590	182	786	95

<sup>1/</sup> The proportion of pyrethrins to piperonyl butoxide was 1:10. The test numbers are the same as in table 1.

<sup>2/</sup> These samples were drawn on October 1, 1956, and represent the amount of insecticide accumulated during the first 3 months of the study.

<sup>3/</sup> These samples were drawn on January 4, 1957, and represent the amount present 6 months after the first application and 3 months after the last.

## CHANGES IN COMMERCIAL GRADE

The commercial grades of the different bins of corn, taken in April 1956 and again in November, showed that there was no downgrading due to treatment. However, the corn in 9 of the 32 bins was downgraded one grade because of increased total damage. These were largely borderline cases.

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