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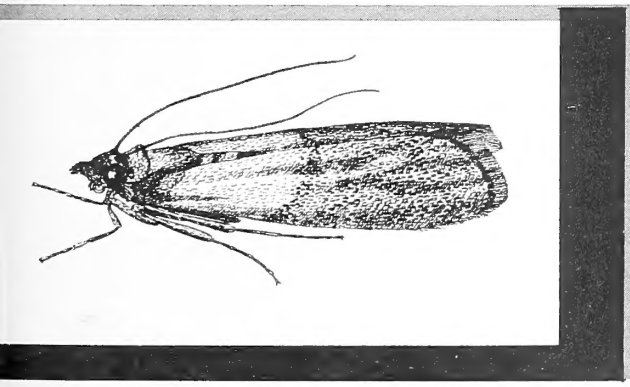
In-Storage Treatments for the Protection of Farmers Stock Peanuts from Insect Damage—Exploratory Tests



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

WARNING

The tests reported here were exploratory and the results presented do not imply recommendations for use. No tolerances have been established for the use of lindane or ryania as post-harvest treatments for the prevention of insect infestation in stored peanuts. Unless such tolerances are announced, lindane or ryania protective treatments should not be used. Established tolerances will permit certain applications of pyrethrum, piperonyl butoxide, and methoxychlor.

This report presents results of tests with various insecticidal dusts and sprays applied to stored farmers stock peanuts for protection against insect attack. The work is a part of a broad program of research to reduce the cost of marketing farm products, including the cost of preventing insect infestation in stored peanuts.

The term "farmers stock peanuts" refers to unshelled and uncleaned peanuts.

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IN-STORAGE TREATMENTS FOR THE PROTECTION OF FARMERS STOCK PEANUTS FROM INSECT DAMAGE--EXPLORATORY TESTS

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SUMMARY

Exploratory studies were made at Tifton, Ga., between 1952 and 1958, to develop information on the feasibility of four insecticides--lindane, methoxychlor, synergized pyrethrum, and ryania--as surface treatments and protective treatments on farmers stock peanuts in bulk to prevent insect infestation and damage. The results of these studies will be used as a basis for evaluation studies on a practical scale.

The effectiveness of the surface applications was measured (1) by comparing the increase in insect-damaged kernels in treated peanuts in small experimental bins and in a warehouse with the increase in control lots, (2) by the toxicity to the test insects of peanuts from the treated surface layers of piles of peanuts in warehouses, and (3) by the reduction in insect emergence from peanuts taken from treated surface layers.

The effectiveness of the protective treatments was measured (1) by the increase in insect-damaged kernels in treated lots of peanuts during various lengths of storage in small experimental bins and in circular metal 500-bushel bins, compared with the increase in control lots, and (2) by the number of insects recovered from selected bins.

Surface treatments of lindane and methoxychlor dusts to insect-free peanuts were effective in the small experimental bins in which insect invasion must come through the treated surface layer. However, in warehouses much of the moth infestation on the surface came from the subsurface layers, and infestations of various species of beetles developed throughout the load mass from insects in the peanuts when brought to the warehouse.

Synergized pyrethrum at dosages up to 15 milligrams per square foot (mg./sq. ft.) of pyrethrins and methoxychlor at 200 and 400 mg./sq. ft. were not very toxic to moth larvae but were toxic to adult beetles. The residues from weekly applications of synergized pyrethrum at 5 mg./sq. ft. of pyrethrins became increasingly toxic to moth larvae after 6 to 10 applications, but did not completely suppress the moth populations, which were constantly replenished by larvae from subsurface areas. An increase in the toxicity of the residues from the weekly sprayings, or the addition of a protective treatment to the peanuts when placed in storage, was the indicated solution to the problem.

Lindane protective dusts were effective at 3 parts per million (p.p.m.); methoxychlor dusts were fairly effective at 100 to 200 p.p.m.; synergized pyrethrum dusts and sprays were fairly effective for 12 months at 1 to 1.66 p.p.m. and for 23 months at 5.37 p.p.m.; and ryania dust at 75 and 100 pounds per 1,000 bushels gave excellent protection for as long as 33 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. Aklee Cagle, W. O. Farmer, and Huey Hall, of the laboratory staff, assisted in many phases of these studies.

Two materials were selected for large-scale evaluation studies on peanuts under commercial storage conditions--methoxychlor and synergized pyrethrum. Ryania was dropped from further consideration, and testing with lindane was held in abeyance, because of the improbability of residue tolerances being established for these two materials for some time.

INTRODUCTION

Marketing peanuts involves storing large quantities of farmers stock peanuts in commercial storage. Very few producers have facilities for storage on their farms. Therefore, almost all of the peanuts placed under price-support loans are stored in warehouses operating under Commodity Credit Corporation's (CCC) uniform storage contract. In most years a large part of these loan stocks is delivered to CCC in satisfaction of the loan. In recent years CCC has carried over into the new marketing year a portion of its inventories as a reserve, disposing of the rest as the market demands. As a result, large quantities of peanuts remain in commercial-type storage for as long as 18 months, which has presented the problem of protecting them from insects during the storage period.

Insect infestation becomes a serious problem in the stocks stored through the late spring and summer months. For this reason studies were begun in 1952 at the request of the agency administering the price-support operations at that time--since 1953 the program has been administered by the Oils and Peanut Division of the Commodity Stabilization Service (CSS)--and the Oilseeds and Peanut Research and Marketing Advisory Committee. The purpose of the studies was to develop methods of preventing or controlling insect infestations in farmers stock peanuts in storage. Two approaches to control were explored. The first approach was the use of "surface" treatments applied to the top surface of piles of bulk farmers stock peanuts at intervals, and the second, the use of "protective" treatments applied to the entire lot of peanuts as they were placed in the storage bins. Such treatments must not leave an insecticidal residue on the peanuts in excess of established tolerances.

The studies reported in this paper were conducted between 1953 and 1958, at Tifton, Ga., a location considered representative of a large part of the peanut-producing areas in the United States.

INSECT INFESTATION

Farmers stock peanuts are infested in storage by a complex of stored-product insects that includes several species of grain and meal moths and many species of flour and grain beetles common in stored grains. Moth infestation is principally confined to the surface areas of bulk peanuts and is quite noticeable because of the webbing and the flying adults. When the moth larvae become mature, they hunt extensively for a place to pupate. When they begin to migrate, great numbers are often visible on the surface of the peanuts and the walls of the bin or warehouse. Because moths attract so much attention with these habits, warehousemen tend to attribute all insect injury to them, and to direct all control measures toward these species. Among the trade all insect injury to kernels is called "worm cuts."

Actually, beetles cause most of the injury to stored farmers stock peanuts. These insects are present all through the mass of peanuts in the storage, but are usually not noticed until the peanuts are loaded out or are graded.

Until recently it was considered that peanuts entered a storage warehouse insect-free, that insect infestation began after the peanuts were placed in storage, and that the insects were in the warehouse or migrated to it from nearby sources. Studies conducted concurrently with those reported herein have shown that infestation begins in the field during harvesting and is carried into the storage warehouse.[2] The degree of infestation is usually very light at this time, but most of the species of insects found are the same as those present throughout the storage period.

INSECT SPECIES INVOLVED

The insect species associated with stored peanuts in these studies are listed below:

Common name	Scientific name
Indian-meal moth	Plodia interpunctella (Hbn.)
Angoumois grain moth	Sitotroga cerealella (Oliv.)
Ephestia moths (probably the almond moth and tobacco moth)	Ephestia spp.
Corn sap beetle	Carpophilus dimidiatus (F.)
Saw-toothed grain beetle	Oryzaephilus surinamensis (L.)
Flour beetles	Tribolium confusum Duv. and T. castaneum (Hbst.)
Cigarette beetle	Lasioderma serricorne (F.)
Cadelle	Tenebroides mauritanicus (L.)
Miscellaneous beetles	

TECHNIQUES

Drum-type bin test

Five-cubic-foot bins were used in tests with protective treatments (fig. 1). The bins were made by rolling a 2- by 6-foot sheet of masonite into a cylinder and fastening the overlapping edges with roundheaded stove bolts. This cylinder was placed upright on a 24-inch square of masonite, and the sample of peanuts placed in it. Each cylinder held about 3 bushels of farmers stock peanuts. The open-topped bins were placed at random on the second floor of an unheated and rather open barn on the Experiment Station grounds where they were exposed to a vigorous infestation of stored-product insects maintained in other lots of peanuts.

N-29134

Figure 1.--Five-cubic-foot masonite bin filled with peanuts exposed to vigorous infestation of stored-product insects.

Protective treatments were applied to the samples by two methods, both of which adequately distributed the insecticide. In one method the proper amount of a protective dust was placed on the sample in a drum, which was sealed and rolled to distribute the dust. The sample was then transferred to one of the drum-type bins. In the second method either protective dusts or sprays were applied to the samples as they were transferred into the drum-type bins over a belt conveyor.

[2] La Hue, D. W., Clements, B. W., Jr., and Womack, Herbert. Insect Infestation As a Factor in Storing Georgia-Grown Farmers Stock Peanuts. U. S. Dept. Agr., Mktg. Res. Rpt. 364 (In press.)

Measurement of Protection

The effectiveness of the surface sprays was evaluated by counting larvae in samples of treated peanuts, by holding samples of peanuts for counts of emerging moths, and by confining test insects on samples taken from treated surface areas. These data were supplemented by counting the number of insect-damaged kernels at intervals during storage.

The effectiveness of the protective sprays was based mainly upon the increase in percentage of insect-damaged kernels at various intervals during the test compared with the increase in the control lots, and supplemental data on the comparative numbers of insects found.

SURFACE TREATMENTS

The application of dusts or sprays to the top surface of bins or piles of bulk farmers stock peanuts was one of the methods for preventing insect infestation during storage that were investigated. As stated previously, until recently it was considered that peanuts entered a storage warehouse insect-free. Therefore, it appeared logical to prevent insects from invading the bulk lots of peanuts in storage warehouses and to suppress reinfestation by moths by the periodic application of surface sprays. This method was further favored because with the handling practices used in 1955 it would be much easier to apply insect control measures after the peanuts were put in the warehouse than to apply protective treatments while they were being put in, and because most concern was directed to moth infestations which were largely confined to the surface layers of peanuts.

Many miscellaneous tests and observations were made between 1953 and 1958. These tests are assembled into three groups for presentation here, according to the three criteria used to measure the effectiveness of the treatments: (1) The increase in the percentage of insect-injured kernels, (2) the mortality of test insects confined to samples from treated surface areas, and (3) the emergence of moths or other insects.

Prevention of Damage to Kernels

Three series of tests (A, B, and C) were conducted to measure how much insect damage to kernels is prevented by the use of various surface treatments.

Series A.--1953-crop Runner peanuts containing 1.06 percent of insect-damaged kernels were fumigated in October to destroy any self-contained infestation and placed in drum-type bins. Peanuts in four bins were given a surface application of a dust containing 1 percent of lindane in corncob flour, and in four more were dusted with 10-percent methoxychlor in corncob flour. The lindane dust was applied at the rate of 3.2 pounds per 1,000 square feet of surface (14.5 mg./sq. ft.) and the methoxychlor dust at the rate of 16 pounds (725 mg./sq. ft.). The bins remained undisturbed for 21 months, after which the peanuts were removed and the increase in percentage of insect-damaged kernels over that at the start of the test (1.06) was determined.

Both dusts gave very good protection, the increase in the percentage of insect-damaged kernels after 21 months being 2.43 for lindane and 3.98 for methoxychlor, compared with 12.50 for the untreated check lot.

Series B.--Six drum-type bins were placed in a well-infested warehouse and filled with 1954-crop Spanish peanuts containing 0.6 percent of insect-damaged kernels. The exposed surfaces of the peanuts were treated with synergized pyrethrum sprays in November 1954 and in 3 of the bins the peanuts were re-treated in June 1955. The pyrethrum spray, which contained 0.2 percent of pyrethrins and 2.0 percent of piperonyl butoxide, was applied at rates of 0.86, 1.72, and 3.44 gallons per 1,000 square feet of surface (or 6.5, 13, and 26 mg./sq. ft. of pyrethrins) to the bins treated in November only, and at one-half these rates each time for the bins treated in November and in June. All bins were exposed to infestation for 11 months, after which the percentage of

insect-damaged kernels was determined. Four other bins in the same warehouse remained undisturbed from November until April, at which time they were fumigated to destroy the self-contained infestation, which was assumed to still be low at this date. Two of the bins were treated with surface applications of a 10-percent methoxychlor dust and 2 bins with a 1-percent lindane dust. The methoxychlor dust was applied at the rate of 16 pounds per 1,000 square feet of surface (725 mg./sq. ft. of methoxychlor), and the lindane dust at 1.6 pounds per 1,000 square feet (7.25 mg./sq. ft. of lindane).

The results of these tests are given in table 1.

TABLE 1.--Insect-damaged kernels in stored peanuts before and 11 months after application of insecticides to surface layer

Type of formulation, date of application, and application rate per square foot	Replications	Insect-damaged kernels		
		At start	After 11 months	Increase
Pyrethrum spray:				
1 application (November 1954):	*Number*	*Percent*	*Percent*	*Points*
6.5 mg.	1	0.6	7.3	6.7
13.0 mg.	1	.6	6.6	6.0
26.0 mg.	1	.6	4.3	3.7
2 applications (November 1954 and June 1955):				
3.25 mg.	1	.6	7.7	7.1
6.5 mg.	1	.6	4.4	3.8
13.0 mg.	1	.6	3.4	2.8
Methoxychlor dust (April 1955):				
725 mg.	2	.6	3.5	2.9
Lindane dust (April 1955):				
7.25 mg.	2	.6	1.9	1.3
Untreated checks	2	.6	8.2	7.6

The heavier application rates of the pyrethrum sprays were fairly effective in preventing insect injury, and the applications in November and June with one-half the single application rate gave better results than the single application. The lindane and methoxychlor surface treatments were quite effective.

Series C.--Periodic surface applications were made to 10-square-foot areas on the top of large piles of Virginia peanuts in a large, flat tobacco-type storage warehouse in November and December 1955 and in February 1956. The area to be treated was delimited by a wooden frame laid on the top surface of the peanuts. Spray formulations were applied with a small constant-pressure household-type hand sprayer, and dust formulations with a fine-mesh sifting can. The formulations were each applied 3 times--November, December, February (table 2). Samples 1 foot square by 3 inches deep were removed at the end of February from 2 spots within each treated area, then combined and reduced through a peanut divider to 1 quart from which 100 pods were selected at random for use in determining the percentage of insect-damaged kernels.

All of the treatments suppressed the development of infestation, and practically no increase occurred in the percentage of insect-damaged kernels.

TABLE 2.--Insect-damaged kernels before and after three periodic applications of various formulations to surface layer of peanuts in November, December, and February

Type of formulation and application rate	Replications	Insect-damaged kernels		
		At start	Increase after 3 applications	Increase or decrease (-)
Dusts:				
Lindane:	*Number*	*Percent*	*Percent*	*Points*
90 mg./sq. ft.	3	3.8	2.4	-1.4
180 mg./sq. ft.	3	3.1	3.0	-.1
Methoxychlor:				
900 mg./sq. ft.	4	4.0	3.7	-.3
1,800 mg./sq. ft.	4	3.5	2.9	-.6
2,400 mg./sq. ft.	3	3.1	2.8	-.3
Synergized pyrethrum:				
9 mg./sq. ft. of pyrethrins	3	6.4	5.6	-.8
13.5 mg./sq. ft. of pyrethrins	3	4.7	5.2	.5
Ryania:				
20 lb./1,000 sq. ft.	3	4.7	2.9	-1.8
40 lb./1,000 sq. ft.	3	5.1	3.4	-1.7
Sprays:				
Synergized pyrethrum emulsion:				
15 mg./sq. ft. of pyrethrins	4	3.6	3.1	-.5
22.5 mg./sq. ft. of pyrethrins	4	5.3	3.0	-2.3
Synergized pyrethrum oil base:				
18.8 mg./sq. ft of pyrethrins	7	4.2	6.7	2.5
Pyrethrum-methoxychlor emulsion:[1]				
7.5-375 mg./sq. ft. of pyrethrins and methoxychlor	3	3.7	2.9	-.8
15-375 mg./sq. ft.	3	4.9	3.0	-1.9
22.5-375 mg./sq. ft.	3	3.8	3.1	-.7
15-188 mg./sq. ft.	3	3.1	3.4	.3
Untreated checks	20	3.2	11.8	8.6

[1] 7.5, 15, 22.5, and 15 mg. of pyrethrins, respectively, and 375 and 188 mg. of methoxychlor.

Toxicity to Test Insects

The effectiveness of various surface treatments was also measured by confining test insects on samples removed from the surface area of piles or bins of peanuts that had been subjected to periodic applications of the treatments.

Series D.--Runner peanuts from the 1954 crop were treated with sprays containing synergized pyrethrum, pyrethrum alone, or the synergist piperonyl butoxide alone. One day later 25 each of adult flour beetles, adult saw-toothed grain beetles, and mature Indian-meal moth larvae were placed in duplicate samples. The mortality of each species was checked after 12, 24, 48, and 96 hours' confinement on the treated peanuts. Eight days after treatment another lot of insects was confined on the samples, and similar mortality records were made. The synergized pyrethrum was applied at the rate per square foot of 10-100, 5-50, and 2.5-25 milligrams of pyrethrins and piperonyl butoxide, respectively--that is 10, 5, and 2.5 milligrams of pyrethrins and 100, 50, and 25 milligrams of piperonyl butoxide--to a single layer of peanuts confined in an area 1 by 4 feet in size.

Enough peanuts were selected at random from the area so that two layers could be placed in each of four 1-pint cardboard cartons. Pyrethrum alone was similarly applied at rates of 10, 5, and 2.5 mg./sq. ft. Replicate samples of each treatment were placed in pint cartons. All of the sprays were prepared from emulsifiable concentrates.

Results of this series are presented in table 3. The 10-100 mg./sq. ft. application rate of pyrethrins and piperonyl butoxide was highly toxic to the adult saw-toothed grain beetles and flour beetles after 1 day of aging, but had lost a third of its effectiveness after 8 days. The 5-50 mg./sq. ft. rate was slightly less effective. Pyrethrum alone was not as effective as the synergized pyrethrum, and piperonyl butoxide alone produced a low degree of mortality. The Indian-meal moth larvae were much more resistant than the beetles, the highest percentage of mortality of the moth larvae being only 30 percent. The method of applying the sprays gave a uniform distribution, as was demonstrated by the regular pattern of mortalities in the tests with beetles.

Series E. --Several dust and spray formulations containing pyrethrum or methoxychlor, or both, were applied in 1955 to small surface areas in a large peanut warehouse in which insects were developing. Moth larvae were confined on samples removed from the treated areas. The treatments were applied the first week in November to 10-square-foot areas within 2.5- by 4-foot wooden frames. The third week in November each area was re-treated at the same rate. Quadruplicate areas were treated with the following formulations:

0.075-0.75 percent pyrethrins-piperonyl butoxide emulsion spray

0.05-0.5 percent pyrethrins-piperonyl butoxide emulsion spray

0.05-0.8 percent pyrethrins-piperonyl butoxide dust

5 percent methoxychlor emulsion spray

0.075-0.75-5.0 percent pyrethrins-piperonyl butoxide-methoxychlor emulsion spray

0.05-0.50-5.0 percent pyrethrins-piperonyl butoxide-methoxychlor emulsion spray

Check--tap water spray

The sprays were applied at the rate of 2 gallons per 1,000 square feet of surface with a constant-pressure garden sprayer. The dust was applied at the rate of 20 pounds per 1,000 square feet with a rotary hand duster; the treatment area was covered with a muslin canopy. Individual pods were picked with forceps at random from the surface of treated areas and placed in half-pint cardboard cartons on the 15th day after the second application of insecticide. Each carton contained three to four layers of peanuts. A mixture of half-grown Indian-meal moth and Ephestia moth larvae were confined on the treated peanuts in two ways. In 1 group about 25 larvae were placed in each carton and confined there by a cheesecloth cover until they pupated and moths emerged. In the other group, in order to produce the effect of larvae migrating upwards through a surface layer of treated peanuts, about 25 larvae were placed in a second carton beneath 1 containing treated peanuts, and permitted to crawl upwards through a 1/8-inch screen bottom in the test carton. The second carton was removed after 3 days, and the bottom of the test carton capped. The larvae were confined in the top carton by means of a screen cap until they pupated and moths emerged.

The results presented in table 4 show that the residues from only one formulation, the pyrethrum-methoxychlor emulsion sprays applied at a rate of 5.6-375 mg./sq. ft., approached a satisfactory control of the moths as only 7 percent of the larvae survived to emerge as adults. In all instances except one, slightly more of the larvae forced to migrate upwards through the peanuts were killed than of those placed directly on top of the sample of treated peanuts, but the difference was not great.

TABLE 3.--Mortality of test insects placed on peanuts 1 day and 8 days after treatment with synergized pyrethrum, synergist alone, and pyrethrum alone and confined 12 to 96 hours

Test insect and application rate of pyrethrins and piperonyl butoxide per square foot	Replications	Mortality of insects							
		1 day after treatment and confined for--				8 days after treatment and confined for--			
		12 hours	24 hours	48 hours	96 hours	12 hours	24 hours	48 hours	96 hours
Saw-toothed grain beetle (adults):									
Synergized pyrethrum:[1]	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
10-100 mg.	4	66	92	94	100	30	53	57	67
5-50 mg.	4	54	72	83	100	23	41	46	55
2.5-25 mg.	4	56	67	78	89	11	28	32	36
Synergist alone:[2]									
100 mg.	4	17	23	41	43	5	10	16	19
50 mg.	4	8	12	19	24	6	8	13	15
25 mg.	4	--	--	--	--	--	--	--	--
Pyrethrum alone:									
10 mg.	4	67	70	81	81	12	27	35	44
5 mg.	4	41	62	66	71	9	20	30	37
2.5 mg.	4	20	51	66	72	4	12	16	21
Untreated check.	4	4	7	7	9	1	1	3	3
Flour beetles (adults):									
Synergized pyrethrum:[1]									
10-100 mg.	4	51	66	84	99	33	39	49	67
5-50 mg.	4	38	55	73	91	23	29	38	46
2.5-25 mg.	4	37	43	57	76	9	13	22	34
Synergist alone:[2]									
100 mg.	4	0	16	19	24	8	10	18	20
50 mg.	4	5	6	16	21	4	7	10	14
25 mg.	4	3	3	6	8	2	3	5	12
Pyrethrum alone:									
10 mg.	4	35	41	56	80	17	26	35	49
5 mg.	4	22	39	45	61	19	22	29	36
2.5 mg.	4	12	23	39	54	5	8	15	27
Untreated check.	8	4	5	5	7	2	3	4	4
Indian-meal moth (larvae):									
Synergized pyrethrum:[1]									
10-100 mg.	4	10	12	20	30	6	12	15	18
5-50 mg.	4	8	10	15	19	7	8	12	13
2.5-25 mg.	4	6	8	8	11	3	5	8	9
Synergist alone:[2]									
100 mg.	4	3	3	6	8	3	3	5	8
50 mg.	4	1	1	2	2	0	0	2	2
25 mg.	4	0	2	2	2	0	0	0	1
Pyrethrum alone:									
10 mg.	4	7	9	14	21	5	9	11	13
5 mg.	4	4	5	9	13	2	5	8	11
2.5 mg.	4	2	4	5	9	0	0	3	7
Untreated check.	12	1	1	1	1	1	1	1	2

[1] 10, 5, and 2.5 mg. of pyrethrins and 100, 50, and 25 mg. of piperonyl butoxide, respectively.
[2] Piperonyl butoxide.

Series F.--Several formulations containing synergized pyrethrum, methoxychlor, or combinations of the two, were applied to 1,500-square-foot surface areas of 1956 bulk peanuts stored in a large well-infested warehouse. Individual pods were collected with forceps at random over each treated area and placed in half-pint cardboard cartons; 10 adult flour beetles were confined in 1 set of cartons and 10 adult saw-toothed grain beetles in another set. Records were made of the resulting mortality with various periods of confinement.

TABLE 4.--Moth larvae completing their development when confined on samples of peanuts from treated surface areas (average of 4 replications)

Location of larvae, formulation of insecticide, and concentration per square foot	Test larvae	Larvae killed	Larvae pupating	Adults emerging	Larvae becoming adults
Larvae confined on peanuts:					
Pyrethrum emulsion spray:	*Number*	*Number*	*Number*	*Number*	*Percent*
5.6 mg. of pyrethrins	26.8	12.0	14.8	10.3	38.4
3.8 mg. of pyrethrins	27.3	8.8	18.5	14.8	53.7
Pyrethrum dust:					
4.5 mg. of pyrethrins	28.5	8.8	19.8	15.0	53.1
Methoxychlor emulsion spray:					
375 mg	26.3	12.0	14.3	10.3	39.0
Pyrethrum-methoxychlor spray:[1]					
5.6-375 mg	28.0	23.8	4.3	2.0	7.0
3.8-375 mg	29.0	16.5	10.0	7.5	25.9
Check--water spray	29.5	6.3	23.3	21.3	72.0
Larvae migrating through peanuts:					
Pyrethrum emulsion spray:					
5.6 mg. of pyrethrins	21.3	13.3	8.0	6.8	31.9
3.8 mg. of pyrethrins	21.5	9.8	11.8	9.5	43.8
Pyrethrum dust:					
4.5 mg. of pyrethrins	20.3	8.5	11.5	10.3	50.9
Methoxychlor emulsion spray:					
375 mg	20.3	15.0	5.3	5.0	24.9
Pyrethrum-methoxychlor spray:[1]					
5.6-375 mg	21.0	18.3	3.8	1.8	8.5
3.8-375 mg	20.5	13.5	7.0	6.3	30.9
Check--water spray	22.8	3.5	19.3	18.3	80.1

[1] 5.6 and 3.8 mg. of pyrethrins, respectively, and 375 mg. of methoxychlor.

The peanuts were piled on both sides of a central driveway, and the various applications were made to the surface area extending from the driveway to the sidewall between two rows of roof supports. Duplicate areas were treated with the following formulations:

10 percent methoxychlor in an inorganic carrier (dust)

0.25-0.20 percent pyrethrins-piperonyl butoxide oil-base spray

0.75-7.5 percent pyrethrins-piperonyl butoxide wettable powder spray

0.1-1.0-2.5 percent pyrethrins-piperonyl butoxide-methoxychlor spray prepared from methoxychlor wettable powder and pyrethrum emulsifiable concentrate

0.75-7.5-2.5 percent pyrethrins-piperonyl butoxide-methoxychlor emulsion spray

The treatments were applied at 2-week intervals beginning about January 1. The dusts were applied with a rotary hand duster, the oil-base sprays with a knapsack sprayer, and the other sprays with a power sprayer equipped with an agitator.

The results are given in table 5. With a 30- to 38-day aging period after the last application, the residues of all formulations at all dosage rates were highly toxic to saw-toothed grain beetles, even with only 12 hours' confinement on the samples. All were likewise effective against flour beetles, but only with a more extended confinement on the samples. With the 110-day aging period the residues were still fairly toxic to flour beetles confined on the samples for 16 hours. In fact, when the mortalities resulting from 16 hours' confinement are interpolated between the mortalities with 12 and 36 hours' confinement after a 30- to 38-day aging, the residues seem to have lost very little toxicity with the longer aging.

Series G. --The toxicity of residues from several spray formulations applied to moth webbing was studied by confining larvae on samples of sprayed webbing. Sheets of webbing with numerous mature moth larvae on them were spread out on a flat surface and sprayed with one of the following formulations:

Pyrethrum-piperonyl butoxide (1-10) wettable powder spray

Pyrethrum-piperonyl butoxide (1-10) emulsion spray

Pyrethrum-piperonyl butoxide (0.25-0.20) oil-base spray

Methoxychlor emulsion spray

Methoxychlor wettable powder spray

Check--water spray

Check--petroleum distillate (deodorized kerosene) spray

The mature moth larvae on the webbing when it was sprayed were confined there under small screen cages made from the rim of a pint carton cover with a piece of 20-mesh screen replacing the paper disk. Ten cages with 10 larvae in each were held for 3 days, and dead larvae were removed on the first, second, and third days. The uncaged larvae were removed from the webbing and held for mortality observations. On the second day, 10 additional cages for each treatment were set up on the sprayed webbing, using fresh unsprayed larvae. These were observed on the fourth and seventh days after spraying. The first part of the test was repeated, except that 20 larvae were confined in each of 5 rings. This procedure was repeated once again but with higher application rates of the insecticides, and with two additional formulations, synergized pyrethrum-methoxychlor oil-base spray and synergized pyrethrum-methoxychlor emulsion spray.

The mortalities of larvae confined on the treated webbing are presented in table 6. The formulations used were not effective at the dosage rates applied, except for the synergized pyrethrum-methoxychlor oil-base spray, which approached a satisfactory mortality of 86 percent. However, it was noticeable that the petroleum distillate alone killed as many larvae as some of the formulations that contained petroleum distillate.

Mortality due to direct contact of the insecticides with the larvae was not very great in any case, as is shown in the last column in table 6.

Series H. --Peanuts were removed from surface and subsurface areas in a peanut warehouse that had been sprayed nine times with surface sprays before November 26, 1957. The formulation applied per 1,000 square feet of surface was a synergized pyrethrum wettable powder spray composed of 9 ounces of a 2.0-20.0 percent pyrethrins-piperonyl butoxide concentrate in 2 gallons of water, giving a rate of 5 mg./sq. ft. of pyrethrins. Ten samples of peanuts were selected at random from the treated surface

TABLE 5.--Mortality of test insects placed on samples of peanuts taken from surface areas in a warehouse 30 to 38 days and 110 days after areas were treated with various formulations of insecticides

Days from last treatment of peanuts to confining of insects, and application rate of formulations per square foot	Replications	Applications of insecticides	Mortality of insects confined on samples for--							
			12 hours	16 hours	24 hours	36 hours	48 hours	91 hours	117 hours	312 hours
30 to 38 days after treatment:										
Flour beetles (adults):										
Methoxychlor dust:	*Number*	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
450 mg.	2	4	0	--	--	100	95	--	100	--
900 mg.	2	4	20	--	95	60	--	--	--	--
Pyrethrum oil-base spray:										
18.8 mg. pyrethrins.	2	4	0	--	--	50	85	--	100	--
Pyrethrum wet. pow. spray:										
5 mg. pyrethrins.	1	2	20	--	50	80	--	--	100	--
10 mg. pyrethrins.	2	2	30	--	70	80	--	--	--	--
20 mg. pyrethrins.	2	2	10	--	70	50	--	--	100	--
Pyrethrum-methoxychlor wettable powder spray:										
7.5-188 mg.	1	4	0	--	--	70	80	--	100	--
Pyrethrum-methoxychlor emulsion spray:										
5.6-188 mg.	2	4	60	--	10	50	70	--	100	--
Untreated check.			0	--	0	0	20	--	0	--
Saw-toothed grain beetle (adults):										
Methoxychlor dust:										
450 mg.	2	4	100	--	--	--	100	100	--	100
900 mg.	2	4	100	--	100	--	--	--	--	100
Pyrethrum oil-base spray:										
18.8 mg. pyrethrins.	2	4	80	--	--	--	100	100	--	100
Pyrethrum wet. pow. spray:										
5 mg. pyrethrins.	1	2	100	--	--	--	100	--	--	100
10 mg. pyrethrins.	2	2	100	--	100	--	--	--	--	100
20 mg. pyrethrins.	2	2	100	--	100	--	100	--	--	100
Saw-toothed grain beetles:										
Pyrethrum-methoxychlor wettable powder spray:										
7.5-188 mg.	1	4	100	--	--	--	100	100	--	100
Pyrethrum-methoxychlor emulsion spray:										
5.6-188 mg.	1	4	100	--	90	--	100	100	--	100
Untreated check.			0	--	0	--	0	--	--	10
110 days after treatment:										
Flour beetles (adults):										
Methoxychlor dust:										
450 mg.	4	4	--	45	--	--	--	--	--	--
900 mg.	4	4	--	90	--	--	--	--	--	--
Pyrethrum oil-base spray:										
18.8 mg. pyrethrins.	4	4	--	23	--	--	--	--	--	--
Pyrethrum wet. pow. spray:										
5 mg. pyrethrins.	4	4	--	13	--	--	--	--	--	--
10 mg. pyrethrins.	4	4	--	33	--	--	--	--	--	--
20 mg. pyrethrins.	4	4	--	33	--	--	--	--	--	--
Pyrethrum-methoxychlor wettable powder spray:										
7.5-188 mg.	4	5	--	18	--	--	--	--	--	--
Pyrethrum-methoxychlor emulsion spray:										
5.6-188 mg.	4	5	--	50	--	--	--	--	--	--
Untreated check.	8		--	4	--	--	--	--	--	--

TABLE 6.--Mortality of mature moth larvae after confinement on webbing removed from peanuts sprayed with various surface sprays and mortality of uncaged larvae removed from webbing after spraying

Test and application rate of formulations per square foot	Accumulative mortality of original larvae on sprayed webbing after confinement for--			Accumulative mortality of larvae placed on sprayed webbing 48 hours after spraying as observed on--		Mortality of uncaged larvae removed from sprayed webbing immediately after application of spray	
	1 day	2 days	3 days	4th day	7th day	Larvae	Mortality
First test:							
Pyrethrum emulsion spray:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Percent*
5 mg. of pyrethrins	10	16	21	10	14	61	23.0
10 mg. of pyrethrins	11	19	26	12	17	171	18.7
Pyrethrum wettable powder spray:							
5 mg. of pyrethrins	10	18	24	11	16	79	14.0
10 mg. of pyrethrins	12	20	32	13	20	112	23.2
Pyrethrum oil-base spray:							
10 mg. of pyrethrins	19	29	37	13	16	126	34.1
Methoxychlor emulsion spray:							
200 mg	11	16	21	14	22	77	15.6
Methoxychlor wettable powder spray:							
200 mg	9	13	18	11	18	89	16.9
Checks:							
Water spray	6	7	7	4	8	59	15.3
Petroleum distillate spray	13	24	27	6	9	71	23.9
Second test:							
Pyrethrum emulsion spray:							
5 mg. of pyrethrins	10	14	19	--	--	94	14.9
10 mg. of pyrethrins	14	17	22	--	--	72	18.1
Pyrethrum wettable powder spray:							
5 mg. of pyrethrins	10	19	21	--	--	124	12.9
10 mg. of pyrethrins	15	21	26	--	--	167	18.6
Pyrethrum oil-base spray:							
10 mg. of pyrethrins	22	26	29	--	--	71	31.0
Methoxychlor emulsion spray:							
200 mg	7	11	15	--	--	96	11.5
Methoxychlor wettable powder spray:							
200 mg	9	11	14	--	--	59	10.2
Checks:							
Water spray	5	6	8	--	--	62	11.3
Petroleum distillate spray	11	13	15	--	--	111	18.0
Third test:							
Pyrethrum emulsion spray:							
15 mg. of pyrethrins	18	23	24	--	--	--	--
Pyrethrum wettable powder spray:							
15 mg. of pyrethrins	20	25	30	--	--	--	--
Pyrethrum oil-base spray:							
15 mg. of pyrethrins	26	28	30	--	--	--	--
Methoxychlor emulsion spray:							
400 mg	15	20	25	--	--	--	--
Methoxychlor wettable powder spray:							
400 mg	20	27	30	--	--	--	--
Pyrethrum-methoxychlor oil-base spray:							
15-100 mg. of pyrethrins and methoxychlor	47	70	86	--	--	--	--
Pyrethrum-methoxychlor emulsion spray:							
15-100 mg	41	52	60	--	--	--	--
Checks:							
Water spray	4	5	6	--	--	--	--
Petroleum distillate spray	10	14	17	--	--	--	--

areas and placed in half-pint cardboard cartons that held about 32 pods each. Twenty cartons were filled with untreated pods taken from subsurface areas. Moth larvae crawling over the treated surface layer were confined in each of the 10 cartons of treated peanuts and in 10 cartons of untreated peanuts. Larvae from subsurface layers were collected and confined in the remaining 10 cartons of untreated peanuts. The cartons were placed upside down on screen cloth, then reversed every other day for three turnings to cause the larvae

to crawl upwards through the peanuts. The cartons were then capped and held until the larvae pupated and moths emerged.

The percentages of larvae becoming adults are shown in the following tabulation:

Source of peanuts and larvae	Number of larvae confined	Percentage of larvae becoming adults
Treated peanuts:		
Surface larvae	2,377	2.2
Untreated peanuts:		
Surface larvae	2,026	49.1
Subsurface larvae	946	77.7

It was evident that larvae from the surface layer of peanuts had not yet received the full effect of the residues at the time they were put in the cartons, since 49.1 percent of those removed from the treated peanuts completed their development. Only 2.2 percent of those that remained on the residues completed their development. These results indicate that not many larvae migrating to the surface from subsurface layers and remaining in contact with treated peanuts until ready to pupate would survive the level of residue present after 9 applications of spray.

Series I.--The efficiency of a wettable powder spray applied at weekly intervals in a commercial storage warehouse was evaluated. The spray was applied at the rate of 9 ounces of a 2-20 percent pyrethrins-piperonyl butoxide wettable powder concentrate in 2 gallons of water per 1,000 square feet of surface area (5 mg./sq. ft. of pyrethrins).

Peanuts were removed from surface areas following the fourth, fifth, sixth, and seventh weekly sprayings, and replicated series of half-pint cardboard cartons each holding about 32 pods were infested in groups with flour beetles, corn sap beetles, saw-toothed grain beetles, and half-grown and mature moth larvae.

The mortalities obtained with the residues from the fourth, fifth, sixth, and seventh applications are given in table 7. The mortalities of the corn sap and saw-toothed grain beetles were 75 and 73 percent after 4 applications, 85 and 86 percent after 5 applications, 91 and 93 after 6 applications, and 98 and 100 after 7 applications. The flour beetles were not as susceptible as the other species of beetles, and mortality progressed from 24 to 33 to 86 to 95 percent, respectively, with the fourth, fifth, sixth, and seventh applications. The mature moth larvae were almost totally unaffected and the half-grown larvae only partially so by the 9-day confinement on residues produced by the sixth and seventh applications.

Reduction in Insect Emergence

The insects emerging from surface areas, or from samples taken from surface areas to which surface treatments had been applied, were recorded in a number of instances to indicate the effectiveness of such treatments.

Series J.--This series of tests was a part of series A, discussed on page 6, in which fumigated peanuts in drum-type bins were given a surface application of dusts containing 1 percent of lindane in corncob flour or of 10 percent of methoxychlor in corncob flour, at rates of 14.5 and 725 mg./sq. ft., respectively. The bins remained undisturbed for 21 months, from October 1953 until July 1955, at which time they were removed and the insects screened out and counted. Each bin contained approximately 3 bushels of peanuts.

Table 8 shows that the insect populations in the bins treated with lindane were relatively low compared with the checks, whereas the bins treated with methoxychlor contained about half the number of insects in the checks. The percentage of insect-damaged kernels in these bins, as given on page 6, was in the same order as the insect populations; that is, both the percentage of kernels damaged and the insect population increased less

TABLE 7.--Mortality of test insects confined in peanuts from surface areas in a warehouse after 4 to 7 periodic applications of a wettable powder pyrethrum spray

Number of applications of surface spray and test insect	Replications	Accumulative mortality of insects confined on samples		
		3 days	5 days	9 days
	Number	*Percent*	*Percent*	*Percent*
Four applications:				
Flour beetles	16	9.4	18.8	23.8
Corn sap beetle	16	--	[1] 46.3	[1] 75.3
Saw-toothed grain beetle	16	30.0	58.8	73.1
Five applications:				
Flour beetles	16	8.8	23.8	33.1
Corn sap beetle	16	30.5	69.8	85.3
Saw-toothed grain beetle	16	42.5	78.1	86.3
Six applications:				
Flour beetles	8	10.0	45.0	86.3
Corn sap beetle	8	38.0	70.5	90.5
Saw-toothed grain beetle	8	31.5	72.5	93.0
Mature moth larvae	8	2.5	3.8	7.5
Half-grown moth larvae	8	5.0	20.0	30.0
Seven applications:				
Flour beetles	8	7.5	62.5	95.0
Corn sap beetle	8	53.0	86.0	98.0
Saw-toothed grain beetle	8	61.5	91.5	100.0
Mature moth larvae	8	1.3	2.5	6.3
Half-grown moth larvae	8	10.0	21.3	43.8

[1] Readings made at 4 and 7 days.

TABLE 8.--Insect population in peanuts fumigated before storage, dusted in storage with lindane or methoxychlor, and stored 21 months in drum-type bins

Insect	Lindane[1]	Methoxychlor[2]	Untreated check
	Number	*Number*	*Number*
Indian-meal moth	72	468	1,219
Ephestia moths	14	183	407
Angoumois grain moth	4	93	198
Flour beetles	218	1,759	3,698
Saw-toothed grain beetle	394	3,653	6,492
Cadelle	40	235	428
Cigarette beetle	6	52	122
Miscellaneous beetles	30	317	632
Total	778	6,760	13,196

[1] 14.5 mg./sq. ft.
[2] 725 mg./sq. ft.

in the bins treated with lindane than in those treated with methoxychlor. However, the difference in the percentage of kernels damaged was not as great as the difference in the insect populations.

Series K. --The number of insects found in drum-type experimental bins to which surface applications were applied in the tests in series B, discussed on page 6, were also recorded in series K. Three bins were given a surface application of synergized pyrethrum spray containing 0.2-2.0 percent pyrethrins and piperonyl butoxide in November 1954, and another three were given two applications at half the rate of the first three, in November and in June 1955. Four other bins were fumigated in April to destroy any self-contained infestation; two of them were given a surface treatment of methoxychlor dust, and two of them lindane dust. The contents of all bins were screened in October 1955. The number of live insects recovered per bin are shown in the following tabulation:

Application rate	Live insects per bin
Pyrethrum spray (1 application):	
6.5 mg./sq. ft. of pyrethrins	650
13 mg./sq. ft. of pyrethrins	525
26 mg./sq. ft. of pyrethrins	313
Pyrethrum spray (2 applications):	
3.25 mg./sq. ft. of pyrethrins	527
6.5 mg./sq. ft. of pyrethrins	369
13 mg./sq. ft. of pyrethrins	254
Methoxychlor dust:	
725 mg./sq. ft.	153
Lindane dust:	
7.25 mg./sq. ft.	90
Check	555

The pyrethrum treatments suppressed the insect populations to a small degree; the higher application rates were the most effective, and the dual applications were more effective than the single. The lindane protected the peanuts against infestation fairly well, and the methoxychlor was less effective than the lindane but more effective than the pyrethrum. The percentages of insect-damaged kernels from these bins, as given on page 7, follow this same pattern and reflect about the same degree of protection.

Series L. --This series was part of series C, described on page 7, in which surface treatments were periodically applied to 10-square-foot areas of peanuts in a warehouse in November and December 1955 and in February 1956. Samples 1 foot square by 3 inches deep were removed from the treated areas at the end of February and screened to remove the insects.

The insects recovered from samples from two replicate areas treated with each formulation are shown in table 9.

Series M. --In this series, small areas were covered to keep the spray off during the 10th, 11th, 12th, and 13th weekly applications of a wettable powder pyrethrum spray to the surface layer of peanuts in a warehouse. Counts of the live and dead moth larvae in these areas were compared with counts made in the areas treated each week.

The spray contained 9 ounces of 2.0-20.0 percent pyrethrins-piperonyl butoxide concentrate per each 2 gallons of water, and had been applied weekly for 9 weeks prior to November 26, 1957. The next four applications were made November 26 and December 3, 10, and 17. Areas of 1 and 2 square feet were covered by cages, and the cages were covered

TABLE 9.--Insect population in two samples, 1 foot square by 3 inches deep, of peanuts after 3 applications of spray or dust

Formulation and application rate	Moth larvae	Beetles	Total
Dusts:			
Lindane:	*Number*	*Number*	*Number*
90 mg./sq. ft.	2	5	7
180 mg./sq. ft.	1	2	3
Methoxychlor:			
900 mg./sq. ft.	5	7	12
1,800 mg./sq. ft.	4	7	11
2,400 mg./sq. ft.	1	4	5
Pyrethrum:			
9 mg./sq. ft. of pyrethrins	14	12	26
13.5 mg./sq. ft. of pyrethrins	12	11	23
Ryania:			
20 lb./1,000 sq. ft.	3	3	6
40 lb./1,000 sq. ft.	4	1	5
Sprays:			
Pyrethrum emulsion:			
15 mg./sq. ft. of pyrethrins	5	9	14
22.5 mg./sq. ft of pyrethrins	1	6	7
Pyrethrum oil-base:			
18.8 mg./sq. ft. of pyrethrins	15	28	43
Pyrethrum-methoxychlor emulsion:			
7.5-375 mg./sq. ft.	0	0	0
15-375 mg./sq. ft.	0	2	2
22.5-375 mg./sq. ft.	0	0	0
15-188 mg./sq. ft.	1	0	1
Check	52	59	111

during spraying to prevent them from being contaminated by spray residue. The larvae in the cages and in similar-sized treated, or uncovered, areas were counted before and after each spraying.

The results of these observations are given in table 10. The population of larvae increased from week to week in about the same degree in both the covered and the uncovered areas. Since larvae could not crawl onto the caged areas, it is assumed they migrated upwards from the subsurface areas into the cages. The number of dead larvae under the cages increased steadily so that at the end of the 4 weeks they amounted to from 2/5 to 1/2 the number of live larvae. The number of dead larvae in the uncovered areas increased faster than the number of live larvae, which were assumed to be migrating to the surface from subsurface areas, and at the end of the period the dead exceeded the live by about 2 to 1. The increase in the proportion of larvae that were dead indicates a trend towards an increasingly greater degree of mortality, since the number of moths could be expected to decrease sharply with the advance of winter.

Series N.--The condition of active larvae crawling on webs over the surface of peanuts receiving periodic applications of the wettable powder pyrethrum spray mentioned in

TABLE 10.--Moth larvae counted on covered[1] and uncovered[2] surface areas before and after the 10th to 13th weekly sprayings with wettable powder pyrethrum sprays

Areas sampled and size	Replications	10th weekly application				11th weekly application			
		Before		After		Before		After	
		Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
Covered areas:	No.	No.	No.	No.	No.	No.	No.	No.	No.
1 square foot..	10	44	12	71	27	74	44	74	61
2 square feet..	3	31	10	38	20	47	30	53	38
Uncovered areas:									
1 square foot..	10	69	17	53	47	40	70	46	91
2 square feet..	3	27	7	22	23	22	40	16	51

Areas sampled and size	Replications	12th weekly application				13th weekly application			
		Before		After		Before		After	
		Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
Covered areas:	No.	No.	No.	No.	No.	No.	No.	No.	No.
1 square foot..	10	179	89	143	112	314	136	351	173
2 square feet..	3	115	79	195	93	293	124	449	186
Uncovered areas:									
1 square foot..	10	100	273	122	427	213	507	306	564
2 square feet..	3	76	292	125	387	271	541	338	734

[1] Areas covered with lumite-covered frames; protected from sprays by polyethylene sheeting.

[2] Areas marked by frames only.

the preceding series was determined in relation to their ability to complete their development and emerge as moths. In spite of 5 to 8 applications of the spray, sheets of webbing had been formed over the top surface of the piles of peanuts. On October 30 and November 7, 1957, quantities of webbing and the larvae on them were peeled from the surface layers of peanuts in 6 warehouses and placed in paper bags. After 2 weeks the adults and larvae still remaining alive were counted.

The results are presented in table 11. Forty percent of the moth larvae on the webs with residues a week old were still alive 2 weeks after removal from the warehouses. Only 20 percent of the larvae survived when the webs were removed directly after the spray was applied. In each case the survivals consisted of larvae, pupae, and adults.

Series O.--Samples were collected from the surface and subsurface layers on November 23 and 26, 1957, in a warehouse that had received nine weekly surface treatments of the wettable powder pyrethrum spray mentioned in the two previous series. The samples were placed in bags and held for 26 days. A second group of samples was collected on December 21 and 24 after 13 weekly surface applications had been made, and similarly held for about 20 days. After the holding periods the larvae, pupae, and adults in the bags were counted.

TABLE 11.--Moths surviving in webbing 2 weeks after removal from surface layer of peanuts that had been sprayed weekly with pyrethrum wettable powder

Type and source of sample and age of residue	Applications of insecticides	Larvae		Pupae		Adults
		Alive	Dead	Alive	Dead	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Virginia, segregation 2, Moultrie, Ga.:						
Residue 7 days old.....	5	93	667	68	22	38
Residue fresh.....	6	22	687	28	30	26
Virginia, segregation 1, Sylvester, Ga.:						
Residue 7 days old.....	6	40	3	9	1	58
Residue fresh.....	7	9	27	7	5	16
Spanish, segregation 1, Sylvester, Ga.:						
Residue 7 days old.....	6	29	27	8	0	27
Residue fresh.....	7	19	43	11	6	23
Virginia, segregation 1, Tifton, Ga.:						
Residue 7 days old.....	8	26	221	83	6	86
Residue fresh.....	9	24	401	69	46	16
Runner, segregation 1, Tifton, Ga.:						
Residue 7 days old.....	7	76	309	47	3	57
Residue fresh.....	8	30	211	29	27	9
Virginia, segregation 1, Fitzgerald, Ga.:						
Residue 7 days old.....	6	103	47	19	3	23
Residue fresh.....	7	31	91	11	11	23

The results are presented in table 12. In the subsurface samples 88.6 percent of the moth larvae present when the samples were collected were surviving 20 or more days later. In the surface samples 88.7 percent of the moth larvae present when the samples were collected were dead when examined 20 or more days later.

Series P.--Samples were collected November 26, 1957, from unwebbed and webbed surface areas and from subsurface areas in a warehouse that had received 10 weekly surface treatments of the wettable powder pyrethrum spray discussed in the three previous series. The larvae were screened from them, placed in cartons, and held for 24 to 27 days, at which time the number of original larvae surviving were recorded.

The results are given in table 13. In the surface samples 73 percent of the larvae present when collected had died by the time the examination was made 24 to 27 days later. In the subsurface samples 76 percent of the original larvae survived.

Discussion

The data presented indicate that surface treatments apparently were effective in the experimental drum-type bins when insect-free peanuts were put in the bins and when insect invasion must come through the treated surface layer (series A and B, pages 6-7).

TABLE 12.--Cumulative emergence of moths and counts of larvae and pupae 20 to 26 days after samples of peanuts were collected from warehouse in which surface layers of peanuts had been sprayed 9 and 13 times at weekly intervals with pyrethrum wettable powder

Number of applications of insecticides and location of sample	Replications	Larvae		Pupae		Adults
		Alive	Dead	Alive	Dead	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
9 weekly applications:						
Surface samples	10	68	1,161	9	34	30
Subsurface samples	10	242	55	43	5	96
13 weekly applications:						
Surface samples	10	53	459	4	5	32
Subsurface samples	10	262	31	17	3	73

TABLE 13.--Cumulative emergence of moths and counts of larvae and pupae 24 to 27 days after samples were collected from warehouse in which surface layer of peanuts had been sprayed 10 times at weekly intervals with pyrethrum wettable powder

Type of sample	Replications	Larvae		Pupae		Adults
		Alive	Dead	Alive	Dead	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Surface, no webbing	20	4.5	22.0	1.8	1.4	3.0
Surface, with webbing	20	2.4	17.3	1.7	.8	1.7
Subsurface	20	13.1	4.7	3.7	1.9	4.9

However, in other studies made concurrently with these, peanuts stored in bulk in warehouses carried an incipient infestation of several species of moths and beetles into the warehouse with them, and these insects developed in the subsurface areas. The beetles did not leave the pile of peanuts in any great numbers, so that they had little contact with the treated surface layer. The moths, however, migrated as mature larvae to or through the surface layer to pupate, and the adults, after flight and mating, returned to the surface to lay eggs. Early in the studies, therefore, it became evident that surface treatments would be effective principally against moths.

Toxicity studies indicated that residues of synergized pyrethrum and combinations of synergized pyrethrum and methoxychlor were much more effective at given rates to the 2 or 3 most important species of beetles than to moth larvae (tables 3, 5, and 7). In one instance, a residue of synergized pyrethrum was more effective than that of pyrethrum or the synergist alone (table 3) and a residue of a combination of synergized pyrethrum and methoxychlor was more effective than one of either component (table 4). A residue from a pyrethrum oil-base spray with the pyrethrins and piperonyl butoxide in a 2.5 to 2 ratio appeared to be as effective as residues from the emulsion and wettable powder sprays with a 1 to 10 ratio (tables 5 and 6). Dusts containing synergized pyrethrum or methoxychlor were about equal to emulsion sprays containing these insecticides (tables 4 and 5). Pyrethrins at 5, 10, and 15 mg./sq. ft. and methoxychlor at 200 and 400 mg./sq. ft. were not very toxic to moth larvae as contact sprays (table 6 and page 12).

Collaborative studies conducted by Kantack and Laudani[3] at the Stored-Product Insects Laboratory, Savannah, Ga., showed that residues from wettable powder sprays were superior to residues from emulsion sprays on a sorptive surface. The wettable powder produced quicker action, higher mortalities, and greater persistence against adults and larvae of the Indian-meal moth.

The tests in 1957 were concentrated, therefore, on the effectiveness of wettable powder synergized pyrethrum sprays. After 6 or 7 applications, residues of such wettable powder sprayed on piles of peanuts at the rate of 5 mg./sq. ft. of pyrethrins per application built up to the point where they were highly toxic to adult beetles confined on peanuts from the treated surface, but very poor against moth larvae (table 7). Single applications of wettable powder sprays to webbing at the rate of 5, 10, and 15 mg./sq. ft. of pyrethrins killed only 20 to 30 percent of the moth larvae confined on the webs (table 6). Residues after 10 to 13 weekly sprayings killed about two-thirds of the larvae on the treated surface (table 10). Eighty percent of the larvae died when removed the day after a spraying from webbed surfaces which had received 5 to 8 previous weekly sprayings. Sixty percent died when removed a week after the last spraying (table 11). Residues after 9 weekly sprayings caused 89 percent mortality of larvae (table 12). Residues after 10 sprayings in another warehouse caused 73 percent mortality.

The habits of Indian-meal moths and Ephestia moths make it difficult to measure the effectiveness of surface treatments. Moth populations, originating from infestation present in the peanuts when placed in storage, apparently developed in subsurface areas. Mature larvae from these populations migrated to the treated surface layer and crawled all over it before pupating. The adults returned to the surface layer to lay eggs, and apparently many eggs fell or rolled down between the peanuts to the subsurface layers. Therefore, as the density of the population increased, a large number of mature larvae migrated upwards from the subsurface layer. At the dosage levels used, a rather long exposure to the residues of pyrethrum was needed to cause mortality, and the surface population of larvae was continually being supplemented by fresh larvae from the subsurface layers.

Therefore, even though it was evident that residues from the weekly sprayings were killing large numbers of moth larvae, it was also evident that there were enough larvae left on the peanuts to produce quantities of webbing on the surface and quantities of adult moths. The residues that accumulated as the weekly sprayings progressed were not toxic enough to keep ahead of the population build-up, to kill the fresh larvae migrating upwards from the subsurface areas before a substantial number had pupated, or to kill enough moths returning to the treated surface before they laid eggs. It is indicated, therefore, that two lines are open for further study of surface applications: (a) An increase in the toxicity of the residues from the weekly sprayings, or (b) the addition of protective treatments applied to the peanuts when placed in storage to prevent moth development in the subsurface layers. The surface applications used in the experiments are useful only for control of moth infestation and do little or nothing toward controlling beetles in the mass of the load, which are causing a good portion of the damage to kernels.

PROTECTIVE TREATMENTS

Exploratory tests were made with four insecticides--lindane, methoxychlor, synergized pyrethrum, and ryania--to study their possibilities as protective treatments for farmers stock peanuts. These materials were selected for testing because at the time it was believed they would give satisfactory protection at application rates that would not create objectionable residues.

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[3] Kantack, Ben H., Laudani, H. Comparative Laboratory Tests With Emulsion and Wettable-Powder Residues Against the Indian-Meal Moth. Jour. Econ. Ent. 50(4):513-514. 1957.

Tests With Lindane

Two series of tests were made with lindane dusts. One series was begun in the fall of 1953 and continued for 21 months; the second was begun in 1954 and continued for 16 months.

In the first series, 1953-crop Runner peanuts containing 1.06 percent of insect-damaged kernels were treated with a dust containing 1 percent of lindane in corncob flour at dosage rates of 2 and 3 p.p.m. of lindane. Replicate samples of each rate were placed in the small experimental drum-type bins where they remained undisturbed for 21 months, from October 1953 until July 1955. At that time the peanuts were removed from the bins, and each replicate was screened to remove insects and then reduced through a peanut divider to 1 gallon. One thousand pods were selected at random for use in determining the percentage of kernels damaged by insects.

Table 14 shows that even though both dosage rates gave good protection, the 3 p.p.m. gave the best protection.

TABLE 14.--Percentage of kernels damaged by insects in peanuts dusted with 1 percent lindane at dosage rates of 2 and 3 p.p.m., at start and after 21 months of storage

Dosage rate	Replications	Kernels damaged by insects		
		At start	After 21 months	Increase
	Number	*Percent*	*Percent*	*Points*
2 p.p.m.	3	1.06	4.73	3.67
3 p.p.m.	4	1.06	2.67	1.61
Untreated check	4	1.06	13.56	12.50

Table 15 shows that the average number of insects per bin at the end of the storage in the bins treated with 2 and 3 p.p.m. of lindane was 50 and 21 percent, respectively, of those in the check bin.

TABLE 15.--Insects per bin in peanuts treated with lindane at dosage rates of 2 and 3 p.p.m. and stored 21 months

Insect	Insects per bin		
	Check	2 p.p.m.	3 p.p.m.
	Number	*Number*	*Number*
Indian-meal moth	96	29	7
Ephestia moths	23	13	2
Angoumois grain moth	15	9	0
Flour beetles	214	77	47
Saw-toothed grain beetle	291	175	82
Cadelle	27	23	5
Cigarette beetle	7	3	0
Other beetles	31	23	7
Total	704	352	150

In the second series, 1954-crop Spanish peanuts with 1.1 percent of the kernels damaged by insects were dusted with 3 concentrations of lindane in corncob flour--0.5, 1.0, and 2.0 percent--so as to give dosage rates of 2 and 3 p.p.m. of lindane with each formulation. Three replicate samples of each rate were placed in the small experimental drum-type bins where they remained undisturbed for 16 months, from November 1954 until March 1956. At that time the peanuts were removed, and each replicate was reduced to 1 quart, from which 100 pods were selected for examination.

Table 16 shows that the protection was not as good in this series as in the first one. There did not appear to be any advantage to a greater volume of dust since all three formulations gave unsatisfactory protection.

TABLE 16.--Percentage of kernels damaged by insects in peanuts treated with 0.5, 1, and 2 percent lindane at dosage rates of 2 and 3 p.p.m., at start and after 16 months' storage

Concentration of lindane and dosage rate	Replications	Kernels damaged by insects		
		At start	After 16 months	Increase
0.5 percent:	*Number*	*Percent*	*Percent*	*Points*
2 p.p.m.	3	1.1	8.1	7.0
3 p.p.m.	3	1.1	7.9	6.8
1 percent:				
2 p.p.m.	3	1.1	9.1	8.0
3 p.p.m.	3	1.1	6.6	5.5
2 percent:				
2 p.p.m.	3	1.1	7.9	6.8
3 p.p.m.	3	1.1	6.1	5.0
Untreated check	3	1.1	12.6	11.5

Tests With Methoxychlor

Two series of tests were made with methoxychlor as a protective treatment, one in 1953-54 and the other in 1954-55.

In the first series, 1953-crop runner peanuts with 1.06 percent of the kernels damaged by insects were treated with a dust containing 10 percent of methoxychlor in corncob flour at dosage rates of 50, 75, and 100 p.p.m. of methoxychlor. Replicate samples of each treatment were placed in the small experimental drum-type bins where they remained undisturbed for 21 months, from October 1953 until July 1955. The peanuts were then removed and run over a screen to remove the insects, then through a peanut divider to get a 1-gallon sample; 1,000 pods were selected at random from this sample to determine the percentage of kernels damaged by insects. The results are given in table 17.

The dosage rates of 75 and 100 p.p.m. gave good protection, but not as good as lindane at 3 p.p.m. in parallel tests (pages 23-24).

The suppression of insect populations amounted to 0.4, 46, and 66 percent of those in the check for the 50, 75, and 100 p.p.m. treatments, as shown in table 18.

In the second series 1954-crop Spanish peanuts with 1.1 percent of the kernels damaged by insects were treated in November 1954 with a dust containing 10 percent of methoxychlor in corncob flour, at rates of 100 and 200 p.p.m. of methoxychlor. Three replicate samples of each rate were placed in the small experimental drum-type bins

where they remained undisturbed for 16 months, from November 1954 until March 1956. At that time the peanuts were reduced to 1 quart by use of a peanut divider, and 100 pods examined at random to determine the percentage of insect-damaged kernels. Table 19 shows that protection was not as good as in the first series.

TABLE 17.--Percentage of kernels damaged by insects in peanuts dusted with 10 percent methoxychlor at dosage rates of 50, 75, and 100 p.p.m., at start and after 21 months of storage

Dosage rate	Replications	Kernels damaged by insects		
		At start	After 21 month	Increase
	Number	*Percent*	*Percent*	*Points*
50 p.p.m.	3	1.06	8.08	7.02
75 p.p.m.	3	1.06	4.87	3.81
100 p.p.m.	4	1.06	4.27	3.21
Check	4	1.06	13.56	12.50

TABLE 18.--Insects per bin in peanuts treated with methoxychlor at dosage rates of 50, 75, and 100 p.p.m. and stored 21 months

Insect	Insects per bin			
	Check	50 p.p.m.	75 p.p.m.	100 p.p.m.
	Number	*Number*	*Number*	*Number*
Indian-meal moth	96	33	25	24
Ephestia moths	23	14	10	6
Angoumois grain moth	15	8	5	5
Flour beetles	214	142	67	74
Saw-toothed grain beetle	291	457	244	106
Cadelle	27	16	7	1
Cigarette beetle	7	5	5	3
Other beetles	31	26	14	20
Total	704	701	377	239

TABLE 19.--Percentage of kernels damaged by insects in peanuts dusted with 10 percent methoxychlor at dosage rates of 100 and 200 p.p.m., at start and after 16 months of storage

Dosage rate	Replications	Kernels damaged by insects		
		At start	After 16 months	Increase
	Number	*Percent*	*Percent*	*Points*
100 p.p.m.	3	1.1	8.6	7.5
200 p.p.m.	3	1.1	5.9	4.8
Check	3	1.1	12.6	11.5

Tests With Pyrethrum

Four series of tests were made with synergized pyrethrum between 1952 and 1956.

The first series included 4 lots of Spanish peanuts prepared in November 1952, and held in storage for 11, 12, 21, and 33 months, respectively. The following formulations were applied in one or more tests.

0.05-0.8 percent pyrethrins-piperonyl butoxide in a talc carrier at 100 pounds per 1,000 bushels.

2-20 percent pyrethrins-sulfoxide in an inorganic carrier at 100 pounds per 1,000 bushels.

0.04-0.03-0.8 percent pyrethrins-allethrin-piperonyl butoxide in a talc carrier at 100 pounds per 1,000 bushels.

0.03-0.06-0.8 percent pyrethrins-allethrin-piperonyl butoxide in a talc carrier at 100 pounds per 1,000 bushels.

0.75-10 percent pyrethrins-piperonyl butoxide wettable powder at 10 pounds in 5 gallons of water per 1,000 bushels.

0.02-2 percent pyrethrins-piperonyl butoxide emulsion spray at 5 liters per 1,000 bushels.

Three bushels of peanuts with less than 1 percent insect-damaged kernels were treated with each formulation and placed in one of the small experimental drum-type bins for the indicated storage period. At that time replicate samples were taken from each bin and the percentage of insect-damaged kernels was determined.

The results given in table 20 show that the pyrethrum-sulfoxide dust, which was applied by mistake at the high rate of 66.7 p.p.m. of pyrethrins, gave excellent protection throughout the 33-month period, but that the others failed after the 12-month period. The protection from the other formulations was not consistent in parallel tests at 11 and 12 months nor with the different dosage rates of pyrethrins.

In the second series of tests, the application rate of the 0.05-0.8 percent pyrethrum-piperonyl butoxide dust was increased from 100 to 200 and 300 pounds per 1,000 bushels. Lots of Runner peanuts containing 1.1 percent of insect-damaged kernels were treated in October 1953 and placed in the small experimental drum-type bins where they remained undisturbed for 23 months, until September 1955. At that time the insects were screened from the peanuts; then 1,000-pod samples were examined for the percentage of insect-damaged kernels.

Table 21 shows that the 300-pound rate (5.37 p.p.m. of pyrethrins) gave excellent protection, and table 22 shows that it held the insect population to about one-fourth that in the check. This was a very severe test, because after 1 year of storage the pods become very dry, crack, and are attacked by the insects. The ratio of insects in the 3 treated lots to those in the check, and the ratio of the percentage of damaged kernels in the 3 treated lots to those in the check are very close.

The third series with 1954-crop Spanish peanuts was made at the same time as the tests with lindane, methoxychlor, and ryania. Lots of peanuts were treated with a dust and a spray formulation of synergized pyrethrum, and a spray of pyrethrum alone, and placed in the small experimental drum-type bins in November 1954, for 16 months' storage, until March 1956. At that time 100-pod samples were examined to determine the percentage of insect-damaged kernels.

TABLE 20.--Percentage of kernels damaged by insects in peanuts dusted with various formulations of pyrethrins and stored from 11 to 33 months

Formulation and application rate	Kernels damaged by insects after--			
	11 months	12 months	21 months	33 months
	Percent	*Percent*	*Percent*	*Percent*
Pyrethrum-piperonyl butoxide dust 1.66 p.p.m. pyrethrins	10.7	2.3	6.0	11.1
Pyrethrum-sulfoxide dust 66.7 p.p.m. pyrethrins	2.0	1.3	2.4	1.5
Pyrethrum-allethrin dust 1.34-1.0 p.p.m.	--	4.3	10.4	15.0
Pyrethrum-allethrin dust 1.0-2.0 p.p.m.	--	3.1	8.02	16.9
Pyrethrum wettable powder spray 2.5 p.p.m. pyrethrins	--	7.7	--	21.5
Pyrethrum emulsion spray 0.4 p.p.m. pyrethrins	--	10.2	13.7	19.8
Untreated checks	11.3	11.2	17.0	24.6

TABLE 21.--Percentage of kernels damaged by insects in peanuts dusted with pyrethrum-piperonyl butoxide dust at 100, 200, and 300 pounds per 1,000 bushels and stored for 23 months

Application rate	Repli-cations	Kernels damaged by insects		
		At start	After 23 months	Increase
	Number	*Percent*	*Percent*	*Points*
100 lb./1,000 bu. 1.79 p.p.m. of pyrethrins	3	1.1	12.3	11.2
200 lb./1,000 bu. 3.58 p.p.m. of pyrethrins	3	1.1	7.0	5.9
300 lb./1,000 bu. 5.37 p.p.m. of pyrethrins	4	1.1	2.0	.9
Check	4	1.1	13.6	12.5

TABLE 22.--Insects per bin in peanuts treated with pyrethrum-piperonyl butoxide at 100, 200, and 300 pounds per 1,000 bushels and stored for 23 months

Insect	Insects per bin			
	Check	1.79 p.p.m.	3.58 p.p.m.	5.37 p.p.m.
	Number	*Number*	*Number*	*Number*
Indian-meal moth	96	85	36	20
Ephestia moths	23	20	16	8
Angoumois grain moth	15	10	3	5
Flour beetles	214	195	107	44
Saw-toothed grain beetle	291	323	181	72
Cadelle	27	24	3	6
Cigarette beetle	7	14	4	3
Other beetles	31	22	16	13
Total	704	693	366	171

The results given in table 23 show that the dust gave partial protection but the sprays almost no protection over this long period.

TABLE 23.--Percentage of kernels damaged by insects in peanuts dusted or sprayed with pyrethrum, with or without a synergist, at dosage rates of 2.5 and 2.1 p.p.m. pyrethrins and stored for 16 months

Formulation and rate	Replications	Kernels damaged by insects		
		At start	After 16 months	Increase
	Number	*Percent*	*Percent*	*Points*
Pyrethrum dust (synergized) 2.5 p.p.m. pyrethrins	3	1.1	7.3	6.2
Pyrethrum spray (synergized) 2.1 p.p.m. pyrethrins	6	1.1	11.7	10.6
Pyrethrum spray (no synergist) 2.1 p.p.m. pyrethrins	3	1.1	11.5	10.4
Untreated check	3	1.1	12.6	11.5

The fourth series of tests were part of a contract study carried on by the agricultural engineers at the Georgia Coastal Plain Experiment Station at Tifton, Ga., and sponsored by the Oils and Peanut Division, CSS, to explore the possibilities of storing farmers stock peanuts on the farm under the price-support program. In the storage seasons between 1952 and 1957 peanuts were stored in 500-bushel circular metal bins 10 feet high and 9 feet in diameter. During the 1952-53 and 1953-54 seasons, a commercially available pyrethrum protective dust, composed of 0.05-0.8 percent pyrethrins and piperonyl butoxide in an inorganic carrier, was applied to the peanuts when binned, at the rate of 100 pounds per bin of approximately 400 bushels, or 4 p.p.m. of pyrethrins. The insect-damaged kernels in pods and in loose shelled kernels were recorded by the Stored-Product Insects Laboratory.

The results of these tests are presented in table 24. The degree of protection was not very great, but was more in the mass of peanuts than on the surface.

TABLE 24.--Percentage of insect-damaged kernels, in pods and loose, in samples of peanuts taken from 400-bushel lots dusted with pyrethrum and stored in circular metal bins[1]

Storage season and date of sampling	Bins observed	Treated				Check			
		Sample from surface		Sample from mass		Sample from surface		Sample from mass	
		In pods	Loose shelled kernels	In pods	Loose shelled kernels	In pods	Loose shelled kernels	In pods	Loose shelled kernels
1952-53 season:	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
November 24 (load-in)	2	0	0	0.20	0	0.19	0	0.18	0
February 3.....	2	.40		.54		.59		.89	
March 6.....	2	.87		.66		.21		.44	
April 6.....	2	1.00		.78		1.75		.97	
May 6.....	2	1.57		1.66		3.52		1.24	
June 2.....	2	6.29		1.93		4.82		1.36	
July 7.....	2	6.61		4.37		7.95		3.97	
August 14 (load-out).	2	6.55	28.0	4.37	33.3	7.28	18.4	6.35	40.0
1953-54 season:									
December 16 (load-in)	3	.39	1.4	.42	0	.79	4.4	.42	0
December 28.....	3	1.21		.76		1.61		.76	
February 9.....	3	3.05		1.50		1.48		1.54	
April 16.....	3	3.93		3.66		3.66		4.42	
June 9.....	3	3.31		2.83		6.54		6.10	
August 17 (load-out).	3	4.02	30.0	3.44	30.7	6.30	26.0	6.92	41.9

[1] Peanuts treated with pyrethrum protective dust composed of 0.05-0.8 percent pyrethrins and piperonyl butoxide in an inorganic carrier at the rate of 4 p.p.m. of pyrethrins.

Tests With Ryania

Four series of tests were made with ryania dusts in the 1952-53, 1953-54 and 1954-55 seasons.

The first series was made with 1952-crop Spanish peanuts treated with three different formulations of ryania dusts. One portion of each treated lot was stored for 11 months, one for 12 months, a third for 21 months and a fourth for 33 months. One formulation was composed entirely of ground stems of ryania without any other diluent. The formulation contained ryanodine as the active ingredient, at a strength of about 0.25 percent. The other two consisted of ryania dust with 3 percent of N-propyl isome or of sulfoxide added as a synergist. The peanuts were treated in November 1952 and placed in small experimental drum-type bins. At the end of each storage period the bins were emptied, and the percentage of insect-damaged kernels in 1,000-pod samples was determined.

Table 25 shows that all three formulations gave excellent protection, especially considering the severity of such tests.

A second series of tests was made in the 1953-54 season with Runner peanuts, with the same three formulations used in the first series. The peanuts were treated in October 1953 and 4 replicate lots were placed in the small experimental drum-type bins for 23 months' storage, until September 1955. At that time the peanuts were screened as they were removed from the bins to recover the insects present, and then 1,000-pod samples were examined to determine the percentage of insect-damaged kernels.

Table 26 shows that the protection was again excellent with all three formulations, and table 27 shows that the insect populations were held to a low level.

A third series of tests was conducted with Spanish peanuts treated with ryania dust at the rate of 100 pounds per 1,000 bushels in November 1954 and stored for 16 months in

TABLE 25.--Percentage of kernels damaged by insects in Spanish peanuts dusted with various formulations of ryania and stored for 33 months

Formulation and dosage rate per 1,000 bushels	Kernels damaged by insects after--			
	11 months	12 months	21 months	33 months
Ryania:	*Percent*	*Percent*	*Percent*	*Percent*
50 lb.		3.0		
75 lb.		1.2	3.2	4.0
100 lb.	0.7	1.7	2.8	3.2
Ryania-N-propyl isome:				
75 lb.		1.6	.9	1.1
100 lb.	3.5	2.5	.7	1.3
Ryania-sulfoxide:				
50 lb.		.8	5.6	2.9
75 lb.		1.1	3.4	1.5
100 lb.	4.9	1.0	2.7	3.5
Untreated checks	14.8	11.2	17.0	24.6

TABLE 26.--Percentage of kernels damaged by insects in Runner peanuts dusted with various formulations of ryania and stored for 23 months

Formulation and dosage rate per 1,000 bushels	Kernels damaged by insects		
	At start	After 23 months	Increase
Ryania:	*Percent*	*Percent*	*Points*
75 lb.	1.1	2.7	1.6
Ryania-N-propyl isome:			
75 lb.	1.1	1.2	.1
Ryania-sulfoxide:			
50 lb.	1.1	2.2	1.1
Untreated checks	1.1	13.6	12.5

TABLE 27.--Number of insects per bin in peanuts treated with ryania dusts at dosage rates of 50 and 75 lb./1,000 bu. and stored for 23 months

Insects	Check	Ryania	Ryania-N-propyl isome	Ryania-sulfoxide
	Number	*Number*	*Number*	*Number*
Indian-meal moth	96	10	14	9
Ephestia moths	23	2	3	1
Angoumois grain moth	15	0	0	0
Flour beetles	214	42	8	27
Saw-toothed grain beetle	291	71	17	48
Cadelle	27	2	2	2
Cigarette beetle	7	1	0	1
Other beetles	31	10	6	7
Total	704	138	50	95

small experimental bins. In March 1956, 100-pod samples were examined to determine the percentage of insect-damaged kernels.

The protection was good in this test, the percentage of insect-damaged kernels being 1.1 at the start of the test and 4.2 after 16 months, compared with 1.1 and 12.6, respectively, for the check.

The fourth series of tests was made in the 1954-55 season with Spanish peanuts. A lot of peanuts was treated with ryania dust at a rate of 100 pounds per 1,000 bushels in November. One portion was stored for 11 months in small experimental drum-type bins placed in a well-infested warehouse with other lots of peanuts, and the other portion, was stored in the same type of bin in an insect-free warehouse. After the storage period each bin was emptied, the peanuts were screened to recover the insects present, and a 100-pod sample was examined to determine the percentage of insect-damaged kernels.

The results are given in table 28. The protection was almost perfect in this test, which involved a shorter period than most of the preceding tests.

TABLE 28.--Percentage of kernels damaged by insects and insects per bin in Spanish peanuts dusted with ryania and stored for 11 months

Source of sample and type of treatment	Replications	Kernels damaged by insects			Insects per bin
		At start	After 11 months	Increase	
Infested warehouse:	*Number*	*Percent*	*Percent*	*Points*	*Number*
Ryania dust	2	0.6	1.0	0.4	25
Untreated check	2	.6	8.2	7.6	555
Uninfested warehouse:					
Ryania dust	2	.6	.7	.1	2
Untreated check	2	.6	5.6	5.0	219

Discussion

The results of the exploratory tests with selected insecticides to study their possibilities as protective treatments for farmers stock peanuts would indicate that all four materials tested--lindane, methoxychlor, synergized pyrethrum, and ryania--would give good protection from insect attack during storage. On the basis of the studies conducted the effective dosage rate of lindane would range from 3 to 5 p.p.m., of methoxychlor from 100 to 300 p.p.m., of synergized pyrethrum from 2 to 3 p.p.m. or more of pyrethrins, and of ryania dust from 75 to 100 pounds per 1,000 bushels. Synergized pyrethrum would be expected to perform better for shorter than for longer periods, such as 12 months or less, whereas the more stable materials such as lindane, methoxychlor, and ryania could be expected to give long-term protection with no increase in application rate, or only a relatively small increase.

However, in the selection of insecticides for use as protective treatments, it is necessary to consider not only their effectiveness in preventing insect infestation and damage, but the level of insecticidal residues remaining as a result of their application at effective rates. It is doubtful that a residue tolerance can be established on peanuts for ryania for some time, in the light of recent considerations. There is no specific chemical analysis method for the level of residues of ryanodine that would be present following the effective application rates, and much data on the toxicological effects of ingested ryania are needed to evaluate the hazard of residues even if their level could be determined. Therefore, it is not planned to conduct further studies with ryania at this time.

The status of lindane residues on raw foodstuffs resulting from post-harvest applications has not been established, and further testing with lindane is being held in abeyance.

Tolerances for residues on peanuts have been established under the Miller Amendment to the Food, Drug, and Cosmetic Act at the following levels:

Pyrethrins	1 p.p.m.
Piperonyl butoxide	8 p.p.m.
Methoxychlor	14 p.p.m.

It has been found in other studies that application rates on farmers stock peanuts can be considerably higher than the tolerance for synergized pyrethrum and can be several hundred p.p.m. for methoxychlor without exceeding the tolerances on the peanuts after they are shelled. The actual deposit is not as great as the calculated rate of treatment because some insecticide is lost during application and there is a further depletion of deposit upon aging during the storage period. The major portion of the residue is removed with the shells during shelling. This means that the dosage levels of synergized pyrethrum or methoxychlor indicated to be required on the basis of these tests could be applied to farmers stock peanuts for protection against insects during storage and the shelled peanuts would not exceed established tolerances.

The residues of pyrethrins or piperonyl butoxide in relation to tolerances are determined on the basis of the nuts with the shells removed. The tolerance for methoxychlor is not so designated and applies to either farmers stock or shelled peanuts, whichever form may enter into interstate commerce. Therefore, farmers stock peanuts treated with 100 to 300 p.p.m. of methoxychlor would have to be shelled to comply with the tolerance before they enter interstate commerce, are offered for sale in interstate commerce, or are sold with a guarantee of compliance with Food and Drug requirements.

Evaluation tests under commercial storage conditions have been started with synergized pyrethrum and with methoxychlor.

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