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Marketing Research Report No. 334

Pyrethrum Mists and Aerosols for Control of Insects in Tobacco Warehouses

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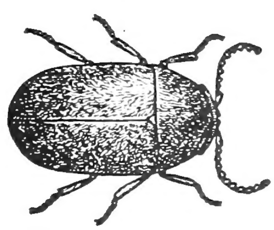

Marketing Research Division
Agricultural Marketing Service
U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

ACKNOWLEDGMENTS

The author is indebted to W. D. Reed (now with the Department of Defense), R. W. Brubaker, A. H. Yeomans, C. O. Bare, and Dana P. Childs, of the U. S. Department of Agriculture; to C. C. Scott, of the Flue-Cured Tobacco Cooperative Stabilization Corporation; to J. P. Vinzant, of the American Tobacco Company; to C. D. Delamar, of Liggett & Myers Tobacco Company; to C. M. Sprinkle, of R. J. Reynolds Tobacco Company; and to various tobacco companies for advice, assistance, and cooperation.

This report is a part of a broad program of research to reduce the cost of marketing farm products, in this instance by reducing the cost of controlling insect infestation in stored tobacco.

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PYRETHRUM MISTS AND AEROSOLS FOR CONTROL OF INSECTS IN TOBACCO WAREHOUSES

By Joseph N. Tenhet
Stored-Tobacco Insects Laboratory, Richmond, Va.[1]

SUMMARY

Pyrethrum mists and aerosols have been used extensively in tobacco warehouses and factories for the control of the tobacco moth, Ephestia elutella (Hbn.), and the cigarette beetle, Lasioderma serricorne (F.). Both types of treatments are highly effective against the moth but relatively ineffective against the beetle.

Mists and aerosols are not as effective as fumigation for controlling the cigarette beetle. However, they are very useful for controlling insects in loosely constructed buildings where fumigation cannot be used.

The difference between mists and aerosols is in the size of the particles produced, the mists having the larger. Because of this fact, the mists can be used in both open and closed warehouses whereas the use of aerosols is restricted to closed or semi-closed buildings.

The highly refined, very volatile hydrocarbon oil used in these studies proved quite satisfactory. Heavy oils are undesirable because they leave an objectionable greasy deposit in tobacco warehouses.

Synergists for pyrethrum, when used as a contact insecticide, appeared to be of little value against the cigarette beetle.

Concentration of insecticide in the mists and aerosols should be 0.2 percent pyrethrins for the moth, and 1 percent for the cigarette beetle. For the mists, the insecticide should be applied at the rate of 3 fluid ounces per 1,000 cubic feet of air space, and for aerosols at 2-1/4 to 3 fluid ounces. In small warehouses where the method of storing tobacco permits unusually good distribution of an aerosol, the dosage and concentration sometimes can be slightly reduced. Applications are usually made 1 to 3 times a week but may be made daily if necessary. Weekly applications will control the tobacco moth; daily applications often may not control the cigarette beetle.

Aerosols and mists kill only those beetles that emerge from the tobacco, but since some beetles complete their life cycle and reproduce within the tobacco hogshead, control is not complete.

For the cigarette beetle, mists or aerosols should be applied between 5 p. m. and midnight, and should be concentrated in the upper areas of the warehouse.

INTRODUCTION

Pyrethrum mists and aerosols have been used extensively in tobacco warehouses and factories to control the tobacco moth and the cigarette beetle. They are highly effective against the moth, but much less so against the beetle. A pyrethrum mist, originally called a "space spray," was developed to control the tobacco moth in open-type storage warehouses. It did this most efficiently. Later, an effort was made to adapt this treatment to control the cigarette beetle in all types of warehouses and factories. This was much less successful. Many misconceptions have arisen as to what can be expected of mists and aerosols. This method of applying insecticides has certain inherent limitations.

[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.

The object of this paper is to explain how, where, and why pyrethrum treatments are effective, and where and why they may not be effective.

The terms "fumigation," "spraying," and "fogging" are often misapplied. They are not the same, but are three different treatments:

Fumigation is the use of a gas, lethal to insects, either in vacuum, in atmospheric chambers, or in a warehouse or factory. This is one of the most efficient means of insect control. It not only kills the insects in the air space, but the gas penetrates into the hogsheads, cases, or bales, killing the eggs and immature stages of the insects within the tobacco. However, a warehouse must be almost airtight to be effectively fumigated. Often this is not practical.

"Spraying" generally refers to the use of mists, which are relatively fine sprays, applied to the airspace in a warehouse, usually by means of especially designed, mobile, electrically powered blowers. A mist has larger droplets than an aerosol, and usually is a contact insecticide that kills those insects actually hit by the spray particles. It does not penetrate the hogsheads, bales, or cases of tobacco, and consequently does not reach many of the eggs or immature stages of the insects; but it has one big advantage--it can be used against the cigarette beetle or the tobacco moth in open sheds where fumigation or aerosols cannot be used.

An aerosol consists of extremely small particles suspended in the air. The use of thermal, or heat-generated, aerosols is often called "fogging." The same insecticides used in mists are also used as aerosols, and the aerosol particles, like those of a mist, must hit an insect to kill it. Aerosols do not penetrate tobacco or containers, and therefore do not usually reach the eggs or immature insect stages. Aerosols can be used in buildings that cannot be fumigated because of cracks and small openings in the floors, walls, or roof. They are not effective in open sheds.

In tobacco warehouses, both mists and aerosols are more of a preventive measure than a control. They are aimed at killing the adult insects before they have time to lay many eggs. If treatment is applied so infrequently that an appreciable number of eggs are deposited before beetles are killed, the purpose of the treatment is defeated. Therefore, treatment must start as soon as the insects become active in the spring and continue throughout the summer until cold weather terminates activity. Treatment must be performed regularly even though few adult insects are observed. Even a few insects can lay many eggs, and once the eggs are laid an infestation has started. The larvae do the damage, and they are not reached by sprays or aerosols.

EARLIER STUDIES

The tobacco moth was first reported as a major pest of tobacco in the United States in 1930 (1).[2] Shortly thereafter, Reed and Vinzant (3) developed the use of pyrethrum dusts to control this insect. These dust treatments were fairly effective against the moth, but of little or no value against the cigarette beetle, which was usually present also. Furthermore, accumulations of spent dust in the tobacco warehouses presented a physical nuisance as well as a fire hazard.

In 1938, laboratory tests were begun at Richmond, Va., in an effort to develop an insecticidal spray to replace pyrethrum dusts in tobacco warehouses. In 1941, experiments were begun under industrial conditions to develop methods of applying such sprays in warehouses. To be effective, a contact spray had to be distributed throughout the entire air space of the building. This posed a difficult problem, as the insecticidal mist had to be driven from 50 to 100 feet over the hogsheads of tobacco racked 3 tiers (over 10 feet) high. Equipment was developed which would do this, and some results of such treatments have been published in various papers (3, 4, 5, 6, 7, 8, 9, 10, 11).

[2] Underlined numbers in parenthesis refer to items in Literature Cited, p. 18.

Following World War II (about 1945-1946), high-capacity generators became available for producing thermal aerosols, and shortly thereafter other equipment was introduced that produced mechanically formed aerosols. From about 1947 to 1955, extensive research was conducted with oil-based mists and aerosols. The results of much of this research have not been published previously.

ADVANTAGES OF PYRETHRUM

Pyrethrum is one of the safest insecticides known. It is toxic to insects, but has a very low toxicity to man. There is an occasional individual who is allergic to it, but in nearly 20 years of experimental work and more than 15 years of industrial use in tobacco warehouses, no instance is known of injurious effect to applicators or laborers in treated buildings. Applications as often as 6 days a week for 7 months have not injured flue-cured tobacco in hogsheads. Spillage of liquid insecticide may taint tobacco, but this rarely occurs except under unusual circumstances. Nevertheless, it is considered undesirable to apply spray or aerosol directly to uncovered tobacco, in order to avoid even the most remote possibility of taint on account of dripping or excessive dosage.

Other contact insecticides may be as effective as pyrethrum in killing the tobacco moth or the cigarette beetle. Some have been used to a limited extent, particularly lindane (12). No other contact insecticide tested up until this time, however, has been found to be more effective as a killing agent against these insects. Some are cheaper, but to offset that advantage they are much more dangerous to use.

The use of oil-based pyrethrum insecticides in tobacco warehouses has been approved by fire insurance underwriters, if recommended precautions are followed.

The question is sometimes raised whether the cigarette beetle will develop resistance to pyrethrum, since many insects have developed resistance to the new chlorinated hydrocarbon and the phosphate insecticides. To date no such resistance has been observed.

DIFFERENCE BETWEEN SPRAYS, MISTS, AND AEROSOLS

The layman often thinks of the terms "spray" and "aerosol" as synonymous. However, there is a real difference. An aerosol is defined as a suspension in the air of particles none of which have a diameter greater than 50 microns. A mist is not as finely atomized as an aerosol and has droplets of 50 to 100 microns in diameter. A fine spray has droplets of 100 to 400 microns in diameter. An insecticidal aerosol has particles with diameters ranging from 1 to 50 microns (1/25,400 to 50/25,400 inch) (13). However, in most aerosols produced under industrial conditions, a few of the particles, 1 to 2 percent, may have diameters in excess of 50 microns.

In a mist used in tobacco warehouses, such as is described in this paper, approximately 75 percent of the droplets range from 5 to 50 microns in diameter, and 25 percent are in excess of 50 microns. Therefore, the treatment is a mixture of a mist and an aerosol.

Because of the larger droplets in a mist, this form of application is especially well adapted to use in open-type warehouses or sheds, where air currents sweeping through such buildings would carry out an aerosol almost as fast as it was introduced (fig. 1). On the other hand, with an electric mist blower operated from the central aisle of the warehouse, a mist may be blown over the entire building, and reasonably good distribution obtained.

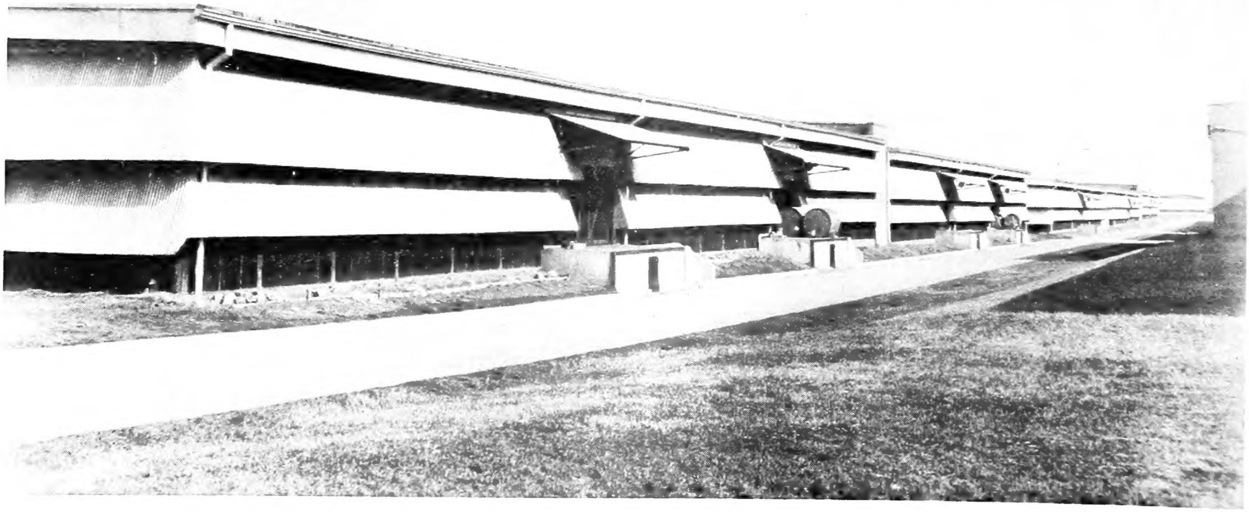

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Figure 1. --Open type of tobacco warehouses or "sheds."

BN-7618

Figure 2. --Semiclosed type of tobacco warehouse.

At one time, data seemed to indicate that the larger droplets of a mist were more effective than the smaller droplets of an aerosol against the cigarette beetle. This was later disproved, and it was shown that the smaller droplets were just as effective as the larger (table 1). Consequently, in closed buildings (fig. 2), where air currents do not dissipate the aerosols, they can be used to advantage. The finer droplets of an aerosol hang in the air for a much longer time and often facilitate better distribution. However, the heavier droplets of insecticide produced by a mist blower operated from the aisle within a warehouse may be blown against a light breeze to better advantage than an aerosol. For the foregoing reasons, mists can be used efficiently in open sheds (figs. 3 and 4), but aerosols cannot. Either mists or aerosols can be used in closed buildings, but, as a rule, better coverage can be obtained with an aerosol. However, there are limitations on the use of aerosols. Thermal aerosols are produced by heat, and in most of the commonly used generators the source of heat is a gasoline flame, burning in a combustion chamber. Because of the fire hazard involved, fire insurance underwriters have banned taking such machines into tobacco warehouses. Consequently, the aerosol is usually blown into a warehouse through an open door (fig. 5). Some machines for making mechanically produced aerosols do not have this disadvantage.

In large warehouses when the aerosol must be introduced through a door it is often difficult to get satisfactory distribution. The blast of aerosol from the generator can be delivered in only one direction, which is usually down the central aisle. The walls of hogsheads on either side of the aisle tend to channel the aerosol and interfere with its movement over and between the hogsheads. This distribution is further complicated by certain methods of storing tobacco. If the hogsheads are so racked that there is only a little free space between the tops of the hogsheads and the ceiling (fig. 6), distribution of an aerosol is handicapped. This may be complicated further by the large mains of a sprinkler system partially blocking the head space above the hogsheads. If such pipes are filled with cold water, the aerosol may condense on the pipes and drip on the hogsheads below. In at least one known instance, such a drip was enough to taint a small amount of tobacco in the top hogsheads.

Some tobacco companies have 2- or 3-story warehouses, and getting the aerosol into the upper stories of such buildings is a problem. This difficulty has been solved in part by the use of large, permanently installed pipes, such as are shown in figures 7 and 8.

OIL DILUENTS

Oil-based sprays are usually more effective than water-based emulsions. Moreover, tobacco is almost hygroscopic, and excess moisture favors the development of rots and molds. Because of this, the use of oil-based insecticides was deemed more practical in tobacco warehouses. In Great Britain, a heavy oil has been used as the solvent in pyrethrum sprays (2) with certain advantages. However, heavy oils leave an objectionable greasy deposit in tobacco warehouses. Consequently, in these studies a highly refined, very volatile hydrocarbon oil was used. Specifications for such oil are:

Specific gravity at 60° F.	0.77 - 0.80
Flash point (Tag closed cup) ° F.	140 minimum
Initial boiling point ° F.	160 - 170 preferable
Distillation end point ° F.	(370 minimum) (490 maximum)
Unsulfonated residue	97% minimum
Color	Water white
Odor	Neutral, no kerosene or naphtha odor, no residual odor.

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Figure 3. --Mobile power space sprayer especially designed for use in tobacco warehouses.

BN-7619

Figure 4. --Aerosol escaping from an open shed type of tobacco warehouse.

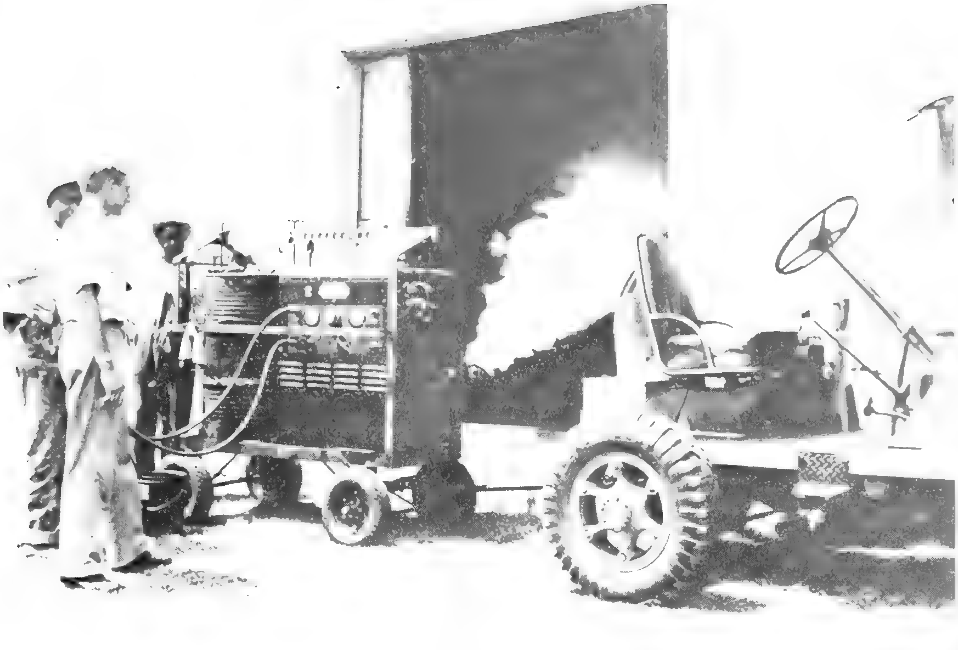

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Figure 5. --Thermal aerosol being introduced into a tobacco warehouse.

BN-7620

Figure 6. --Interior view of tobacco warehouse showing the lack of head room between hogsheads and ceiling.

Oils of this type have proved quite satisfactory (14). Some of the oils on the American market that meet these specifications are suitable for use in tobacco warehouses, whereas others are unsuitable, because they leave a greasy deposit. Many tobacco firms have had experience with a specific oil that they have found to be suitable. However, if a firm has had no experience with a specific oil, it is suggested that it make small-scale tests with the oil before using it in a tobacco warehouse.

SYNERGISTS

Because of the high price of pyrethrum, the use of synergists, or activators, as additives to insecticides has become widespread. Such materials are highly effective against many insects, especially house flies and mosquitoes. Many people cannot seem to understand why an insecticide may be highly effective against one insect and almost completely ineffective against another. Yet this is often true. They would not expect the same medicine to be equally effective against different disease organisms. However, in tests made of synergists for pyrethrum, none has been found sufficiently effective as a contact insecticide against the cigarette beetle to justify its use. Two of the most commonly used synergists, piperonyl butoxide and sulfoxide of isosafrole, have been widely tested. Both are slightly effective against the tobacco moth, but are of little advantage against the cigarette beetle (table 2). Neither one is objectionable in a spray formula for use in tobacco warehouses, but they should not be substituted for the pyrethrins content of the insecticide. For the cigarette beetle, it has been demonstrated repeatedly that the effectiveness of a pyrethrum spray is closely correlated with the amount of pyrethrum it contains.

CONCENTRATION AND DOSAGE

For maximum effectiveness, a contact insecticide is primarily dependent upon two factors--hitting the insects (1) with the spray particles and (2) with a lethal concentration of the insecticide. To obtain insecticidal contact with all the insects in the air space of the warehouse, it is obviously necessary to fill the air space with an insecticidal mist. The volume of liquid insecticide required to accomplish this is partly dependent upon the fineness of atomization--droplet size--and the method of dispersion. In open sheds, when a mobile mist blower can be moved up and down the central aisle to dispense an insecticide, a volume of 3 fluid ounces (approximately 100 ml. per 1,000 cubic feet of air space) has been found adequate to fill the air with mist. More than this volume of liquid was not needed and appreciably less failed to give satisfactory coverage. In closed buildings, when an aerosol is used, a volume of 2-1/4 fluid ounces (75 ml.) per 1,000 cubic feet of air space has been found sufficient to fill the building.

The killing power of a pyrethrum insecticide is primarily dependent upon its total pyrethrins content regardless of its dilution (pyrethrins are the active principle of pyrethrum). In other words, when the pyrethrins content is the same, a small amount of a concentrated spray may be as effective as a large amount of diluted insecticide. The mortality of the tobacco moth and of the cigarette beetle produced by a given volume and concentration of pyrethrum oil has been worked out under controlled conditions and is shown in figures 9 and 10. It will be noted that when plotted on logarithmic paper, the curves produced are straight lines. At a dosage of 100 ml. per 1,000 cubic feet, a concentration of 0.2 percent pyrethrins was required to give approximately 100 percent mortality of the tobacco moth (fig. 9). At the same dosage rate, 0.1 percent pyrethrins gave 95 percent mortality, 0.05 percent pyrethrins gave 90 percent, and 0.025 percent pyrethrins gave 75 percent. However, at a dosage rate of 200 ml. per 1,000 cubic feet, a concentration of 0.1 percent pyrethrins gave 99.5 percent mortality, and at a dosage rate of 50 ml. per 1,000 cubic feet, 0.2 percent pyrethrins gave 97 percent mortality of moths. It is essential, therefore, that an adequate concentration of insecticide be used to give high kills, and that an adequate volume of liquid be used to give satisfactory distribution.

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Figure 7. --Multistory tobacco warehouses with permanently installed pipes for the introduction of thermal aerosols.

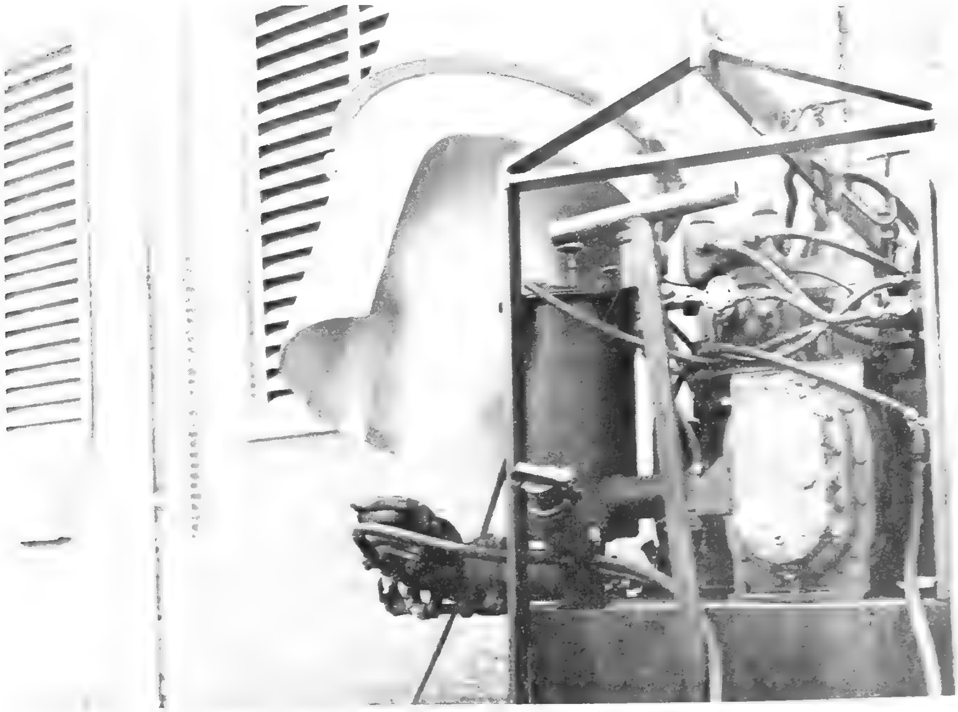

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Figure 8. --Introducing a thermal aerosol into the second story of a tobacco warehouse through a permanently installed pipe.

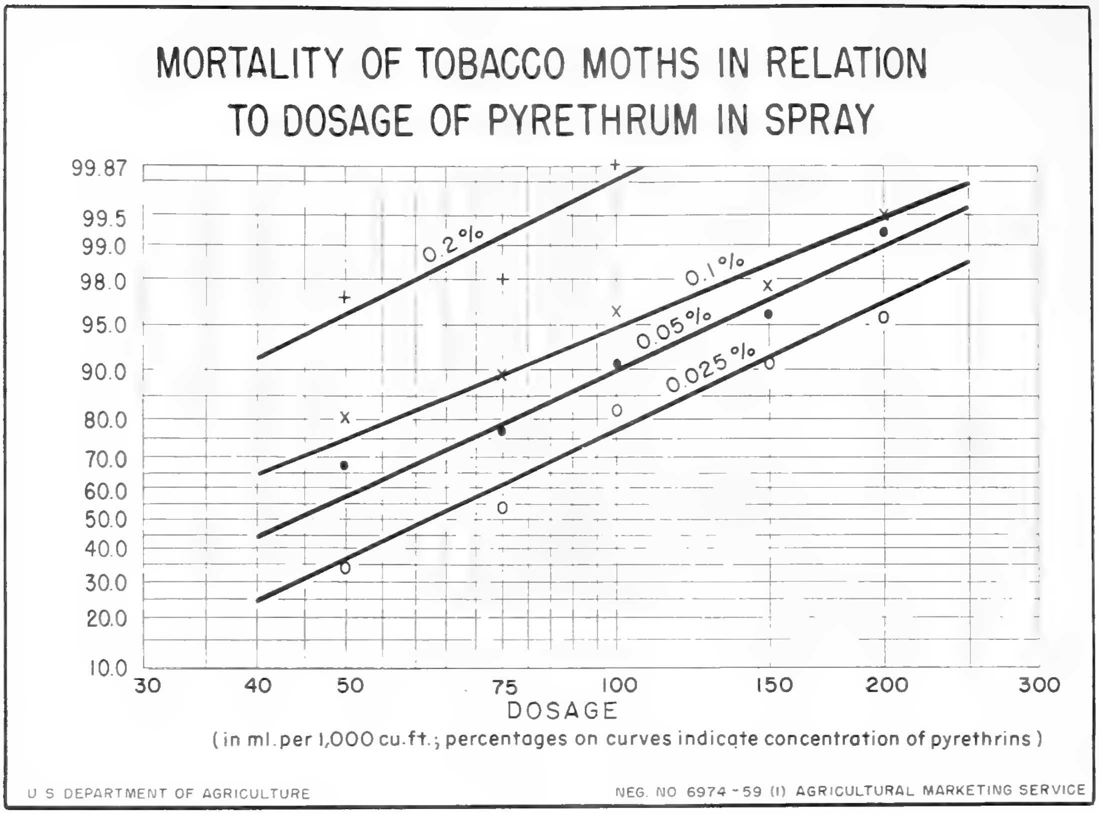

Figure 9.

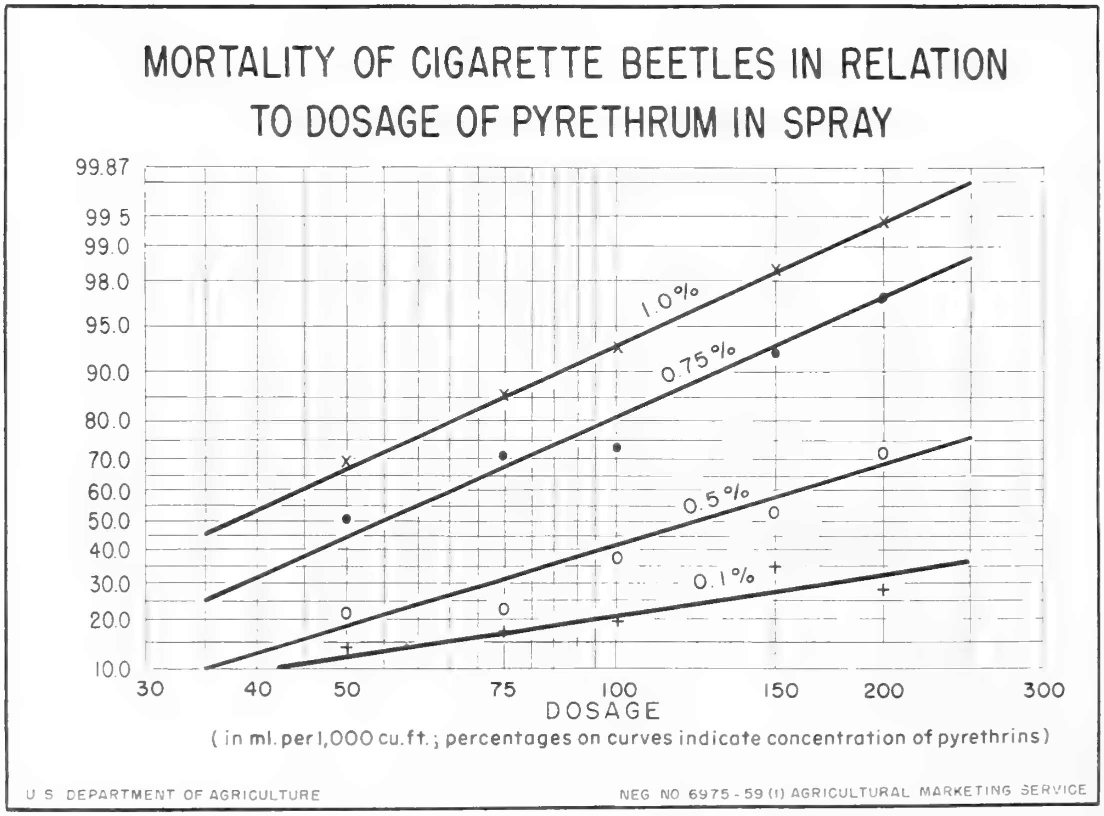

Figure 10.

As stated previously, the cigarette beetle is much more resistant to pyrethrum than is the moth. At a dosage rate of 100 ml. per 1,000 cubic feet, a concentration of 1.0 percent pyrethrins killed 93 percent of the cigarette beetles (fig. 10). At the same concentration, a dosage rate of 75 ml. per 1,000 cubic feet killed 86 percent, and 50 ml. killed 70 percent. A concentration of 0.75 percent pyrethrins at a dosage rate of 100 ml. per 1,000 cubic feet killed 80 percent; at 75 ml., 70 percent; and at 50 ml., 45 percent.

SUBLETHAL EFFECT OF PYRETHRUM ON CIGARETTE BEETLES

The effect of pyrethrum upon the cigarette beetle is not entirely limited to its killing power. There is an additional dividend from its use which is not readily apparent. It has been found that beetles exposed to a sublethal dosage of pyrethrum (beetles that were not killed and apparently recovered completely) deposited only half as many eggs as beetles not exposed to the insecticide (7). Thus, a space spray or aerosol that kills 93 percent of the beetles has a practical control value of approximately 96-97 percent, because the surviving beetles lay only half as many eggs as they would normally.

FREQUENCY OF APPLICATION

Two of the factors limiting the effectiveness of mists and aerosols are the accessibility of the insects to the insecticide and the rapidity with which eggs are deposited. The tobacco moth has to emerge from the tobacco in order to mate and lay eggs. Therefore, all of the moths become accessible to the spray. Furthermore, the moth does not deposit eggs as soon after emergence as does the cigarette beetle. Consequently, weekly applications of pyrethrum have been found to give excellent control of the moth. The progressive buildup of a tobacco moth population in a tobacco warehouse after one application of spray, as indicated by suction-light trap records, is shown in figure 11.

In contrast to the tobacco moth, the cigarette beetle does not have to emerge from the tobacco in order to mate, and an appreciable percentage of the beetles infesting tobacco will mate and continue to breed without ever coming out of the tobacco. This percentage increases with the intensity and age of the infestation. With tobacco in storage for 3 years or longer, the percentage of beetles not emerging may exceed 1/3 of the total population. However, the beetles that do emerge usually begin laying within 24 hours after emergence, and 66 percent of all eggs are deposited within 4 days after emergence. Because of these factors, control of the beetle by means of mists or aerosols is very difficult; in heavy infestations of old tobacco, it is impossible. Under such conditions even daily applications of aerosol 6 days a week have failed to give control. The best that can be anticipated from frequent applications is to reduce the potential beetle population increase, and retard the development of the infestation. No definite rule can be offered for the optimum frequency of application of sprays or aerosols for the cigarette beetle. For light infestations in tobacco stored for only a short time, once a week may be sufficient. In heavier, older infestations, the frequency may be increased to advantage. The number of applications will have to be determined in each instance on the basis of economics. If valuable tobacco becomes heavily infested, and no more efficient means of insect control is available, daily applications may be desirable. Usually, however, 2 to 3 applications a week are as many as can be economically justified.

TIME OF APPLICATION

Studies of the habits of the cigarette beetle have indicated that approximately 85 percent of the beetles are actively flying in a tobacco warehouse between 5 p. m. and midnight. Between 8 a. m. and 5 p. m. (the usual working day) less than 25 percent are active (10). For this reason, mists or aerosols applied between 5 p. m. and midnight give the best results.

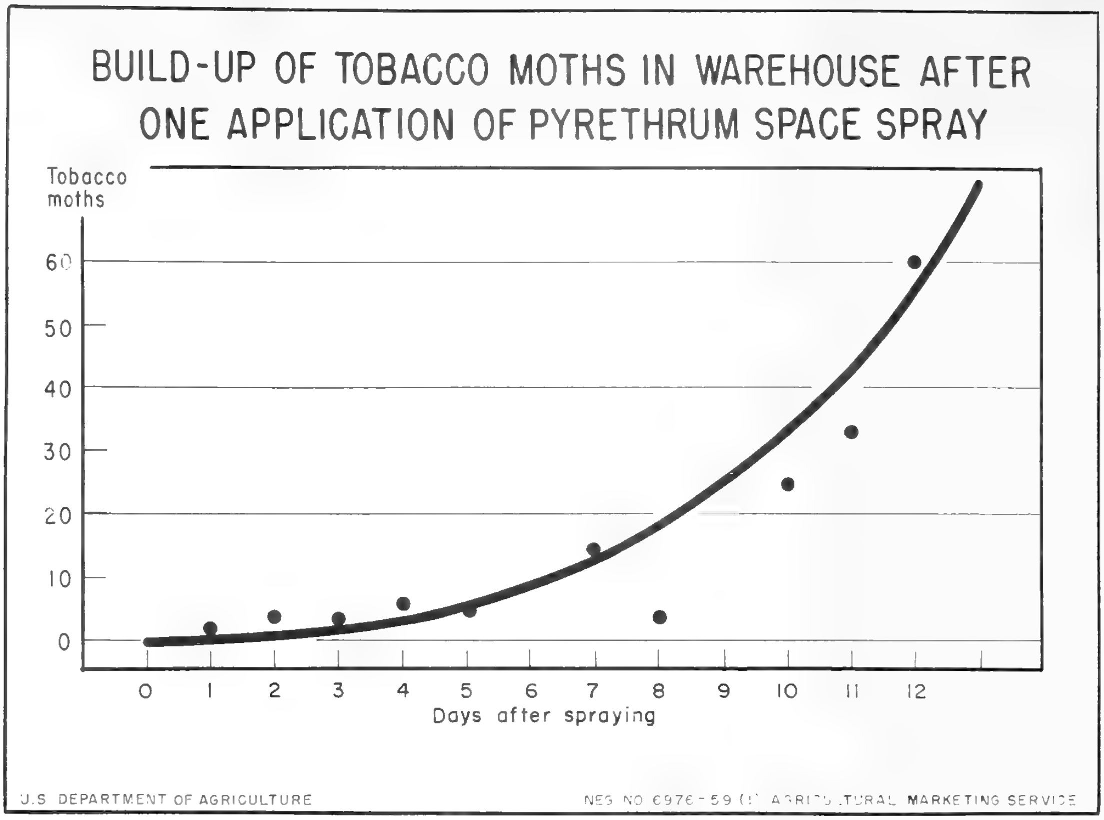

Figure 11.

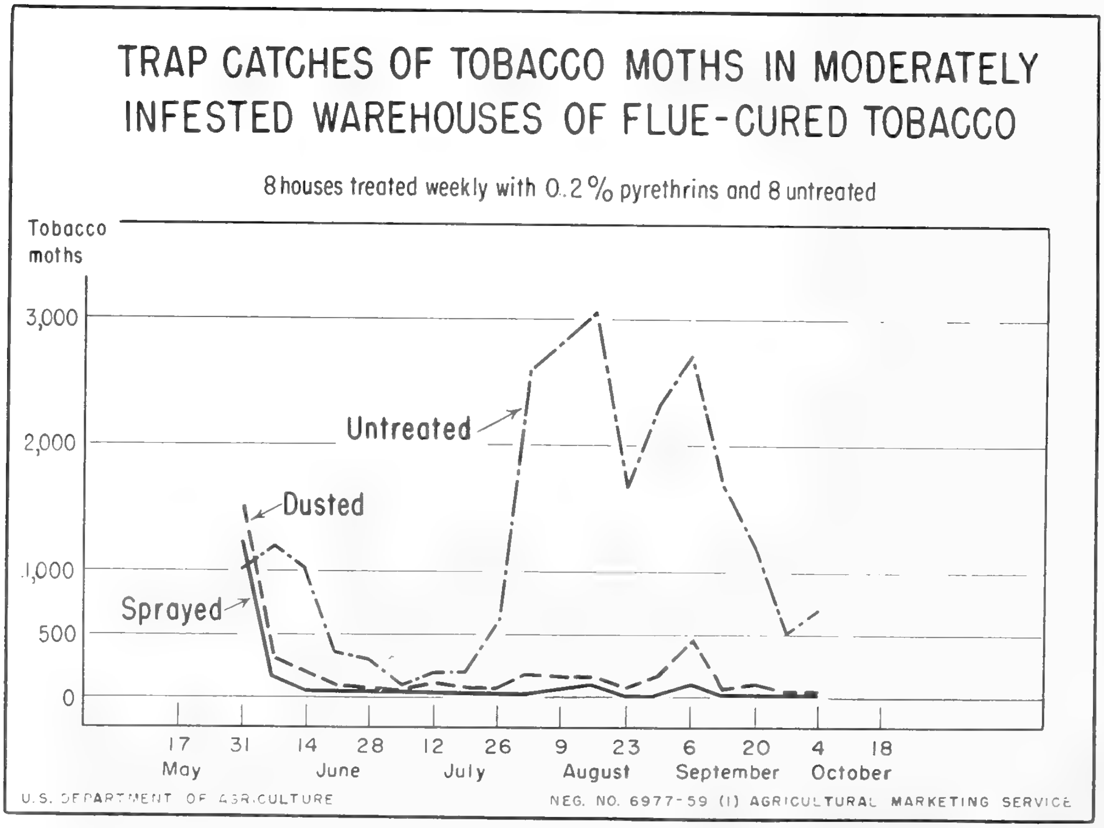

Figure 12.

TECHNIQUE OF APPLICATION

Most of the cigarette beetles flying in a tobacco warehouse are concentrated in the upper areas of the building. In a warehouse with a ceiling 15 to 16 feet high, approximately 3 percent of the beetles caught were taken in traps at the 1-foot level above the floor, 22 percent at the 6- to 7-foot level, and 75 percent at the 12-foot level. Therefore, when applying a contact insecticide to control this insect, it is important to concentrate on filling the air space above the hogsheads.

On the other hand, the tobacco moth is usually rather evenly distributed at all heights in the air space. If a large number of moths are present, therefore, it is desirable to pay more attention to the narrow areas between the rows of hogsheads. When applying a mist from the central aisle of a tobacco warehouse, remember that several seconds are required for the insecticide to travel the length of the hogshead rows. Move the machine slowly and pause opposite the narrow openings between the rows.

When introducing a thermal aerosol into a warehouse, direct the aerosol slightly upward along the aisle, and take care to see that enough insecticide is used to fill the entire air space to the back walls of the building.

EFFECTIVENESS OF PYRETHRUM MISTS AND AEROSOLS

Against the Tobacco Moth

Extensive experiments over 14 years have shown that weekly applications of 0.2 percent pyrethrins in an oil solution, applied as either a mist or an aerosol, will effectively control the tobacco moth. In fact, where used systematically, the treatment has eliminated the moth as an economic problem.

The effectiveness of weekly applications of a mist containing 0.2 percent pyrethrins applied at a rate of 100 ml. per 1,000 cu. ft. and of a dust containing 0.8 percent pyrethrins applied at a rate of 3 oz. per 1,000 cu. ft. is compared in figure 12. Within 2 weeks after the start of spraying, the weekly trap catch of tobacco moths dropped below the arbitrary danger line of 50 moths a week, and remained below that line the entire summer, except for 3 weeks when it rose slightly above it. Dusting also gave reasonable control of the moth, although not as good as the mist.

The relative effectiveness of weekly applications of pyrethrum mist and of 2 warehouse fumigations with HCN against the tobacco moth is shown in figure 13. The spraying was much more effective against the moth than the 2 fumigations.

In other tests with thermal aerosols, moths were almost exterminated in the test warehouses, and not enough moths could be found to record.

Against the Cigarette Beetle

Control of the cigarette beetle with mists and aerosols has not been too satisfactory. As can be seen in figure 14, in moderately infested warehouses, a weekly application of pyrethrum mist was approximately as effective as 2 fumigations with HCN. However, neither fumigation nor sprays gave satisfactory control. Figure 15 shows that in heavily infested warehouses, weekly applications of pyrethrum mist were not as effective as 3 fumigations with HCN.

In many tests, treatments with a thermal aerosol have been less effective than treatments with a mist. However, this has not been due to the form of application itself. As shown in table 3, in a series of replicated tests in large warehouses, an aerosol containing 1 percent pyrethrins gave an average mortality of caged cigarette beetles of

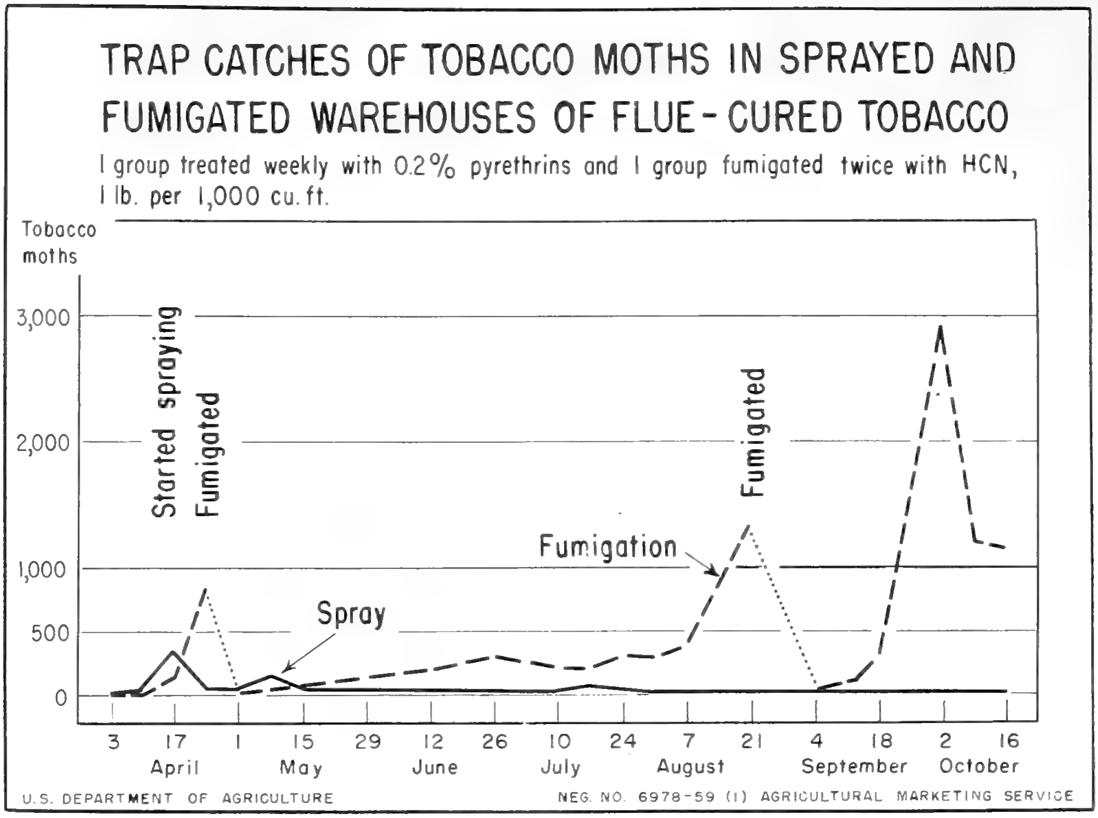

Figure 15.

only 56 to 60 percent. Yet, at certain locations in the warehouses where heavy concentrations of aerosol were obtained, the average mortality was up to 98 percent. In almost every test, complete mortality was obtained at one or more locations. Evidently, therefore, low effectiveness could not be attributed to lack of killing power, and it seemed to be due to inadequate distribution. This was corroborated by the results shown in figure 16. The deposit of aerosol on coated, glass microscope slides was closely correlated with mortality of cigarette beetles in that area of the warehouse.

In smaller warehouses of Turkish tobacco where better distribution of aerosol was obtained, the mortality of test beetles was also higher. Table 4 gives the results obtained in such warehouses with 3 insecticide formulations, all containing 0.75 percent pyrethrins, and 2 containing the synergist piperonyl butoxide. The average mortality of insects in all the tests ranged from 84 to 100 percent and the averages for the 3 treatments were 92, 96, and 97 percent, respectively. Kill of beetles approached perfection in all tests, and there was no significant difference in effectiveness between the 3 formulations. Yet, in spite of the high mortality obtained in this experiment, control of the cigarette beetle was not satisfactory (table 5). Weekly applications were started the second week in May, as soon as the beetles became active, and continued for approximately 5 months until the cool weather began. The beetle infestation was not homogeneous in the 5 warehouses, but in each building, as many or more beetles were present late in the season as were found early in the season. The infestation was not reduced by the treatment.

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UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D.C. September 1959

In Marketing Research Report 334, "Pyrethrum Mists and Aerosols for Control of Insects in Tobacco Warehouses," the following page should be substituted for page 15 as it appears in the publication:

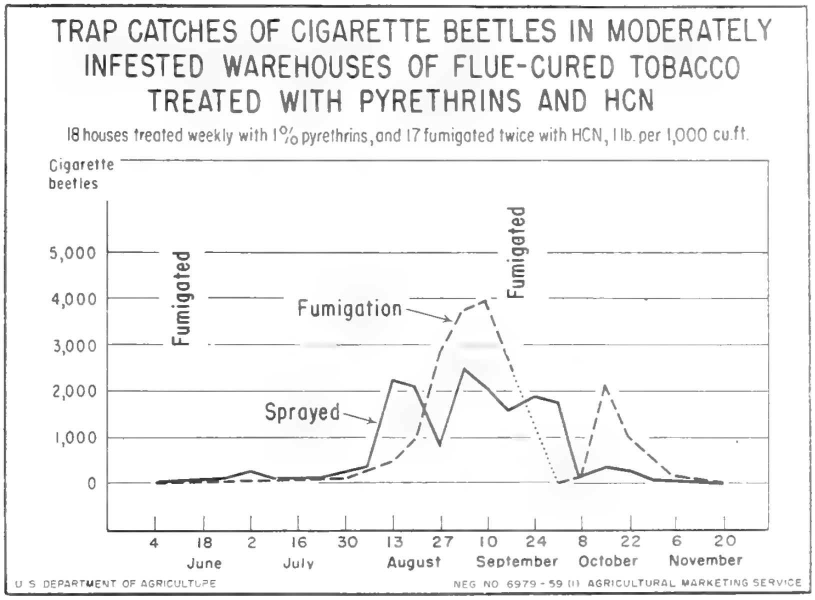

Figure 14

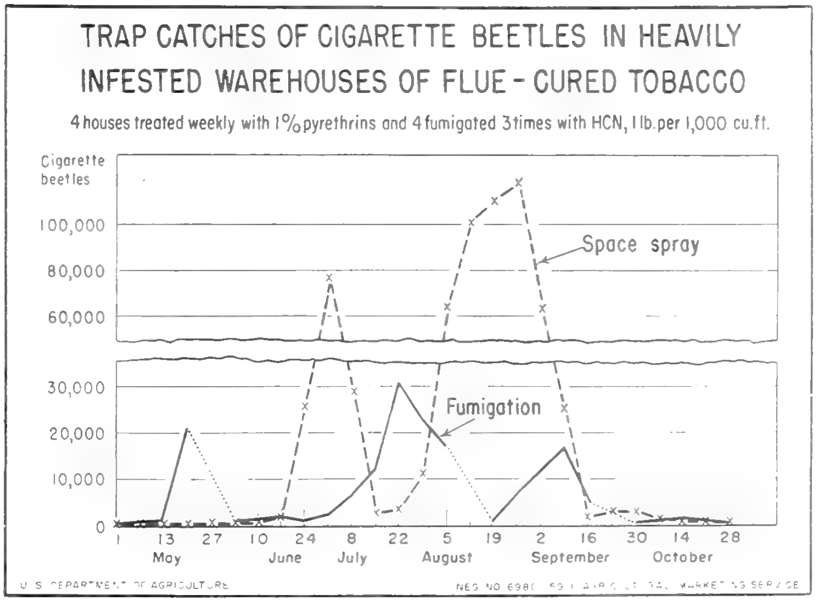

Figure 15.

(Note: In fig. 12, page 12, the subheading now reads: "8 houses treated weekly with 0.2% pyrethrins and 8 untreated." It should read: "8 houses treated weekly with spray containing 0.2% pyrethrins, 8 dusted with powder containing 0.8% pyrethrins, and 8 untreated."

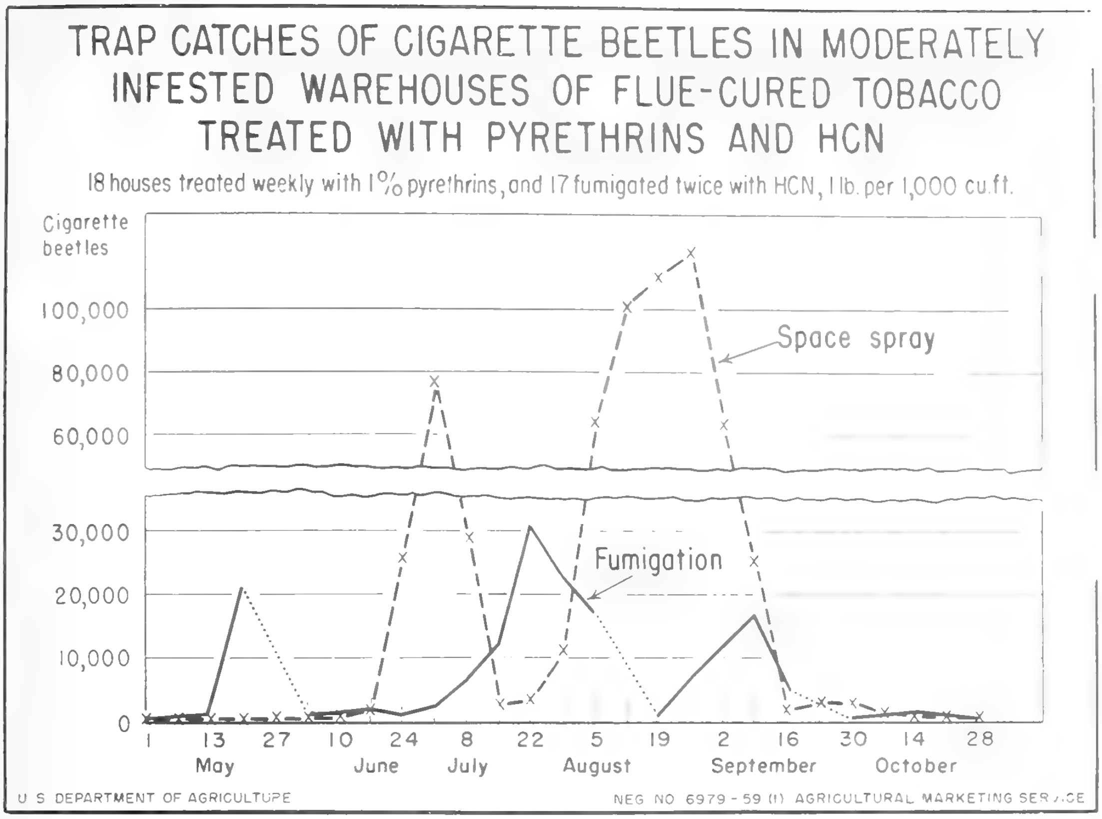

Figure 14

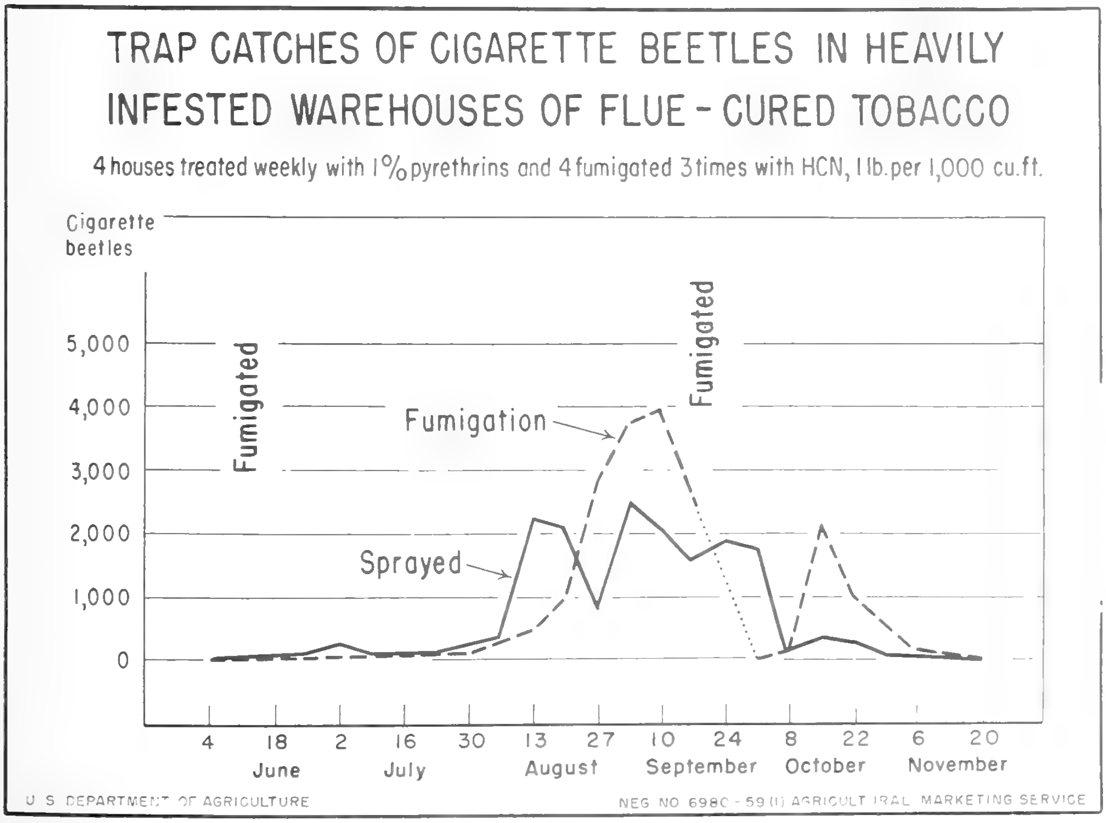

Figure 15.

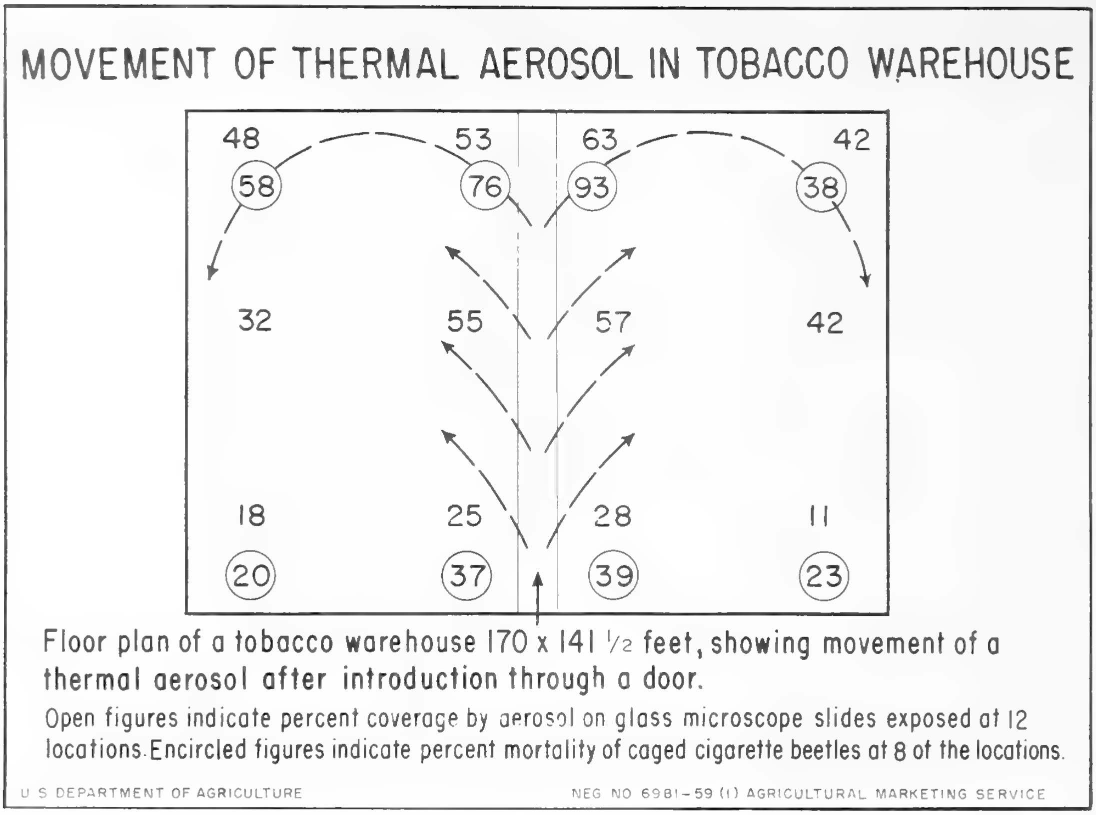

Figure 16.

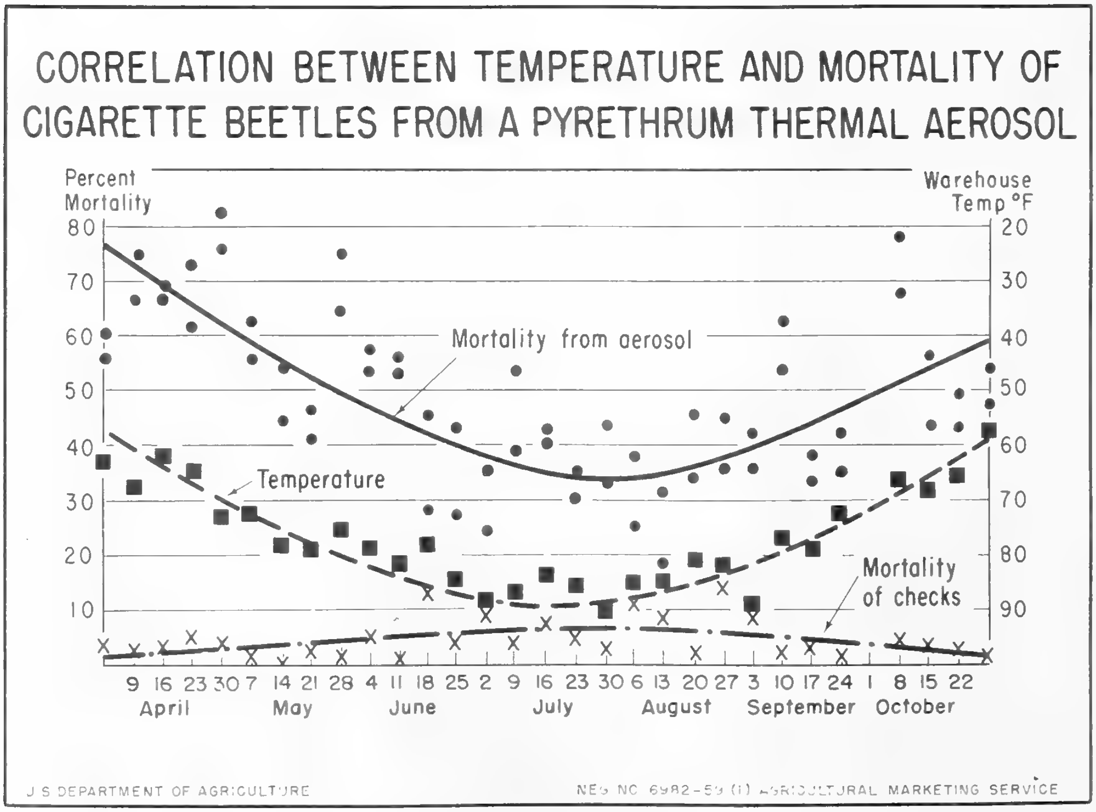

Figure 17.

EFFECT OF TEMPERATURE

There is some evidence that the relative effectiveness of a pyrethrum thermal aerosol decreases with higher midsummer temperatures. In one large-scale experiment covering a summer season of 7 months, such a correlation was demonstrated. In figure 17, the relation between mortality of caged test insects and temperature is clearly shown. In this experiment, the mortality of the checks (untreated insects) actually increased with higher temperatures, while the mortality of test insects decreased.

Under some conditions, the very high temperatures produced in the combustion chamber of a thermal aerosol machine may cause a slight breakdown of the pyrethrum. Some indication of this has been observed, but although considerable effort was expended attempting to prove or disprove this, the results were inconclusive.

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TABLE 1.--Effect of droplet size in a mechanically produced oil-based pyrethrum aerosol on mortality of the cigarette beetle

Mass median diameter of droplets	Droplets with diameters less than--					Maximum diameter of droplets	Mortality of uncaged beetles
	10 Microns	20 Microns	30 Microns	40 Microns	50 Microns		
Microns	Percent	Percent	Percent	Percent	Percent	Microns	Percent
5	-	-	-	-	-	-	92
15	25	75	85	98	-	50	100
20	8	45	64	80	90	100	89
35	1	20	40	65	75	150	100
Controls (untreated)							5

TABLE 2.--Mortality of tobacco moths and cigarette beetles exposed to pyrethrum aerosols in replicated laboratory tests

Treatment	Concentration of insecticides			Mortality	
	Pyrethrins	Piperonyl butoxide	Sulfoxide	Tobacco moths	Cigarette beetles
	Percent	Percent	Percent	Percent	Percent
Pyrethrum in oil..........	0.025			86	28
	.05			85	19
	.1			96	20
	.2			100	42
	.4			100	38
	.5			100	36
	.75			100	75
	1.0			100	93
Controls (untreated)...				9	4
Pyrethrum-piperonyl butoxide in oil.........	.0314	0.314		100	18
	.063	.63		100	12
	.125	1.25		100	22
	.418	4.18		100	30
	.627	6.27		100	74
	.89	8.9		100	84
Controls (untreated)...				8	2
Pyrethrum-sulfoxide of isosafrole in oil.......	.0388		0.3113	89	27
	.0775		.6225	94	42
	.155		1.245	99	43
	.31		2.49	98	45
	.62		4.98	100	61
Controls (untreated)...				11	10

TABLE 3.--Mortality of caged cigarette beetles in tobacco warehouses treated with a pyrethrum thermal aerosol containing 1 percent pyrethrins

Dosage per 1,000 cu. ft.	Replica-tions	Mortality at 8 locations in warehouse								Average mortality
		1	2	3	4	5	6	7	8	
Ml.	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
100	12	46	37.5	36	18	98	84	95	59	60
75	12	49	21	55	29	87	63	94	48	56

TABLE 4.--Mortality of caged cigarette beetles in small warehouses of Turkish tobacco treated with a pyrethrum aerosol at a dosage of 100 ml. per 1,000 cubic feet of air space

Treatment and warehouse number	Replications	Mortality at 6 locations in warehouse						Average mortality in warehouse
		1	2	3	4	5	6	
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Pyrethrins 0.75% in oil (w/v).								
8-A	1	100	96	100	100	100	100	99
	2	100	84	76	84	80	80	84
Pyrethrins 0.75% + pip. butoxide in oil (w/v).								
7-A	1	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	100
7	3	64	96	100	48	96	100	84
	4	100	100	100	92	100	100	99
Pyrethrins 0.75% + piper-onyl in oil and tetra-chloroethylene (w/v).								
6-A	1	100	100	100	92	100	100	99
	2	100	100	100	100	96	100	99
	3	100	100	100	84	100	100	97
Pyrethrins 0.75% + piper-onyl in oil and tetra-chloroethylene (w/v).								
6	4	100	100	100	92	100	100	99
	5	100	96	100	100	100	100	99
	6	100	100	100	44	100	100	91
Controls								2

TABLE 5.--Weekly trap catches of cigarette beetles in 5 warehouses of Turkish tobacco treated weekly with pyrethrum aerosols containing 0.75 percent of pyrethrins

Week ending	Beetles trapped				
	Pyrethrum in oil	Pyrethrum-piperonyl butoxide in oil		Pyrethrum-piperonyl butoxide-tetrachloroethylene in oil	
	Warehouse 8-A	Warehouse 7	Warehouse 7-A	Warehouse 6	Warehouse 6-A
	Number	Number	Number	Number	Number
May 9	30	25	1	0	0
16	0	0	0	0	0
23	13	8	12	15	20
31	46	110	39	27	20
June 6	72	113	76	66	18
13	148	126	108	140	31
20	650	800	675	1,450	300
27	175	200	225	850	275
July 11[1]	50	8	21	23	13
18	24	18	36	42	54
25	37	51	47	28	68
Aug. 8[2]	1,500	625	6,500	650	1,000
15	3,400	700	2,000	675	500
22	2,000	55	3,330	330	350
29	1,050	300	2,000	200	325
Sept. 6	1,300	150	1,000	63	100
12	2,700	110	95	29	150
19	1,100	725	150	14	1,400
26	1,300	1,300	18	330	1,300
Oct. 3	333	29	16	58	39
Total	15,928	5,453	16,349	4,990	5,963

[1] Count over 2-week period.
[2] Count not available for first week in August.

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