46th Report, 1946

CONNECTICUT STATE ENTOMOLOGIST

Bulletin 512 November, 1946

R. B. FRIEND, Ph.D.
State Entomologist

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, CONNECTICUT

To the Director and Board of Control
Connecticut Agricultural Experiment Station:

I have the honor to transmit, herewith, the forty-sixth report of the State Entomologist for the year ending October 31, 1946.

Respectfully submitted,

ROGER B. FRIEND,

State and Station Entomologist

CONTENTS

CONTENTS

CONTENTS

CONNECTICUT STATE ENTOMOLOGIST

FORTY-SIXTH REPORT

1946

R. B. Friend

The activities of the Department of Entomology are devoted fundamentally to the development of methods for the protection of plants, structures, food and other material wealth from the deleterious activities of insect pests and, to a certain extent, for aiding the activities of such beneficial insects as honeybees and parasites of pests. Although the principal aim is the control of those pests which affect agriculture, many species which affect the welfare of Connecticut citizens in other ways merit our attention.

Protection must, of course, have in view the effect of such pests over long periods of time and must also result in some economic gain, using this term in a broad sense. In agriculture and forestry, this would mean an increase in yield or at least the maintenance of a high yield, together with an increase in or the maintenance of quality. In the care of crops the nutritive value of the crop and such qualities as flavor and appearance are very important. Even the form and size of the plant products may be significant, not only from the viewpoint of appearance, but also from the viewpoint of waste reduction in preparation for use. In forests it is the production and quality of wood that is significant, for even though our forests are used for recreational purposes, fundamentally it is the production of timber that counts. With such ornamental plants as shade trees, shrubs and garden flowers, it is the appearance of the plant that is important. Any deleterious agent which affects form or function of the roots, stem, branches, buds, flowers and seeds should be guarded against. All this means much in control operations, for the degree of protection attained must be related to the utilization of the product being raised and protected.

During recent years the interest in chemical agents of control, that is, so-called insecticides, has increased greatly, probably due to the development of DDT as much as any one factor. Insecticides are easily and rapidly applied and give quick results. The techniques for their application have developed over a period of years, so that those persons interested have become expert in the utilization of these agents and have attained excellent results therefrom.

In the development of insecticides, which are essentially toxic chemicals, there are many factors involved aside from mere toxicity, and by no means can all chemicals which are toxic to insects or other pests be utilized for protective purposes. Moreover, any chemical agent to be toxic to any insect pest must penetrate into the body cavity by some means or other. Chemicals vary greatly in the concentration which is toxic, and some of them are useless for the simple reason that too high a concentration is necessary for their effective action.

When we come to the use of these chemicals in the field, many problems arise. The proper formulation must be determined, that is, should the insecticide be applied as a solution, a suspension, an emulsion, or in the dry form as a dust? Must there be added to it any materials which will increase its adhesiveness, decrease its surface tension so that it spreads more rapidly, act as a synergist, or have any other quality to increase its utility? The amount to use per area involved is also very important, and we have such factors as the covering of the substratum with the poison, be that substratum either an insect's body or its food or any other material with which the insect may come into contact. Utilization also brings up the problem of the ingredients of mixtures in relation to the effect on their individual toxicity to pests and their injuriousness to plants, etc., for it is frequently necessary to apply a mixture of chemicals each of which has a specific purpose. An insecticide may be toxic, not only to the pest to be controlled, but to the plants upon which that pest may be living, other animals found in the same environment, and man himself. We have sound evidence that the use of certain chemicals to kill one pest results in an increase in the injuriousness of another, presumably because of their action on the natural enemies of the latter.

In the practical use of such materials, efficiency in application is always a significant item, and the apparatus which can be employed economically may be very important. The recent development of airplane sprayers and mist blowers for dispensing concentrated liquid mixtures has markedly increased the practicability of controlling certain pests.

In the initial development of new materials, the cost has a minor place. The objective is to find the toxicity and the possibilities of utilization and allow the price factor to be the last one involved in rejecting or accepting the chemical compound.

Although our knowledge of the action of chemical compounds on pests has increased more in the last 10 years than during any similar preceding period, we cannot use these compounds without a detailed knowledge of the habits, life cycle and ecology of the pest involved. Such factors as manner of feeding, location, reaction to the environment, reproductive potential, length of different stages in the life cycle, injuriousness, etc., are vital to the success of any spraying or dusting operation.

There are thus several factors, other than insecticide application, involved in pest control which are important, and these factors, even if they alone do not operate to attain economic control, may be necessary to the attainment of such control by the use of insecticides. The insect pest problem is a problem of insect populations, and it is the absolute number of pests in the field which is important. In the cases of intense degrees of infestation, where extreme populations occur, an enormous amount of effort and material must be expended to reduce significantly these injurious populations, and sometimes our insecticides fail simply by virtue of the excessive number of insect pests present. Any operation other than the application of chemicals which will keep such injurious populations down to the level where insecticides can handle them is of value. The development of resistant corn varieties, such as is now being carried out in an effort to reduce injuries by the European corn borer, the planting of beans, corn and summer squash at such a date that serious infestations of the Mexican bean beetle, European corn borer and squash vine borer are avoided, the fertilization of peach orchards, where the production of new growth on the tips of the branches is distinctly correlated with an increase in the Oriental fruit moth infestation, the removal of prematurely dropped fruit, harboring insect pests, from beneath the trees, and proper sanitation methods in and around the apple packing shed to reduce the codling moth infestation are all cases in point.

Another very important factor in pest control is the role of natural enemies. The utilization of the parasites and predators of insect pests has been carried out for a number of years in this country. Where a pest is not heavily parasitized, efforts have been made in a number of cases to introduce parasites into the area involved, as has been done in this State in the case of the European corn borer, Oriental fruit moth, gypsy moth, Japanese beetle, etc. In some cases the natural enemies have been colonized in a number of localities and then left to increase and spread by their own power. In other cases they have been propagated in the laboratory and continuously released in the field in order to assure the maintenance of an effective population.

WORK OF THE DEPARTMENT

Research

In this field of so-called biological control, we have been particularly interested for several years in the Japanese beetle, Comstock's mealybug and the Oriental fruit moth. In cooperation with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, there have been introduced into Connecticut several parasites of the Japanese beetle and a bacterium which causes an infection known as the "milky" disease of larvae. These have become established in the State and are effecting a certain degree of control over the pest (page 49).

There was generally throughout the State an increase in the intensity of Oriental fruit moth injury to twigs and fruit in peach orchards in 1946. The parasite (Macrocentrus) population carry-over into 1946, depleted by a lack of sufficient host populations in the preceding years, was very low (page 89). No foreign parasites previously released had been recovered in 1945 nor were any recovered in 1946. The second generation of moths was much more abundant than the first generation in many orchards, and the third generation showed a still further increase except where DDT was used. Favorable results following the use of this insecticide were recorded in the majority of cases (pages 89 to 91). It appears that when a wet spring necessitates frequently repeated applications of sulfur to control brown rot the parasitism is low, since sulfur acts as a repellent and reduces parasite activity in spite of any heavy inoculations which may be made.

We have attempted for some time to obtain an effective control of Comstock's mealybug, a pest of apples and pears in this State, by using parasites. Accompanying a decline of the mealybug population in 1945-46 there was a decline in parasitism. The significance of this is not quite clear. Mealybug infestations in general were very low in the fall of 1946.

Further experiments with reduced spray schedules on apples, for the purpose of improving scab control on McIntosh and codling moth control on this and other varieties, were carried out (pages 71 to 75). In spite of the fact that 1946 was a bad scab year, apples were produced with as little scab as developed under the full spray schedule. The fungicide tetra-methyl thiuram disulfide (Tersan) was used in a series of tests at Mount Carmel and Westwoods. Other schedules included "Puratized" and "Fermate" supplements applied between the reduced program applications. The use of proper adhesives is important in reduced spray schedules, and an intensive research program is being carried out in this field.

Several experiments were conducted to try to find the solution of the mite control problem in apple orchards where DDT-sulfur-lead arsenate sprays are used (pages 76 to 78). Work in this field is being pushed by laboratory experiments during the winter. There are a number of chemicals available which may ultimately provide an answer.

A test designed to compare a non-arsenical with a full arsenical spray program was conducted at Mount Carmel (page 87). For early season sprays benzene hexachloride containing 10 per cent gamma isomer was substituted for lead arsenate, and for the later applications DDT with "DN-111" added was utilized to control late feeders. All in all, the experiment was so promising that we plan to repeat it on a larger scale at the first opportunity.

Treatment schedules using a mist blower were employed in the Burton orchard on apple trees (page 71). Here we attempted to deposit the same amount of insecticide on the trees using one-half gallon per tree as compared to 15-20 gallons commonly employed with the conventional high pressure rigs. In this orchard, at least, it was demonstrated that insect and disease control can be obtained with this type of outfit—much better than was thought possible. With improvement in the mechanics of application, the method should afford a considerable reduction in cost of application. In this work we used a converted duster provided with a small pump and water tank for

Figure 1. Small mist blower mounted on wheel barrow treating an orchard tree.

the spray mixture. The nozzle, an oil furnace type, was inverted in the end of the air delivery tube.

The factors affecting the toxicity of residues of DDT suspension in water have been studied. The particle size of the DDT was found to be very important. Results of laboratory tests were confirmed in the control of flea beetles and leafhoppers on potatoes in the field (page 93). Ingredients other than DDT affect the toxicity of suspensions (page 94). Addition of wetting agents decreased the deposit and reduced toxicity both in the laboratory and in the field. A preliminary study of the effect of tenacity of the diluent on toxicity indicated that the diluent weathered independently of the DDT, but the results were not definite enough to establish the relationship beyond question. In addition to these factors, diluents have a further, as yet undetermined, effect on toxicity. When all known factors are balanced, there is still a difference in toxicity of mixtures prepared with different diluents.

Test of the efficiency of residues of DDT on certain surfaces, using house flies, indicated that kerosene solution left a more effective residue on painted wood than on wire screen, and the same solution left a better residue on unpainted wood than on glass. All three types of formulation, that is, emulsion, solution, and suspension, left deposits which deteriorated on storage. This deterioration took place whether or not the glass slides were exposed to house flies. In the case of solutions, the kind of solvent used has a marked effect on the toxicity of DDT. The amount of DDT deposited was affected by the vehicle used. Water deposited most, a chlorinated solvent (Velsicol AR 50) next and kerosene the smallest amount of DDT. The toxicity of residues from the three vehicles was the greatest in the case of water, next with kerosone and lowest with the solvent. Addition of a wetting agent to DDT spray powder reduced the deposit but apparently did not affect toxicity of the deposit (page 93).

A test for synergism between DDT and nicotine bentonite dusts used to control the European corn borer was made in cooperation with the Eastern Regional Research Laboratory of the United States Department of Agriculture. There were evidences of synergism between mixtures of one part DDT and three parts nicotine-bentonite, but the degree of synergism was too small to be of any practical importance.

The study of the relationship between chemical constitution and toxicity of nicotine compounds to insects has been continued in cooperation with the Eastern Regional Research Laboratory (page 98). Continued work on injection of these same chemicals indicates that the principal reason for the low toxicity of the complex nicotine compounds was the failure to penetrate the insect cuticle.

Work on the codling moth problem in 1946 (page 83) was directed largely toward observations on the effects of the intensified control program, special attention being given to orchards that have been studied for several years. Studies on the biology of the codling moth were limited by shortage of stock of the insect. Data on moth emergence from over-wintered stock and on moth flights from bait pail catches were secured for information on seasonal life history in relation to weather, and for immediate practical use in timing the spray program.

Work on the European apple sawfly (page 79) in the first part of the period in 1946 was taken up largely with attempts to locate an infestation suitable for experimental spraying, but without success, as the orchards chiefly counted on for the purpose were only lightly infested in 1946. In view of the potentialities of this insect as a serious orchard pest, it seemed important to get some definite information on control measures at the first opportunity. Records of emergence of adults were made from over-wintered stock in ground cages, and some pilot spray experiments were made with the adults obtained.

It appears from the results of the experiments carried on in this State as well as elsewhere in the United States, that DDT is an excellent insecticide for the control of Japanese beetle larvae in grassland (page 49). Against the adult beetles DDT in a kerosene solution applied at the rate of 1 3/5 pounds of actual DDT per acre effectively protected vegetation for a period of three weeks, after which the adults returned to the area in small numbers.

A comparison of DDT in the form of water suspension and emulsion showed that water suspensions were much more effective in controlling potato flea beetles than emulsions (page 60). For leafhoppers, suspensions were somewhat more effective than emulsions.

The insecticide dichloro-diphenyl dichloroethane was less effective than the trichloroethane (DDT) for potato foliage pests. Benzene hexachloride was also less effective than DDT.

Field-scale tests of insecticides for control of pests of potatoes were carried out in cooperation with the Department of Plant Pathology and Botany on five farms in Hartford and Tolland counties (page 60). On one of these farms the principal comparisons were between fungicides with the DDT at a standard amount of two pounds of 50 per cent wettable powder in 100 gallons of water. On three farms there were comparisons involving insecticides.

The effect of wetting agents was measured by spraying potatoes in a similar manner (page 67). The wetting agent used reduced insect control sharply and affected the yield as well.

The outstanding feature of the 1946 field studies for the control of wireworms affecting potatoes was the high efficiency of benzene hexachloride, especially when employed as a soil insecticide and to a lesser degree when used as a seedpiece treatment or when incorporated in a poison bait (page 56). From the standpoint of wireworm control, the material is effective and can be applied easily and practically but, from the standpoint of the taste imparted to tubers grown in treated soils under most conditions, further study is imperative. The most satisfactory method for using the material may require some form of rotation in which potatoes are not planted until the year following treatment. This may not hold for tobacco, although the work on tobacco was very limited this year.

We have been interested for some time in the effect of insects on forest trees, particularly those species causing abnormal growths or galls. The galls on Norway spruce caused by the spruce gall aphid are particularly adapted for this study. The morphology of the dormant bud and developing shoot of Norway spruce was studied; and the derivation of certain tissues from their precursors has been established. Extracts of fundatrix salivary glands, injected into normal buds of spruce in the spring just at the time of swelling, caused the initiation of gall formation. Although the stimulus which causes gall formation was shown to originate in the salivary glands, it is not believed that the enzymes isolated constitute the chief causative agency. The results of this investigation will be published as a Station bulletin.

American foul brood, a serious disease of honey bees, constitutes one of the major hazards in the beekeeping industry in the State (page 51). In 1945 it was reported that feeding sugar syrup containing 0.5 gram of sulfathiazole per gallon gave excellent control of this disease. The study of the hives treated in 1945 was continued in 1946, to observe whether or not the disease would reappear. Penicillin, sodium sulfathiazole, sulfapyridine, sulfaguanidine and furacin in sugar syrup solutions were tested as medications in a manner similar to that employed in the use of sulfathiazole. X-ray treatment (deep therapy) of badly infected frames was not effective in controlling the disease.

Unless great care is exercised, honey bees may be seriously poisoned when plants are sprayed for the control of insect pests. In view of the fact that bees are necessary for the pollination of many blossoms, anything which is deleterious to them is of importance to agriculture in this State. Preliminary tests with possible repellents were carried out during the past year. Of a number of materials tried isoquinoline, "2-way Repellent", cresol, meta cresol, azoxybenzene, n-Butyl di-malate and N, n-Amylsuccinimide gave some promise. Some of the organic solvents, volatile in nature, were repellent to some degree and this caused some difficulty in formulations.

During the past two years we have been very much interested in the development of mist blowers in cooperation with the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. These machines apply concentrated insecticides in small quantities in the form of a mist very effectively, and suspensions, emulsions and solutions of the materials may be used. The principle involved is the discharge of a finely atomized mist by an air current developed by a powerful fan. The recent development of very toxic insecticides such as DDT which can be applied in concentrated form in small quantities has been an important factor in developing this type of apparatus. It is possible to discharge a mist 100 feet or more in the air vertically and up to 400 feet horizontally. This apparatus promises to be very useful in controlling a number of species of insects affecting forest, ornamental, and orchard trees. Using a solution of DDT, we obtained control of feeding caterpillars on trees by using as little as one pint of the solution on trees 75 feet to 100 feet high. In addition to its use in controlling many pests of plants, the machine has a great field of usefulness in freeing areas of flies and mosquitoes very cheaply and very rapidly. One of the great savings provided by this machine is due to the small quantity of insecticide employed. At the present time this type of machine is in commercial production and several firms in the United States are manufacturing various models.

We have been interested in developing a smaller type blower which has, we believe, great usefulness in treating plants up to 35 feet in height. This apparatus weighs only 85 pounds and can be mounted on either a wheelbarrow or a platform. It is easily transported, uses efficiently suspensions, emulsions and solutions of insecticides in the concentrated form, and is easy to handle. It is not suitable for the treatment of large trees due to limits in vertical distribution of the mist. At least one commercial concern has gone into the manufacture of this apparatus.

Prevalence of Certain Pests

Among the many pests which affect Connecticut agriculture, the European corn borer has long attracted a great deal of attention. The Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture has conducted an annual survey of corn borer abundance in Connecticut for many years and this Department has cooperated in this survey.

According to E. W. Beck (Insect Pest Survey, Special Supplement 1947, No. 4, dated March 4, 1947), a decrease in abundance occurred in Connecticut in 1946 and in no county was there an infestation of over 50 larvae per 100 plants. This decline was general throughout New England, although not to the same extent in all states. A significant decline in borer abundance occurred in Maine, Massachusetts and New York, and an insignificant decline in borer abundance occurred in New Hampshire, Rhode Island and Vermont. In certain other parts of the United States an increase in borer abundance took place during the year. The areas involved included three counties in North Carolina and the states of Iowa and Minnesota. The number of borers per 100 plants in eight counties in Connecticut in 1945 and 1946 is given below:

	1945	1946
Fairfield	108.4	14.4
Hartford	200.0	16.4
Litchfield	53.6	1.6
Middlesex	145.0	8.0
New Haven	389.0	13.6
New London	131.4	3.6
Tolland	63.2	2.0
Windham	69.4	14.6
Average for the 8 counties	145.0	9.3

In the other five New England states the borer population in 100 plants in 1945 and 1946 was:

	1945	1946
Maine	56.9	22.1
New Hampshire	29.1	26.0
Vermont	23.2	16.9
Massachusetts	180.7	87.1
Rhode Island	351.6	181.4

It should be noted that the average fall population in Connecticut as a whole was below that of any other New England state this year, a phenomenon for which we have no good explanation at present. The monetary loss which took place in 1946 has been estimated by Beck (Insect Pest Survey, Special Supplement 1947, No. 5) to be $2,131 for the grain corn crop and $10,654 for the sweet corn crop. This is less than 1 per cent of the total value of the corn crop in Connecticut in 1946.

The Bureau of Entomology and Plant Quarantine has for a number of years determined the extent of parasitism of the European corn borer in New England. Jones, Carter and Cosenza (Insect Pest Survey, Special Supplement 1947, No. 3) have reported on the parasitism of larvae collected in the fall of 1945 and reared out in the spring of 1946, the collections having been made in Connecticut, Massachusetts and Rhode Island.

Borers observed	6123
Macrocentrus gifuensis	18.5%
Lydella grisescens R. D.	0.6
Inareolator punctoria Roman	5.3
Chelonus annulipes Wes.	0.2
Eulophus viridulus Thom.	0.0
Native parasites	$<$0.05 (trace)
Total parasitization	24.6%

The effect of parasites on the European corn borer population in this State has never been sufficient to warrant any laxity in the use of insecticides.

The potato tuber worm is a serious pest of potatoes in certain parts of the United States, and the Bureau of Entomology and Plant Quarantine has conducted surveys throughout the country to determine where the pest was abundant and where it may be considered a dangerous pest of certain crops. During the years 1942-1945, inclusive, the surveys were carried out and have been reported by W. H. White (Insect Pest Survey, Special Supplement 1946, No. 5, dated August 1, 1946). The insect was not found in Connecticut and in this State 160 potato fields and gardens and 68 storages and cull piles, etc., were examined in eight counties. The insect was found in New Jersey and Pennsylvania in the field, but not in New England nor in New York State. In view of the fact that this insect has been present for untold years in the United States and has never spread naturally into Connecticut, we can see no reason to anticipate any danger of its becoming established here in the near future.

Control and Service

It has been feared for some time that a potato rot nematode from Prince Edward Island might have gained entrance into Connecticut. To determine whether or not it was present in the northeastern states, the Bureau of Entomology and Plant Quarantine conducted a survey which closed March 31, 1947. Twenty-one hundred and seventy-one locations in 94 counties in the 16 northeastern states were examined. The results were entirely negative, no nematode of this species being found. Five counties were surveyed in Connecticut. This survey extended from Maine in the north to North Carolina in the south, and to Wisconsin in the west.

The Department cooperates with the Fish and Wildlife Service of the Department of the Interior in rodent control, particularly in orchards. Although this work has not been pursued very vigorously during the war period and immediately afterward due to a shortage of manpower, certain reports have been published. According to the quarterly report of W. W. Dykstra, which included the months of July, August, and September of 1946, the meadow mouse population appeared to be low in orchards in representative areas in New England. Intense control operations did not appear to be necessary. The Annual Report of Dykstra, Schuler, Scott and Alpaugh, dated July 1, 1946, states that the pine mouse continues to be an important orchard problem in Connecticut. A Microtus census made in this State in April, 1946, indicated a low survival during the winter months of this meadow mouse.

In addition to its research activities, the Department carries on certain control and service operations, many of them under legal authority. This includes inspection of nurseries (page 17), enforcement of gypsy moth, Japanese beetle and European corn borer quarantines (page 20), certification of seed for export (page 22), control of the white pine blister rust (page 34) and gypsy moth (page 25), inspection of apiaries and control of foul brood (page 23). As part of our service to the public we investigate insect-caused damage to crops, forests, ornamental plants, households, etc., and handle a great deal of correspondence in these matters.

During the year November 1, 1945, to October 31, 1946, 412 samples of insects were received at the office with requests for information about their injuriousness and control.

TABLE 1. SUMMARY OF SPECIMENS RECEIVED, 1946

Type of Insect	Number of samples received
Forest and shade tree pests	89
Pests of the household and stored grain	82
Timber and wood products pests	58
Pests of shrubs and vines	42
Soil and grassland inhabiting pests	23
Fruit pests	16
Field and vegetable crop pests	15
Parasitic and predaceous insects	15
Flower garden and greenhouse pests	12
Insects annoying to man and domestic animals	11
Miscellaneous	49
	412

The following species were received five or more times.

TABLE 2. INSECTS RECEIVED FIVE OR MORE TIMES, 1946

Insect	Times received
Termite, *Reticulitermes flavipes* (Kollar)	40
European pavement ant, *Tetramorium caespitum* (Linn.)	13
Elm leaf beetle, *Galerucella xanthomelaena* (Schrank)	12
Saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linn.)	11
Black carpenter ant, *Camponotus herculeanus pennsylvanicus* (DeG.)	10
Indian-meal moth, *Plodia interpunctella* (Hbn.)	10
Oriental beetle, *Anomala orientalis* (Wtrh.)	9
Black carpet beetle, *Attagenus piceus* (Oliv.)	6
Variable oak borer, *Phymatodes testaceus* var. *variabilis* (Linn.)	6
Japanese beetle, *Popillia japonica* (Newm.)	5

As usual the pests received in this office are not necessarily an indication of the economic importance of the species involved. This is due in part to the fact that farmers and others engaged in agricultural pursuits in this State are well acquainted with many of the common insect problems and can solve them without further assistance, or are aided in their work by the Extension Service. We very frequently receive insects which are nothing but nuisances and are not destructive to materials in any way.

In the table giving names of insects received five or more more times, it should be noted that 10 species are listed and of these six include those commonly found in households. In the case of the elm leaf beetle much of our correspondence concerned the discovery of these in the attics of houses during the spring cleaning season. Even the variable oak borer is more frequently sent in to us by a person finding it in his cellar than by a woodsman discovering it in the wooded areas of the State. It is quite true and should be recognized, however, that even though many of these insects found in the house are not actually injurious, they are nevertheless an unmitigated nuisance to the housewife or to other people living in the building and hence must be controlled by some means or other.

Much of the work of the Department is published as bulletins or papers in scientific journals. A list of these will be found on page 112.

INSPECTION OF NURSERIES, 1946

M. P. Zappe and L. A. DeVaux

The annual inspection of nurseries, as required by Section 2136 of the General Statutes, began on July 1, 1946. Two temporary inspectors, Messrs. F. A. Luddington and F. M. Richards, who had been nursery inspectors in previous years, were employed during July and August. Mr. L. A. DeVaux worked with the other men during July and August, and Mr. M. P. Zappe was with them for part of the time when other duties permitted. On September 24 all regular inspections were finished, although occasional inspections were made after this date to see that nurserymen had made a proper clean-up of their nursery pests and to inspect several new nurseries.

Nursery sales were extremely good during the spring and fall planting season. Some of the larger nurseries had more orders for nursery stock than they could fill and had to curtail their sales. Most of the nurseries were in good condition, but a few of the smaller ones were very weedy. A few of the nurseries that suspended business during the war period have re-entered the business of growing and selling plants.

The usual number and type of nursery pests were found. Of a total of 326 nurseries inspected, 166 were free from any pests that required control methods. Pine leaf scale was present in only eight nurseries; in 1945 there were 12 nurseries infested and in 1944 there were 53. Oyster shell scale remains one of the most common nursery pests and is found on a number of host plants such as lilacs, fruit stock, willows, poplars, ash, etc. Borers are rather common and were noted 80 times on various plants, being most abundant on dogwood and mountain ash. The oak pruner was found in nine nurseries. Ordinarily, when on oak or maple it causes little damage. The borer cuts off a twig and the larvae is left in the cut-off section. When the borers attack beech they often cut off larger branches, sometimes several feet long and up to an inch in thickness. In some cases this is serious because it disfigures the tree.

Since peach trees have been grown under special regulations that require the removal of all choke cherries within 500 feet of peach blocks, no peach "X" or red virus disease has been found in Connecticut nurseries, although it is still a menace to peach orchards if there are chokecherries nearby. Fall webworm was very abundant this year, especially in the eastern part of the State. As this insect is a leaf feeder and is present only during the late summer, it is not considered a serious pest. In the nurseries lilac is one of its favorite hosts. White pine blister rust was found only once and was present on both hosts, white pine and gooseberries. Dutch elm disease was found in five nurseries and the trees were immediately destroyed.

Table 3. Ten-Year Record of Certain Nursery Pests

Pest	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946
European pine shoot moth	128	130	110	108	106	54	6	39	46	43
Oyster-shell scale	84	53	49	57	77	68	78	65	66	59
Pine blister rust	4	5	3	3	4	0	2	1	0	1
Pine leaf scale	60	25	50	48	46	23	10	53	12	8
Poplar canker	26	20	14	15	15	11	28	12	11	14
San José scale	8	2	1	2	7	4	10	15	15	7
Spruce gall aphids[1]	306	312	216	231	227	210	140	83	110	46
White pine weevil	101	97	93	70	61	27	28	31	37	47
Nurseries uninfested	25	32	19	33	32	126	148	123	135	166
Number of nurseries registered	377	402	399	376	356	331	318	297	302	326

[1] Includes both *Adelges abietis* and *A. cooleyi.*

Only one nurseryman in the state received the special raspberry inspection based on two inspections annually.

A total of 326 nurseries was registered and inspected but all have not been granted certificates as they have not completed the required clean-up of their nursery pests. The nurseries in Connecticut have a total of 4,120 acres of land devoted to the growing of nursery stock. A classification of nurseries by size is given in Table 4.

TABLE 4. CLASSIFICATION OF NURSERIES BY AREA

Area	Number	Percentage
100 acres or more	6	1.84
50 to 99 acres	8	2.45
10 to 49 acres	42	12.88
5 to 9 acres	30	9.2
2 to 4 acres	78	23.93
1 acre or less	162	49.7
	326	100.

The list of nurserymen and number of acres varies from year to year. In 1946 the number of nurseries showed a gain of 24 over 1945. The total number of acres in 1946 was 4,120, a loss of 107 acres in spite of the fact that there were 24 more nurseries. Some of the large nurseries cut their acreage more than enough to offset the gain by new nurseries. Most of the new nurseries were of one acre or less in size.

Some of the nurserymen failed to register before July 1, 1946 and, as required by Section 2137 of the General Statutes, were charged for the cost of inspection. Nine nurserymen paid the cost of inspection and 45 dollars has been turned over to the treasurer of the Station to be sent to the State Treasury. Nurserymen who registered late and failed to pay the cost of inspection, and those who failed to eradicate their pests properly were not issued a certificate and, therefore, cannot legally sell their nursery stock. Cost of inspecting the nurseries, including a few additional visits to see that pests were properly eradicated, was $2,600, exclusive of travelling expenses.

Other Kinds of Certificates Issued

During the year 199 duplicate certificates were issued to Connecticut nurseries to be filed in other states. Seventy dealers' permits were issued to stores and individuals who sell but do not grow their own nursery stock. No inspection is required before issuing these certificates as all dealers are obliged to purchase their plants from certified nurseries.

Approximately 235 lots of nursery stock and plant material were inspected and certified for private individuals. Three hundred and seventy blister rust control area permits were issued. These permit the planting of currants and gooseberries where there are no timber stands of white pine.

Importation of Foreign Plants and Seeds

Certain kinds of foreign nursery stock are allowed to enter the United States at designated ports of entry under permits issued by the Federal Bureau of Entomology and Plant Quarantine. These are released for transit to destination points where they are inspected by State inspectors. Most of the nursery stock entering Connecticut consists of rose seedlings and rooted cuttings which are grafted by florists and then grown for cut flowers in greenhouses. Since the beginning of the war the importation of rose stocks has practically stopped and florists purchase their rose stocks from the western states. This year no rose stocks were imported and only five small shipments of fruit trees of foreign origin were inspected by State inspectors.

Miscellaneous plant material and seeds are also allowed entry into the United States under the same permit system as above. All this material is sent to Washington, D. C., where it is inspected by Federal men and, if found free from injurious insects and plant diseases, is reshipped to its final destination. This year there was quite a lot of this material, mostly bulbs of flowering plants for propagation purposes and several shipments of grown rose plants to be offered for sale to the public. Some of the members of our Armed Forces who were in foreign countries sent considerable plant material home.

The following list of foreign plant material came into Connecticut in 1946:

50	andromeda
51	anemone
34	apple
25	asparagus roots
551	pounds assorted seeds
44	chionodoxa
175	crocus
35	dahlia
50	galanthus
1	pound garlic
305	gladiolus
65	hyacinth
50	magnolia
22	muscari
50	narcissus
18,164	orchids
100	peony
243	miscellaneous perennial plants
6	prunus
2	quince
70	raspberry plants
374	rhododendrons
5,072	rose plants
65	scilla
30	scions for grafting
64	packets of seed
999	tulip bulbs

QUARANTINE ENFORCEMENT AND MISCELLANEOUS INSPECTIONS, 1946

M. P. ZAPPE AND L. A. DEVAUX

Many states have quarantines in order to protect themselves from damage that various pests might cause if they were introduced from infested states. This, of course, hinders the free movement of plants and plant material. Nurserymen and others who do considerable shipping of this type of material are more or less familiar with the requirements of other states. The average person knows very little about such matters and only hears of them when he or she tries to ship plants from Connecticut to other parts of the country. The postal department and transportation companies know that it is illegal to accept plants and plant material for shipment unless accompanied by a valid certificate of inspection. We are often called upon to make inspection and furnish certification for such shipments. We are obliged in some cases to refuse such certification because the shipment does not comply with the requirements of the state to which it is consigned. Although most of the requirements of the nearby states are such that we can certify the materials, the requirements of some of the western and mid-western states make it almost impossible to ship certain plants, fruits, etc., into them.

Twenty-one states still maintain quarantines of their own preventing importation of host plants of the European corn borer unless properly certified. A total of 207 European corn borer quarantine inspection tags was issued to certify 107 shipments to these states and Canada. Most of this material was shelled seed corn destined for Canada and greenhouse grown plants.

There is only one state that still maintains a quarantine because of the Oriental fruit moth, preventing the movement of fruit, used fruit containers and fruit trees. If the material is fumigated in an approved fumigation chamber, it may be shipped to this state, but the cost of the apparatus is so high that no such fumigations have been made.

Since the establishment of the Japanese beetle and gypsy moth quarantines in Connecticut, this department has cooperated with the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture in their administration. The state is divided into two sections, using the gypsy moth quarantine line as a boundary. The section of the state within the gypsy moth quarantine area, which includes Hartford, Middlesex, New London, Tolland, Windham, some towns in northern and eastern Litchfield, and eastern New Haven counties, is under the supervision of Mr. H. N. Bartley, in charge of the federal Japanese beetle and gypsy moth quarantine office at Waltham, Mass. His inspectors make the necessary inspections to comply with the Japanese beetle and gypsy moth quarantine regulations in his area. Fairfield County, which is wholly within the Japanese beetle quarantine area, and the balance of New Haven and Litchfield counties outside of the gypsy moth quarantined area, including the towns of Branford and North Haven in the gypsy moth area, are under the supervision of Mr. M. P. Zappe, who is in charge of the New Haven office.

The Japanese beetle quarantine enforcement activities consist of seasonal scouting of certain nursery and greenhouse properties for classification purposes, the inspection and certification of all articles included in the quarantine regulations, and other tasks necessary to the operation of the quarantine.

Scouting for adult Japanese beetles has been conducted yearly to determine whether or not beetles were present on classified properties. Because of the decrease in the number of classified areas to be scouted, the district inspectors have performed the scouting activities instead of hiring scouting crews for this purpose.

Only two districts in the State, containing three classified firms, were scouted during the 1946 season. This work was performed by Mr. J. F. McDevitt, Middletown, Conn., and Mr. W. J. Ahearn, Westerly, R. I. They began scouting on July 8 and finished on September 16, 1946. In all, three nursery, greenhouse or other similar establishments were examined from two to three times. No establishments were found infested. One firm was removed from the classified list because of the introduction of uncertified plant material into certified greenhouses.

During the past year, two firms treated 223,700 square feet of land containing 18,573 plants with arsenate of lead and 1,805 square feet of land, containing 802 plants, with DDT to eliminate larvae. One firm treated 1,080 cubic feet of soil with carbon disulphide. There were 32 ethylene dichloride dip treatments made at six establishments in which 15,204 plants were treated.

The total number of plants inspected and certified for shipment to other states and foreign countries was 855,239. The number and kinds of certificates issued are shown in the following table:

TABLE 5. NUMBER OF CERTIFICATES ISSUED, 1946

Kind	Farm Products	Cut Flowers	Nursery and Ornamental Stock	Sand Soil	Manure	Total
"A"[1]	0	0	3,012	0	0	3,012
"B"[2]	0	0	42	0	0	42
Total	0	0	3,054	0	0	3,054

1 Used in shipments from nurserymen to customers.
2 Used between classified nurserymen for carload shipments.

No inspections of farm products and cut flowers were made because no towns in Connecticut are within the area requiring such inspection and certification.

The gypsy moth work consists of the inspection and certification of all materials included in the gypsy moth quarantine regulations, occasional scouting of certain areas in order to issue the necessary certificates, and other tasks necessary to the operation of the quarantine.

The total number of plants inspected and certified for shipment to points outside of the quarantine area was 4,323,553. Forest products inspected and certified totalled 45,508 pieces, 627.5 cords of wood, 12,024,481 board feet of lumber, 3,235 cable reels and 1,495 bundles. Evergreen products totalled 7,046 bales, 1,474 boxes and 9,321 pieces. Stone and quarry products amounted to 794 tons and 122 pieces.

TABLE 6. NUMBER OF CERTIFICATES ISSUED, 1946

Kind	Nursery stock	Forest products	Stone and quarry products	Evergreen products	Total
"A"[1]	54,460	343	20	2,150	56,973
"B"[1]	1,716	1,163	51	218	3,148
Total	56,176	1,506	71	2,368	60,121

1 See footnotes to Table 5.

We are also called upon to certify miscellaneous seed shipments to foreign countries as required by their regulations. Most of these shipments are consigned to South and Central America and Canada, but during the year 1946 there were several countries in other continents to which seed shipments were made. There were 1,067 such certificates issued covering 507 shipments, a list of which follows:

Africa	1	Honduras	4
Argentina	104	Iceland	1
Australia	7	Ireland	10
Belgium	1	Luxemburg	1
Bolivia	4	Mexico	6
Brazil	114	Morocco	2
British Guiana	1	Netherlands	10
British West Indies	2	Netherlands W. I.	2
Canary Islands	1	New Zealand	13
Chile	12	Nicaragua	2
Colombia	11	Norway	1
Costa Rica	5	Palestine	3
Cuba	19	Panama	11
Curacao	1	Paraguay	1
Denmark	2	Peru	35
Dutch Guiana	1	Portugal	4
Ecuador	3	Puerto Rico	5
Egypt	16	South Africa	22
El Salvador	1	Sweden	5
England	1	Switzerland	6
France	14	Syria	1
Guatemala	1	Uruguay	24
Haiti	7	Venezuela	9

INSPECTION OF APIARIES

M. P. Zappe

In the early spring of 1946 Mr. Cyril B. Simpson of Glastonbury was appointed as bee inspector to work in Litchfield and Hartford counties. Mr. W. H. Kelsey, who retired at the end of the 1945 inspection season, formerly had charge of this area. Mr. Elbra Baker of Brooklyn has Tolland, Windham and New London counties under his care. Mr. Roy Stadel of Southington has charge of Fairfield, New Haven and Middlesex counties.

This season there were 2,827 apiaries inspected in the State, an increase of 238 over 1945. The total number of colonies, 11,920, was lower, a loss of 1,433. This reduced the average number of colonies per apiary from 5.15 in 1945 to 4.07 in 1946. The inspectors were able to inspect practically all of the known apiaries in the State during the season.

Winter mortality of bees was very much less this last winter than the winter of 1944-45. The loss for the winter of 1945-46 was 12.65 per cent of the colonies and for 1944-45 it was 21.6 per cent. According to the inspectors, most of the winter mortality was due to starvation rather than low temperatures, and in many apiaries mortality took place in the spring when many colonies probably could have been saved by feeding. It was highest in Middlesex and Fairfield counties, 17 and 16 per cent respectively, and only 8 per cent in Litchfield County where temperatures are usually much lower in the winter than in the other two counties. This fact seems to support the statement that starvation is the primary cause of winter mortality rather than extremely low temperatures.

The amount of American foul brood found by the inspectors was slightly more than last year—2.29 per cent for 1946 and 2.23 per cent for 1945. Most of the disease was found in the western part of the State. Fairfield County had 5 per cent and Litchfield over 3 per cent, while Tolland and Windham counties had less than 0.5 per cent. Some of the diseased colonies were destroyed by burning, but in some cases the inspectors treated the colonies with sulfathiazole and in others the owners were allowed to treat their colonies if they promised to follow the inspectors' instructions. There were no cases of sac brood or European foul brood reported this year.

The total cost of inspection varies slightly from year to year. As the number of apiaries increases, the cost per apiary decreases slightly.

Financial Statement

January 1, 1946—December 31, 1946

Disbursements

January 1 to June 30, 1946:		
Salaries	$ 581.25	
Travel	265.45	
Miscellaneous	31.14	$ 877.84
July 1 to December 31, 1946:		
Salaries	1,336.35	
Travel	661.50	1,997.85
Total disbursements for 1946		$2,875.69

REGISTRATION OF BEES

Section 2129 of the General Statutes provides that each beekeeper shall register his bees on or before October 1 of each year with the Town Clerk of the town in which the bees are kept, and that each Town Clerk, on or before December 1, shall report to the State Entomologist whether or not any bees have been registered and if so shall send a list of names and the number of colonies belonging to each registrant. Even though there is a penalty for not registering bees, many beekeepers neglect to do so. Even the Town Clerks are negligent in sending in lists of registered beekeepers to the State Entomologist. It would seem a much better plan to have beekeepers register their bees direct with the State Entomologist rather than with the Town Clerks. In 1946, 2,827 apiaries consisting of 11,920 colonies of bees were inspected, but only 1,406 apiaries were registered. This shows that 1,421 more apiaries were inspected than were registered by the Town Clerks. No doubt some unregistered apiaries were not inspected by the apiary inspectors who did not know of their existence. Uninspected bees may be a fertile source of foul brood infection for other bees in the community. Every effort short of arrests and fines is being made to have all beekeepers registered so that the location of their bees may be known and visited by the apiary inspectors.

TABLE 7. INSPECTION OF APIARIES, 1946

County	Apiaries		Colonies		Per cent diseased	Per cent died (winter)
	Inspected	Diseased (Am.f.b.)	Inspected	Diseased (Am.f.b.)		
Fairfield	502	58	2,156	112	5.19	16.56
Hartford	607	24	2,609	46	1.76	12.69
Litchfield	341	25	1,525	51	3.34	7.80
Middlesex	189	8	903	13	1.44	17.05
New Haven	421	28	1,857	37	1.99	11.47
New London	335	7	1,387	7	.50	10.89
Tolland	205	3	679	3	.44	14.43
Windham	227	3	804	4	.49	10.57
	2,827	156	11,920	273	2.29	12.65

TABLE 8. SUMMARY OF INSPECTION

	Apiaries	Colonies
Inspected, 1946	2,827	11,920
Infected with American foul brood	156	273
Percentage infected	5.51	2.29
Average number of colonies per apiary		4.07
Average cost of inspection	$1.02	$0.2428
Total cost of inspection, 1946		$2,875.69

The number of colonies winterkilled in 1946 was as follows:

County	No. of colonies
Fairfield	357
Hartford	331
Litchfield	119
Middlesex	154
New Haven	213
New London	151
Tolland	98
Windham	85
Total winterkilled	1,508

GYPSY MOTH CONTROL[1]

O. B. Cooke

Inasmuch as this insect is now firmly established in Connecticut and occurs in greater or less abundance over much of its area, the elimination of the pest is not practical with the means available. Therefore, our main concern becomes the prevention of outbreaks that would cause the stripping of the foliage from the trees. In order to be able to anticipate where serious outbreaks might be expected to occur, a survey of the most favorable locations for outbreaks in the various towns where the insect is present is conducted. With information obtained from the survey, combined with a study of the maps of the towns where type-mapping[2] has been performed, it is felt that the small force now available for the work can, by the use of aircraft equipped with spraying apparatus, new ground spraying equipment and new insecticides, effectively prevent any large outbreaks of the insect occurring in that area of the State east of the "Barrier Zone".[3]

During the past year a survey to determine the gypsy moth population was conducted in 63 towns in Windham, New London, Tolland, New Haven, Middlesex, Litchfield, and Hartford counties. One hundred eighty-three infested areas were discovered and inspected to determine their extent and the estimated number of new egg masses present in each area. It is estimated that a total of approximately 400,000 new egg masses were present. A number of the infestations were of such size as to indicate the need for control measures in order to prevent serious defoliation of the trees.

During the spring and early summer a spraying program was carried out. Two heavily infested areas, one of 200 acres of woodland located in the town of Barkhamsted, and the other of 100 acres of woodland in the towns of Farmington and West Hartford, were sprayed by airplane. DDT was used at both of these infestations, at the rate of one pound of DDT in oil solution per acre of woodland. Fifty-nine other infestations were sprayed during the season by ground spraying equipment. During the spraying operations approximately 350 pounds of DDT and 2,000 pounds of arsenate of lead were consumed. A series of experimental sprayings was also carried out. The first plot was sprayed just prior to the hatching of the caterpillars, the second about the middle of the larval period, and the third just prior to the time when the caterpillars were to enter the pupal stage. In each series different amounts of DDT in an oil solution were applied by means of a high-velocity mist blower. The results of this experiment will be contained in a later report.

A defoliation survey was conducted during the summer in 103 towns in the eastern and central sections of the State. This survey showed that some defoliation occurred in 22 towns this year, the largest amount in the north central section of the State. While the number of acres defoliated this year is somewhat larger than that of last year, this is no cause for alarm and, with the use of proper control measures during the coming year, a reduction in the number of acres defoliated can be effected.

As in several years past, this department has cooperated with the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, in conducting a gypsy moth sex attractant survey in the western part of

1 July 1, 1945—June 30, 1946.
2 Station Bulletin 445, State Entomologist's Report, 1940.
3 A strip of land extending from Long Island Sound to the Canadian Border, with the eastern boundary passing through the western part of Connecticut, established in an endeavor to prevent the spread of the gypsy moth to the west.

TABLE 9. GYPSY MOTH CONTROL OPERATIONS, 1945-46

County	No. of towns	Infestations found	No. of egg masses	No. of infestations sprayed	Amount insecticide used (pounds)		Area surveyed (acres)[2]
Windham	14	42	4,800	1	3 lbs. DDT		304,995
New London	16	52	13,591	16	11 lbs. DDT	31 lbs. 12 oz. A.L.	354,694
Tolland	4	22	2,563	3	3.5 lbs. 2 oz. DDT		73,022
Middlesex	4	11	6,816	2	1 lb. 4 oz. DDT		67,479
Hartford	20	78	225,541	34	134 lbs. 5 oz. DDT	448 lbs. A.L.	343,097
New Haven[1]	16	5	5,042	2	20 lbs. DDT		13,514
Litchfield[1]	14	118	145,680	93	1249 lbs. 8 oz. DDT		106,691
Fairfield[1]	11	0	0	0	0		3,186
	99	328	404,033	151		1449 lbs. 11 oz. DDT 479 lbs. 12 oz. A.L.	1,266,678

[1] Work performed by USDA, Bureau of Ent. and P.Q., except for 2 infestations in Wallingford sprayed with 3 pounds DDT and 200 acres in Barkhamsted sprayed with 200 pounds of DDT.

[2] Acreage taken from Conn. Register and Manual—1945.

TABLE 10. DEGREE OF DEFOLIATION, 1946

Town	25%	50%	75%	100%	Total
Avon	0	1	0	0.5	1.5
Barkhamsted	59	12.2	95.8	151.2	318.2
Bloomfield	0.2	1	0	0	1.2
Burlington	1	3.1	8.1	7	19.2
Canton	6.6	11.4	24.3	5.6	47.9
Cromwell	0	0.9	1	0	1.9
Durham	2	1.7	2.2	0.5	6.4
Farmington	0	0.8	6	0.2	7
Glastonbury	0.1	0.5	0	0	0.6
Granby	23	17.8	7.3	4.1	52.2
Hartland	3	2.1	0	0.2	5.3
Harwinton	0.1	0	0	0	0.1
Meriden	0.9	0	0.9	0.1	1.9
Middletown	0	0	0.1	0	0.1
New Hartford	5.8	2.5	6	1	15.3
Plainfield	0	0.2	0	0.3	0.5
Preston	0.6	0	0.2	0	0.8
Rocky Hill	0	0.1	0.1	0	0.2
Simsbury	0.1	2	2.1	0	4.2
Stafford	0.1	0	0	0	0.1
Sterling	0	0.1	1	0	1.1
Vernon	0	0	0.1	0	0.1
Totals:	103	57	155	171	486

the State to delimit the spread of the insect. During the summer, members of the department placed and patrolled 360 traps located in the towns of Ansonia, Derby, East Haven, Milford, New Haven, Newtown, Orange, Seymour, Shelton and Stratford. All materials used during the survey were furnished by the U. S. Department of Agriculture. The detailed results of this survey (Table 11) are taken from a report by R. A. Sheals, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, Greenfield, Mass., dated October 4, 1946. This survey does not indicate any serious spread of the gypsy moth into hitherto uninfested areas.

Since 1939 a type-mapping project has been carried on in the State, and this was continued during the past year. While not engaged in making surveys or other control projects, the gypsy moth control office carried on and completed type-mapping in the towns of Andover, Barkhamsted, Bolton, Coventry, Enfield and Granby. Since the start of this project, the wooded areas in 54 towns in the State have been completely mapped.

During the spring, as in years past, egg masses were collected from various parts of the State, held outside until the eggs hatched, then taken inside where the hatched and unhatched eggs in each mass were separated and counted. This work is done in an effort to determine the trend of the gypsy moth population within the State. The results of this year's collections are listed below.

Number of egg masses collected	174
Average number of eggs per mass	675
Average number of eggs hatched per mass	547
Per cent hatched	81

Table 11. Gypsy Moth Trap Survey—Summer 1946

Counties and towns	Road miles	Acres	No. traps put out	Serial no. of trap	No. moths caught
FAIRFIELD COUNTY					
Newtown	8	3,000	10	....	None
Shelton	4	1,500	5	....	"
Sherman[1]	15	3,000	10	....	"
Stratford	114	12,288	88	6	1
County Totals:	141	19,788	113	1	1
LITCHFIELD COUNTY					
Bethlehem[1]	16	3,300	11	....	None
Bridgewater[1]	18	3,600	12	....	"
New Milford[1]	36	7,200	24	....	"
Roxbury[1]	24	4,800	16	....	"
Sharon[1]	15	3,000	29	12	8
"				13	7
"				15	4
"				17	16
"				19	3
"				21	2
"				57	2
"				60	1
"				106	2
"				134	6
Washington[1]	21	4,200	14	....	None
Watertown[1]	18	3,600	12	....	"
Woodbury[1]	18	3,600	12	....	"
County Totals:	166	33,300	130	10	51
NEW HAVEN COUNTY					
Ansonia	39	3,968	25	....	None
Derby	32	3,520	25	....	"
East Haven	4	1,500	5	....	"
Milford	133	15,104	85	....	"
New Haven	3	1,500	5	....	"
Orange	53	11,264	55	....	"
Seymour	55	9,408	50	....	"
County Totals:	319	46,264	250	....	None
Grand Totals: 19 Towns	626	99,352	439	11	52

[1] Work performed by USDA.

Since it is known that extremely low temperatures will seriously affect overwintering eggs (-25° will kill exposed egg masses, some eggs are killed at -15°), daily temperature readings are taken at Colebrook and Brooklyn. From the readings taken at these two points, indications are that temperatures during the winter of 1945-46 were not low enough to affect seriously the viability of the eggs.

The first observed hatching of caterpillars in this State occurred at Granby on April 22, 1946. General hatching occurred during the period May 2-

May 17. Pupae were first noticed on June 24, 1946. Moths were first noticed on July 7. The last date on which a male moth was seen was August 2.

The U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, carried on a control program in 44 towns in the western part of the State during the year, for which we hereby express our appreciation to Mr. R. A. Sheals, Chief of the Division of Gypsy and Browntail Moths Control, and to Messrs. S. S. Crossman and H. L. Blaisdell, Assistant Chiefs of the Division. Scouting was performed in 13,114 acres of open country and 10,294 acres of woodland; 103 infestations containing a total of 4,772 egg masses were discovered. During the spraying season, by means of airplane and ground spraying apparatus, these infestations were all sprayed with DDT, 1136.5 pounds being consumed. We are also indebted to Mr. R. C. Brown, of the Division of Forest Insect Investigations, U.S.D.A. Bureau of Entomology and Plant Quarantine, for assistance during the past year.

SPREAD OF THE DUTCH ELM DISEASE IN CONNECTICUT

M. P. Zappe and C. W. Leach

Since 1933 when the first Dutch elm diseased tree was found in Connecticut, the disease has gradually spread to the north and east. At present the disease has been found in about four-fifths of the State. The only towns where Dutch elm disease has not been found are along the eastern boundary of the State. The disease has been found in one location in Rhode Island and also in eastern and western Massachusetts.

From the Connecticut River westward the disease is quite abundant in Connecticut and has caused loss of many valuable shade elms in city parks and along streets. Many towns and cities make a practice of removing diseased elms as soon after they are found as possible. This elm wood is supposed to be burned, but in some cases it has been left too long before burning so that the bark beetles have had a chance to emerge from it. Under these conditions the chances of spreading the disease from this source are very good.

East of the Connecticut River the U. S. Department of Agriculture carries on a program of scouting for the disease. In this area the infestation is still light except in the towns of Portland, Glastonbury, East Hartford, Enfield and Manchester. In these towns trees are dying at a greater rate than anywhere else east of the river. The town authorities in these towns have not been able to carry on a very vigorous program of removal. Often trees are left until the bark beetles have emerged and all the damage that they can do has been done.

Whenever the U. S. Department of Agriculture scouts find a diseased tree, they notify the Experiment Station and we in turn notify the town officials and urge prompt removal and destruction by burning.

Since 1942 a total of 443 diseased elms has been found east of the Connecticut River. Most of these trees are in Hartford County in the towns on the east side of the river. The bark beetles responsible for the spread of this disease have been known to be present in these towns for a number of years. Trap logs placed in the other towns in eastern Connecticut in 1943 and 1944 failed to produce any evidence that the beetles were present at any great distance east of the known infested towns. Since then, however, the beetles have been spreading eastward and now they are present wherever the Dutch elm disease is found.

In Old Lyme the disease was first found in four trees in 1935. This was only two years after the first diseased tree was found in Connecticut at Greenwich. The Bureau of Entomology and Plant Quarantine was actively engaged in the control of the disease in Fairfield County and, when the Old Lyme trees were found, they were removed and a general clean-up of all beetle breeding material in the vicinity was made. The following year another infected tree was found in the same area, but no others were found there until 1942. By that time the disease had spread over about one-half of the State and trees in nearby towns were infected. The same thing happened in Preston. The first diseased tree was found in 1940 and no others were found until 1946. The following is a record of all diseased trees which have been found in the eastern half of the State with the exception of the Old Lyme and Preston trees.

We are helping a few towns with their Dutch elm disease control program. We scout the town for diseased trees and report our findings to the

Five Year Record of Dutch Elm Disease East of the Connecticut River

	1942	1943	1944	1945	1946
Hartford County					
East Hartford			6	22	32
East Windsor			1	1	25
Enfield			2	3	27
Glastonbury			1	25	27
Manchester			8	5	14
Marlborough				1	1
South Windsor			4	8	22
Middlesex County					
East Haddam		1	3	4	1
East Hampton				2	9
Portland	1	2	15	43	9
New London County					
Bozrah			2	2	0
Colchester				2	2
East Lyme					3
Lebanon				4	2
Lisbon				1	0
Lyme			1		4
Montville				3	2
New London				4	5
Norwich				1	1
Old Lyme	1	0	1	7	7
Preston					1
Salem					1
Waterford				2	0
Tolland County					
Columbia					1
Coventry					1
Ellington					7
Hebron				6	4
Mansfield				2	
Somers				2	6
Stafford					1
Tolland					1
Vernon			1	6	11
Windham County					
Chaplin				1	0
Hampton					1
Scotland					1
Windham				4	3
Total Diseased Trees	2	3	45	161	232

Total Diseased Trees All Towns 443

Selectman and Tree Warden. In some cases we teach the Tree Warden or one of his assistants how to find the diseased trees by leaf and twig symptoms so that they can carry on their own program without further assistance. We stress the fact that all diseased and bark beetle infested elm wood must be burned, or the bark removed and burned, before the adults emerge. In spite of this, entire trees and infested wood are often left until after bark beetle emergence. Frequently the wood is given away to be used for firewood with the understanding that it be burned before May 1, and we know of a number of instances where this material has not been properly disposed of in time.

To study the development of the Dutch elm disease in southwestern Connecticut, the oldest infected part of the State, five one-half mile square sample plots were laid out at random in each of the following towns in Fairfield County in 1942: Greenwich, Stamford, Darien and Norwalk. The fifth annual scouting of the plots for diseased trees was done in the summer months of 1946.

A 100 per cent tally was originally made of the elm trees within each plot and annual surveys have been made to locate and record all elm trees within these plots which exhibit the characteristic symptoms of the disease. Table 12 gives a summary of the observations during the past five years. An irregular increase in the incidence of the disease is shown by the table. Only in the town of Darien was there a decrease, amounting to 15.2 per cent in the number of new infections over the previous year. This decline is not uniformly typical of the town as a whole. One plot which had shown relatively little activity in the development of the disease during four years has now suddenly increased almost five times.

The town of Stamford appears to have been most severely damaged by the disease during 1946. One hundred eighty-seven new cases were found, most of which were in four of the five plots. Here two plots have remained consistently high; two plots which have had few previous infections now show large increases; whereas one plot with a low rate of spread remained low. A decline of 31.9 per cent in the number of new infections found in the Stamford plots was reported in 1945, but these same plots showed an increase of 103.3 per cent in 1946.

An increase of 161.5 per cent was found in Greenwich and the ratio for the past three years indicates an increase at the rate of 6:13:34. The actual number, however, is still relatively small. A moderate increase of 14.8 per cent over the previous year occurred in Norwalk.

Table 12. Dutch Elm Disease Summary, 1942 through 1946, Showing the Number of Trees Diseased in Each of 20 Plots over a Period of Five Years in Four Towns in Connecticut

Town	Sq. miles scouted	Town area (sq. miles)	No. elms estimated		Diseased trees in plots[1]				
			in plots	in town	1942	1943	1944	1945	1946
Greenwich									
Plot No. 1	.24		592		5	5	3	7	18
2	.31		387		..	..	..	4	3
3	.25		194		..	..	..	1	7
4	.20		242		3	..	1	1	1
5	.15		235		3	1	2	0	5
Total	1.15	42.7	1,650	61,215	11	6	6	13	34
Stamford									
1	.27		375		9	25	111	52	40
2	.26		250		6	2	..	9	22
3	.25		379		3	11	11	23	53
4	.25		213		1	5	9	2	63
5	.25		224		0	7	4	6	9
Total	1.28	38.1	1,441	42,798	19	50	135	92	187
Darien									
1	.20		215		6	8	5	6	5
2	.25		217		7	5	6	4	19
3	.25		239		1	4	14	30	17
4	.27		359		5	7	5	19	6
5	.25		90		1	0	2	0	3
Total	1.22	14.9	1,120	13,664	20	24	32	59	50
Norwalk									
1	.22		234		1	1	..	2	3
2	.21		226		3	3	30	15	18
3	.20		613		1	4	2	0	2
4	.23		40		0	2	..	2	2
5	.18		70		5	2	4	5	12
Total	1.04	24.6	1,183	27,993	10	12	36	25	37

[1] The data in this table represents trees diseased the year indicated. Trees which were recorded in previous years are *not* included.

Table 13. Percentage of Total Elms in Plots Diseased the Year Indicated

	Year	Greenwich	Stamford	Darien	Norwalk
Graphium ulmi, per cent of total elms in plots.	1942	.66	1.38	1.78	.84
	1943	.36	3.46	2.14	1.01
	1944	.36	9.36	2.85	3.04
	1945	.78	6.38	5.26	2.02
	1946	2.06	12.98	4.46	3.13

Table 14. Number of Trees Diseased in Year Indicated per Square Mile per Town

	Year	Greenwich	Stamford	Darien	Norwalk
Graphium ulmi per square mile of plots.	1942	9.6	15.0	16.0	9.6
	1943	5.2	39.0	19.7	11.5
	1944	5.2	105.4	26.2	34.6
	1945	11.3	71.8	48.3	23.0
	1946	29.6	146.1	41.0	35.6
Graphium ulmi in entire town (estimated).	1942	408	564	244	236
	1943	223	1,485	292	283
	1944	223	4,006	391	851
	1945	482	2,735	719	565
	1946	1262	5,466	611	675

BLISTER RUST CONTROL

J. E. RILEY, JR., Associate Pathologist
Bureau of Entomology and Plant Quarantine, U.S.D.A.

White pine is one of our most valuable forest trees because of its rapid growth, ease of management and high stumpage value. It is seriously threatened by the white pine blister rust, a fungous disease imported from Europe. The rust cannot spread directly from pine to pine, but must live part of its life cycle on the leaves of currant and gooseberry plants (genus Ribes). It can be controlled by eliminating the Ribes within infecting distance of the pine stands. Control work has been carried on in Connecticut since 1916 under a cooperative agreement between the U. S. Department of Agriculture, the Connecticut Agricultural Experiment Station and the State Extension Service. The State Entomologist is the administrative head of the organization and he is assisted by a state leader, two district leaders and such temporary help as is needed.

There are approximately 100,000 acres of white pine area in the State, 80 per cent of which contains 20 per cent or more pine in the stand composition. The hurricane of 1938 and the abnormally heavy cutting during and after the war years has greatly depleted the supply of mature trees, but pine reproduction has more than offset the reduction in the acreage of older pine. About 90 per cent of the pine area lies in the four northern counties of Litchfield, Hartford, Tolland and Windham, and in the town of Voluntown. Previous to the hurricane of 1938, 50 per cent of the pine occurred in pure stands. Recent mapping of "blown down" and cut over areas indicate that a much larger proportion of the new pine will occur in mixture with hardwoods.

The heaviest and most general distribution of Ribes occurs in northern Litchfield and northwestern Hartford counties. In the other northern tier counties wild Ribes are less prevalent and mostly restricted to swamps and moist hardwood areas. Wild Ribes are scarce in central and southern Connecticut. The wild and cultivated Ribes have been removed from control areas, and all the European black currants have been destroyed throughout the State. But, since Ribes regenerate from seed stored in the ground and from broken off root crowns, periodic workings of control areas will be required to maintain a low Ribes population.

The heaviest blister rust infection on pine occurs in northern Litchfield County. It is less prevalent in the balance of the northern counties, and is very light in the southern two-thirds of the State. Infection on Ribes can be found during July and August in any year in any part of the State.

In spite of the early control work, which was necessarily confined to the areas of the most valuable pine and the areas of heaviest infection and to areas where local cooperative funds were available, the disease gradually increased in intensity until it reached a peak in 1926, after which it slowly declined as a result of the gradual reduction of Ribes. Strip lines, 16.5 feet wide, run through pine areas during the years 1930 to 1936, showed the following infections on trees under 20 feet in height:

A few small study plots, taken in areas favorable to infection, showed 75 to 80 per cent pine infection. Today it is difficult to find recent infections, although many of the old cankers are still present and will result in the death of the infected trees. Most of the earlier infected young trees have died and disappeared.

The Great Pond Nursery in Simsbury, the Farmers Nursery and the State Forest Nursery in the Peoples Forest were given continued protection to their 250,000 white pine stock in 1946 by rechecking their nursery sanitation zones.

Pine and control areas were remapped during the year in the towns of Colebrook, Goshen, Putnam, Stafford, Willington and Woodstock. In these towns 45,222 acres were examined and eliminated because they did not contain enough pine to justify control work. There were 51,037 acres mapped in detail and the pine types classified. As a result of the mapping, the proportion of control area to pine acreage was reduced from a ratio of 6-1 to a ratio of 4-1. There was a net gain of 60 per cent in pine area and a reduction of 5 per cent in the control area.

Twenty-two towns in the white pine region are cooperating with the Station by creating town sinking funds with which to pay the local labor for future control work. They are appropriating from $0.05 to $0.10 per acre of pine per year. Since 1940, a total of $16,483.70 has been appropriated; $3,702.30 has reverted to the towns under the terms of the appropriation; $2,681.00 has been spent for control work, and there is a balance of $10,-099.80 available for future control work when needed.

TABLE 15. BLISTER RUST INFESTATION IN LITCHFIELD COUNTY

Town	Year of survey	Trees examined	Per cent of trees infected	Cankers per tree
Salisbury	1930-31	9,445	23.87	1.55
Cornwall	1930-31	23,439	11.50	1.30
Canaan	1930-31	1,572	22.96	1.23
No. Canaan	1930-31	3,305	19.70	1.97
Colebrook	1935-36	16,583	3.60	1.16
Barkhamsted	1935 36	6,086	5.92	1.51
Cornwall	1935-36	1,158	14.53	1.60
Goshen	1935-36	1,267	12.39	1.56
New Hartford	1936-37	5,241	5.80	1.33

TABLE 16. WILD RIBES ERADICATION IN 1946

Town	Acres worked	Ribes destroyed	Man hours	Total cost
Colebrook	9,097	18,746	3,684	$2,975.51
Winchester	3,745	1,580	592	449.01
Goshen	8,018	5,473	1,448	1,022.63
Woodstock	16,307	2,589	2,346	2,096.22
Stafford	7,850	10,466	1,503	1,363.01
Willington	626	39	100	124.06
Totals	45,643	38,893	9,673	8,030.44

MOSQUITO CONTROL IN 1946

R. C. Botsford and Julius Elston[1]
State Board of Mosquito Control[2]

Mosquito control in Connecticut consists principally of the maintenance of an extensive salt marsh drainage system on 11,000 acres of ditched marshland. This past season it has been impossible to recruit sufficient labor at prevailing state wage levels to maintain this properly. In order to carry on properly the routine work of cleaning and recutting ditches and repairing dikes and tide gates, we require a force of about 20 men. This past season we were able to secure the services of only six men, five of them in the New Haven County area and one in the Stonington-Groton area. Fortunately, in spite of the labor shortage, comparatively few mosquitoes were found in the Fairfield, New Haven and Stonington-Groton areas; but in the Guilford, Madison, Clinton and Westbrook areas mosquitoes were abundant and complaints were numerous. The heaviest infestation of mosquitoes seemed to originate in Westbrook, in the Grove Beach area of Clinton and between Leete's Island and Indian Cove, in Guilford.

During the course of the work several species of both fresh water and salt marsh mosquitoes were collected. They are listed below.

Aedes canadensis
North Branford, April 1, 1946; New Haven, April 15, 22, June 25, 1946; West Haven, June 20, 1946; Clinton, July 25, 1946.

Aedes excrucians
Woodbridge, May 10, 1946.

Aedes fitchii
Woodbridge, May 10, 1946.

Aedes vexans
Groton, May 1, 1946; Lyme, May 14, 1946; Fairfield, May 16, 1946; East Haven, May 22, 1946; Norwalk, May 22, 1946; Stamford, May 22, July 29, 1946; New Haven, June 7, 14, 23, 25, 1946; West Haven, June 7, 1946; Old Lyme, June 13, 1946; Orange, July 6, 1946; Hamden, July 8, 1946; Clinton, July 25, 1946; Branford, July 27, 1946; Guilford, August 16, 1946; Windsor, July 25, 26, 1946.

Aedes cantator
East Haven, May 1, 1946; Fairfield, May 16, 1946; Stamford, May 22, July 29, 1946; Clinton, June 17, July 10, 19, 25, 1946; West Haven, June 20, 1946; Milford, July 2, 1946; Guilford, July 3, 26, August 16, 1946.

Aedes sollicitans
New Haven, May 8, June 20, 1946; Fairfield, May 16, 1946; East Haven, May 22, 1946; Stamford, May 22, July 29, 1946; Clinton, June 17, July 10, 12, 19, 25, August 12, 15, 1946; Guilford, July 3, 26, 31, August 6, 15, 16, 1946; Westport, August 2, 1946.

Aedes cinereus
New Haven, April 22, June 7, 1946.

Aedes taeniorhynchus
Stamford, July 29, 1946; Westport, August 2, 1946.

Aedes triseriatus
South Norwalk, September 3, October 16, 1946.

---

1 On April 1, 1946, Mr. Julius Elston was appointed Research Assistant. Mr. Elston received a Bachelor of Science degree from the University of Connecticut in 1941, and a Master of Public Health degree from the Yale School of Public Health in 1943. He served in the U.S. Army Medical Corps during the war.

2 The Board of Mosquito Control is not a part of the Agricultural Experiment Station. This report is published here as a matter of convenience.

Culex pipiens
Old Lyme, June 13, 1946; West Haven, June 20, 1946; New Haven, June 25, 1946; Orange, July 6, 1946; Branford, July 13, 27, 1946; Clinton, July 25, 1946; Stonington, August 2, 1946; Guilford, August 6, 1946.

Culex apicalis
New Haven, June 25, 1946; Branford, July 13, 20, 1946; Guilford, July 26, August 16, 1946; Westport, July 29, 1946.

Culex restuans
New Haven, June 25, July 5, 1946; Orange, June 26, July 6, 1946; Hamden, July 8, 1946; Clinton, July 19, 1946.

Culex salinarius
West Haven, June 20, 1946; Branford, July 20, 1946; New Haven, August 13, 1946.

Culex morsitans
Woodbridge, May 10, 1946.

Uranotaenia sapphirina
Branford, July 20, 1946; Branford, August 3, 1946; New Haven, August 13, 1946.

Psorophora ciliata
Windsor, July 25, August 8, 1946.

Anopheles punctipennis
Windsor, May 25, June 15, 22, 28, 29, July 5, 12, August 10, 1946; Plainville, June 24, July 1, 8, 15, 27, 29, 1946; Berlin, June 27, July 11, 18, 25, August 1, 1946; Branford, July 13, 20, 27, 1946; Guilford, July 26, 1946; New Haven, August 6, 1946; Bristol, June 25, 27, July 9, 16, 30, August 4, 1946; Newington, June 26, July 3, 10, 17, 1946; Wethersfield, June 22, 24, 1946.

Anopheles quadrimaculatus
Branford, July 13, 20, 27, 1946; Guilford, July 26, August 16, 1946; New Haven, August 16, 1946; Plainville, June 24, July 1, 8, 27, 29, August 3, 10, 1946; Windsor, June 28, July 5, August 10, 1946; Berlin, June 27, July 11, 18, 25, 27, August 1, 10, 1946; Wethersfield, August 3, 1946.

Tests on the Airplane Application of DDT on Large Open Breeding and Non-Breeding Areas for Control of Salt Marsh Mosquitoes

The control of salt marsh mosquitoes is mainly a matter of so ditching the salt marshes where the mosquitoes breed that no stagnant water remains on them. The access of each successive tide prevents the water in the ditches and pools from standing long enough to permit the completion of the life cycle of the mosquito and also permits small fish to enter and devour the larvae. The efficiency of this method, first propounded by J. B. Smith in 1904,[1] has recently been borne out in a study by W. A. Connell of the Delaware Agricultural Experiment Station.[2] Connell found that larvae failed to appear in portions of a salt marsh which were flooded by tides as frequently as 25 days per lunar month, and that abundant breeding can be expected only in portions of a salt marsh where frequency of tidal inundations is less than eight days per lunar month.

Ditching of the salt marshes for mosquito control is largely completed in Connecticut, and the work now consists principally of the maintenance of this extensive salt marsh drainage system. The State of Connecticut maintains 11,000 acres of ditched marsh land, and experience shows that, on the average, drainage ditches in salt marshes must have blocked debris removed at least once a year and some must be recut every three years. During the past several years very little systematic routine work of reconditioning ditches, re-

[1] Smith, J. B. 1904. Report of the N.J. Agricultural Experiment Station upon the mosquitoes occurring within the state, their habits, life history, etc. 482 pp. 134 fgs.

[2] Connell, W. A. 1940. Tidal Inundations as a Factor Limiting the Distribution of Aedes spp. on a Delaware salt marsh. N.J. Mosquito Extermin. Assoc.: Proc. 27th Ann. Meeting. 166-177.

pairing dikes and tide gates could be undertaken, and operations have necessarily been confined to areas where mosquito breeding was discovered or threatened to develop. This past year, 1946, several areas along the Connecticut shore line had become infested with large populations of mosquitoes. Once the mosquitoes were on the wing, salt marsh drainage had little effect in immediately reducing their abundance and it became necessary to explore the possibility of employing other control measures.

Shortly after our entry into the war, studies were initiated by the Federal Bureau of Entomology and Plant Quarantine for the purpose of developing control measures for certain pests of importance to the armed forces. Investigations on insecticides and repellents were begun at the Orlando, Fla., Laboratory early in 1942, and a number of materials were recommended for practical applications. Of the various insects considered in these investigations, much emphasis was placed on the mosquito and, of the various chemicals evaluated as insecticides, DDT was outstanding in performance.

The development of DDT greatly stimulated an increased interest in the use of airplanes in controlling mosquitoes and airplane spraying with DDT is now a practical control method. Studies by members of the Orlando Laboratory demonstrated during 1943 that satisfactory control over adult salt marsh mosquitoes can be obtained by airplane application of sprays containing a 5% solution of DDT in fuel oil at the rate of two quarts per acre.[1] In 1944 in Panama both the Army and Navy demonstrated more than 95% control of adult mosquito populations with airplane application of DDT.[2] In 1945 the Suffolk County Mosquito Extermination Commission reported that they had been able to control adult salt marsh mosquitoes with application by airplane of 1/25 pound of DDT dissolved in two quarts of fuel oil to an acre of salt marsh.[2] The tests herein reported were conducted as a pilot study to determine the efficiency of this method in this State.

Materials and Methods

The spray material used in this test was a solution of 5 per cent DDT dissolved in oil and was prepared by mixing 206 gallons of 25 per cent oil soluble DDT concentrate with 1,000 gallons of No. 2 fuel oil. The spray material weighed 7.3 pounds per gallon and contained .36 pounds of DDT per gallon. Both the DDT concentrate and the fuel oil were pumped into a 1,200 gallon tank truck at the same time to insure good mixing.

The plane employed in this test was a navy N3N primary trainer (a two cockpit bi-plane) equipped with breaker bar spray booms beneath each wing and a propeller-driven pump powered by the slip stream of the airplane in flight.[3] New Haven Airport, a distance of about 12 air miles from the spray area, was our base of operations for the test. The spray tank on the airplane was filled by a truck tank equipped with a power pump. Operations were begun at 5:00 A.M. on the morning of August 21 to utilize the most favorable atmospheric conditions.

Spraying of the test area required 16 trips with an average load of 67 gallons of spray material per trip, each trip requiring an average of 37 minutes from take-off to landing. Starting on the western boundary of the spray

---

1 Stage, H. H. 1945. The Development of DDT as a Mosquito Control Agent. N.J. Mosquito Extermin. Assoc.: Proc. 32nd Ann. Meeting 62-73.

2 Report of the Suffolk County Mosquito Extermination Commission 17 pp. 8 fgs. 1945.

3 The plane and pilot were hired from the Tyler Flight Service Company of Massapequa Park, Long Island.

area and flying north and south, 50-60 foot swaths were laid down at tree top level and lower in the open meadows. The spraying of the test area required 10 hours and 40 minutes and 1,030 gallons of spray material applied at the rate of 113 acres an hour. The dosage was .85 gallons or .3 pounds of DDT per acre.

At the completion of the spray operation two hours and 20 minutes of contracted spray time and 136[1] gallons of spray material were left unused. It was decided to use the unexpended time and materials to spray about 250 acres of salt marsh and cottage area at Mulberry Point, a shore community just east of the test area. A total of 1,450 acres was sprayed and 1,206 gallons of spray material were used at the cost of $0.68 per acre.

COST OF AIRPLANE APPLICATION OF DDT ON 1,450 ACRES AT GUILFORD, CONNECTICUT

13 hrs.	Spray Time	@ $40.00 per hr.	$520.00
2 hrs.	Ferry Time	@ 25.00 per hr.	50.00
1000 gals.	#2 Fuel Oil	@ .087 per gallon	87.00
206 gals.	DDT Oil Conc.	@ 1.54 per gallon	317.00
Freight			11.59
	Total Cost		$985.59
Total Acres Sprayed			1450
Cost Per Acre			$0.68[1]

The application was begun on the morning of August 21. Larval and adult populations were heavy at the time. The first plane load took off at 5:40 A.M. and checking of the results was begun immediately by five men who were stationed in the spray area during operations. The responsibility of this crew was twofold. First, they were to watch the spraying to see that the material was going into the right areas and, secondly, they were to inspect all the breeding places previously located to determine what the immediate results were.

Description of the Area

The spray area of about 1,200 acres in Guilford, included Shell Beach, Leete's Island, Great Harbor, Sachem's Head, Vineyard Point and Indian Cove. This area is bound on the north by the New York, New Haven and Hartford Railroad tracks, on the south by the waters of Long Island Sound, on the west by Leete's Island Road and on the east by Indian Cove marsh.

The tests were made in this area for several reasons. First, the area contains salt marsh, woodland, pasture, fresh water swamp and cottage sites and is representative of most salt marsh areas along the Connecticut shore. Secondly, as established by a survey carried out in July and August of 1946, the area contained several large breeding places and was heavily infested with large numbers of adult salt marsh mosquitoes. Thirdly, because the land mass of the area projects into Long Island Sound, it is protected to some extent from cross contamination by adult mosquitoes migrating from surrounding areas.

1 Forty gallons of spray material were lost when the union between the tank and the pump became unscrewed during a flight.

2 The cost per acre includes the cost of 40 gallons of spray material which was lost during the operation. The cost per acre is $.67 when figured less the 40 gallons.

Survey

In order to provide a basis for comparison, to locate the important breeding places and to obtain direct information as to the species causing the annoyance and their relative abundance, our survey was begun on July 26 and completed August 21. By carefully scouting the area, the breeding places were located and mapped. The comparative abundance of larvae in each section was estimated by the usual dipping methods. In order to obtain a fair sample of the larvae present in a breeding place, the dips were well distributed over the breeding area and the number of dips made depended on the size and type of breeding place and the abundance of larvae.

The relative abundance and species of the adult mosquitoes causing the annoyance was determined by several nocturnal and diurnal biting collections. Biting collections were made over a period of 20 minutes per test by two persons, one collecting from the other with an ethyl acetate tube as the mosquitoes began to feed. The infestation in each section of the area was classified as Very Heavy, Heavy, Moderate, Light and Very Light, depending on the numbers of bites experienced. When mosquitoes arrived in clouds and could not be counted it was called a Very Heavy infestation; around 15 to 20 bites was called a Heavy infestation; 10 bites was a Moderate infestation; 5 bites, a Light infestation, and less than 5 a Very Light infestation. Daylight biting collections were made by first disturbing the vegetation and then estimating the relative abundance in each section by the same method described above.

To simplify the survey, the entire area was divided into sections and each section given a number.

Area	Section
Shell Beach	1
Leete's Island	2
Route #140, both sides	3
West Side Great Harbor	4
East Side Great Harbor	5
Sachem's Head Road, both sides	6
Vineyard Point	7
Indian Cove	8

The results of the survey are summarized in Tables 17 and 18. From an examination of them it can be seen that the area was heavily infested with mosquitoes, chiefly of salt marsh origin. Larval populations were heavy in Sections 1, 2, 6 and 7 with some light concentration of larvae in Sections 3 and 8. The amount of breeding in Sections 3 and 8 was negligible until after the middle of August when a very heavy rain storm filled up the low areas in these sections. No mosquito larvae were found during the survey in Sections 4 and 5. These sections are reached by the full sweep of every tide and abound in many small fish.

There was a heavy infestation of adults in every section of the test area except Section 2. The reason for the few adult mosquitoes in this section can be traced to an application of 5 per cent DDT applied on July 18 about a month before the test with a Todd Insecticidal Fog Applicator. Fifty acres of breeding area, cottage area and woodland were thoroughly fogged with 5 per cent DDT in kerosene and 100 per cent kill of adults and larvae was affected.

Table 17. Relative Abundance of Mosquitoes in Each Section of the Test Area

Section no.	Larvae and pupae	Adults[1]	Larvae and pupae	Adults[2]	Larvae and pupae	Adults[3]	Larvae and pupae	Adults[1]	Larvae and pupae	Adults[2]
	July 26		July 31		August 6		August 15		August 21	
1	VH	H	VL	H		H	VH	H	VH	H
2	N	VL	VL	VL		VL	VL	VL	H	L
3	N	H				H	N	H	L	H
4	N	H				H	N	H	N	H
5	N	H				H	N	H	N	H
6	H	H				VH	H	VH	N	VH
7	H	H				VH	H	VH	H	VH
8	VL	H				VH	VL	VH	L	VH

[1] Diurnal and nocturnal biting collection.
[2] Diurnal biting collection.
[3] Nocturnal biting collection.
NOTE: VH-Very Heavy, H-Heavy, M-Moderate, L-Light, VL-Very Light, N-None.

Table 18 lists the species found in each section of the test area in order of abundance. By far the most numerous species was the *Aedes sollicitans*, which was many times more abundant than all the other species combined. Nine out of every ten attacks made by mosquitoes during daylight and evening population checks were made by this species.

Table 18. Species of Mosquitoes Found in the Test Area Tabulated by Section in the Order of Abundance[1]

Section No.	Species Found
1	*Aedes sollicitans*
2	*Aedes sollicitans* *Aedes cantator* *Aedes vexans* *Culex pipiens*
3	*Aedes sollicitans* *Culex apicalis*
4	*Aedes sollicitans*
5	*Aedes sollicitans*
6	*Aedes sollicitans* *Aedes cantator* *Culex pipiens* *Culex apicalis* *Uranotaenia sapphirina* *Anopheles quadrimaculatus*
7	*Aedes sollicitans* *Aedes cantator* *Culex pipiens*
8	*Aedes sollicitans*

[1] Table 18 is based on all collections of both larvae and adults collected during the survey.

Adult populations were greater in Sections 6, 7 and 8 than in any other section of the test area in spite of the fact that the heaviest breeding occurred in Section 1, which was the largest breeding place. The answer to this is perhaps the fact that the flight range of *Aedes sollicitans* is as great as 50 miles when carried along on a wind. Sections 6, 7 and 8 comprise the eastern part of the test area and the prevailing summer wind is from the west. This may account for the heavier infestation in the easterly sections.

Results

The application of 5 per cent DDT was completed at 2:30 P.M., August 22, 1946, and reports from the crew in the area indicated that coverage was excellent in all sections except 7. According to the crew, coverage in this section was spotty especially along the northern edges of Vineyard Point marsh, the main breeding place in Section 7. This observation was later borne out by the comparatively inferior results obtained in Section 7.

The results are summarized in the following table. From the data it can be seen that highly satisfactory control of larvae was obtained within 24 hours of application and that the residue from the treatment prevented larval development for about 20 days. The breeding found 24 hours after application and recorded in Table 19 means, for the greatest part, pupae. Observations made after 24 hours showed practically all the larvae dead, and the remaining few very sluggish in their movements. Pupae were not appreciably affected and no doubt went on to emerge later and probably account for the very few adults found around the breeding places four days after applications. Observations made after 20 days indicated that a slow return to normal numbers of larvae was just beginning, and in several places larval populations had increased from light breeding on the 20th day to moderate breeding on the 36th day, still nowhere approaching pre-test levels.

TABLE 19. RESULTS OF THE AIRPLANE APPLICATION OF 5% DDT SHOWING THE RELATIVE ABUNDANCE OF MOSQUITOES IN EACH SECTION OF THE TEST AREA UP TO 36 DAYS AFTER APPLICATION

Section No.	Larvae and pupae	Adults	Larvae and pupae	Adults	Larvae and pupae	Adults	Larvae and pupae	Adults	Larvae and pupae	Adults
	Within 4 Hrs.		1 Day		2 Days		4 Days		5 Days	
1	H	VL	M[1]	VL	VL	VL	N	VL	N	N
2	H	VL	M[1]	N	N	N	N	N	N	N
3	L	N	VL	N	N	N	N	N	N	N
4	N	N	N	N	N	N	N	N	N	N
5	N	N	N	N	N	N	N	N	N	N
	8 Days		14 & 15 Days		20 & 22 Days		29 Days		36 Days	
1	N	N	N	N	L	VL	L	VL	L	L
2	N	N	N	N	N	VL	VL	VL	VL	VL
3	N	N	N	VL	N	VL	N	VL	N	L
4	N	N	N	N	N	VL	N	VL	N	VL
5	N	N	N	VL	N	VL	N	L	N	L
	Within 4 Hrs.		1 Day		3 Days		4 Days		7 Days	
6	H	VL	VL[1]	N	N	N	N	N	N	N
7[2]	H	VL	VL	VL	L	VL	L	VL	L	VL
8	L	N	VL	N	N	N	N	N	N	N
	13 & 14 Days		19 Days		21 Days		28 Days		35 Days	
6	N	N	VL	VL	VL	VL	VL	L	VL	L
7	L	VL	L	L	L	L	M	L	M	L
8	N	N	N	VL	N	VL	N	VL	N	VL

1 Principally pupae.
2 Spotty coverage.
NOTE: VH-Very Heavy, H-Heavy, M-Moderate, L-Light, VL-Very Light, N-None.

Table 19 shows the striking changes in the adult populations that took place almost immediately after the operation. Observations made within four hours of application indicate that adult salt marsh mosquitoes can be practically eliminated in a very few hours with an aerial application of .3 lbs of DDT per acre. The adult population continued to decrease after 24 hours until no adults were found anywhere in the spray area except for a few newly emerged adults close to the breeding places. Five days after application no live adults were found in the spray area except around the breeding place in section 7. This situation continued to exist for about 15 days indicating that we had obtained a residual effect strong enough to take care of any emerging adults and the nightly influx of mosquitoes migrating into the treated area. Observations made 19, 20 and 22 days after application found adult mosquitoes appearing again in small numbers indicating that a slow return to normal abundance was beginning. The last observation was made 36 days after application at which time the adult populations were still increasing but were yet light and did not begin to approach the number found in the area before the spray operation.

Discussion

Because of the marked residual action of DDT, the dual destruction of larval and adult populations was so great that, not only was perfect control obtained for about two weeks, but the development of these populations was so retarded that as long as five weeks after application the number of mosquitoes in the spray area was negligible. From an operational point of view, the principal merits of this method of treatment are economy, minimal manpower requirements, and the rapid protection afforded against mosquito annoyance. In terms of economy, the average cost of airplane spraying with DDT is in the neighborhood of $0.68 per acre.

Ditching and draining the salt marshes still remains the fundamental method of mosquito abatement work in Connecticut. The State Board of Mosquito Control has no intention of allowing its salt marsh system to deteriorate. It is not suggested in this report that salt marsh drainage should be supplanted by airplane application of DDT, but that airplane application should be employed as a supplementary control in areas where necessary. Under present conditions it is probable that this method of mosquito control would not be employed in more than two or three areas of the State during any one breeding season, making a probable total of between two or three thousand acres at a cost of about $2000.00 a year.

This past summer several occasions for employing ground equipment to control adult mosquitoes outdoors with DDT presented themselves and now enable us to make certain limited comparisons between the application with ground equipment and with aircraft. On July 12, 1946, using a high velocity turbine blower capable of producing a 180 MPH air blast and of spraying to a depth of 200 feet from a roadside, 80 acres along both sides of Grove Beach Road, Clinton, were sprayed with a 5 per cent solution of DDT in No. 2 fuel oil.

Satisfactory control of adult mosquitoes was achieved for about one week at the end of which time adult mosquitoes were found in the sprayed area in moderate numbers. An evening biting collection made 13 days after spraying found adult mosquitoes as numerous as before the spraying. This job was arranged as a demonstration at a cost to the State Board of Mosquito Control of only 60 dollars for materials.

On July 18, 1946, employing a fog applicator capable of producing a heavy penetrating fog, 50 acres of cottage area and woodland on Leete's Island, Guilford, were fogged with a 5 per cent solution of DDT in kerosene. This job was a demonstration at no cost to the State Board of Mosquito Control. Very satisfactory control of adult mosquitoes was obtained for about 12 days and biting collections made 18 and 27 days later still found adult mosquitoes light in numbers in the sprayed area.

Using the same turbine blower as above, on August 9, 1946, about 85 acres of cottage area at Beach Park, Clinton, were sprayed with 5 per cent solution of DDT in No. 2 fuel oil. Satisfactory control was obtained. The area was sprayed for $165 at the rate of 30 dollars per hour for 5½ hours, making a total of 85 acres sprayed at $1.95 per acre.

Despite our rather limited experience with both ground and aircraft applications of DDT, certain facts seem evident. The airplane seems to be the apparatus of choice for spraying large areas because of the rapidity and economy with which the job can be done and the ease with which the airplane reaches areas inaccessible to ground equipment. On the other hand, the cost of spraying small areas by airplane is prohibitive, and ground equipment must be employed. Another fact that seems apparent is that longer periods of control are obtained when larger areas are sprayed with DDT. The longer lasting control of larger areas can probably be explained by the fact that the amount of residual DDT is great enough and complete enough in depth to prevent adult mosquitoes from penetrating the sprayed area for any appreciable distance from the unsprayed surrounding areas. This seems to be well demonstrated by a comparison of the results of the spraying of Grove Beach Road in Clinton on July 12, 1946, with the fogging of Leete's Island, Guilford, on July 18, 1946. The Grove Beach area was a narrow strip 400 feet wide and 1.7 miles long, whereas the fogged area on Leete's Island, Guilford, was roughly the shape of a triangle approximately .4 of a mile deep. Five per cent DDT was used on both jobs. At Grove Beach, Clinton, satisfactory control of adult mosquitoes was achieved for about a week and adult mosquitoes were as numerous as ever 13 days after spraying. On Leete's Island, Guilford, very satisfactory control of adult mosquitoes was obtained for about 12 days and biting collections made 18 and 27 days after the fogging still found adult mosquitoes few in numbers. No burning of vegetation from oil was observed with either the turbine mist blower or the fog applicator. If, however, the truck on which the turbine machine is mounted is allowed to stand still, while the blower is in operation, it will soak the vegetation with oil and result in burning.

During the course of these tests an opportunity to study the effects of DDT on wildlife native to the Great Harbor area was offered to the State Board of Fisheries and Game by the State Board of Mosquito Control.[1] The State Board of Fisheries and Game was especially interested in the effect of DDT on small mammals, water fowl, and lower vertebrate and invertebrate forms of possible ecological importance to coastal water fowl. Tests were begun on August 18 and completed on August 23. The following conclusions drawn from the data are of little more than assumptive value because the project was undertaken with little advance notice and the data are too meager for statistical analysis.

1. The mortality arising from the spraying of 5 per cent DDT with ap-

[1] Hall, A. E. and Wilder, N.G. 1946. Report of Experimental Results in Connecticut with DDT Spraying at Great Harbor, Connecticut. State Board of Fisheries and Game, Hartford, Connecticut. 5 pp.

proximate 100 per cent coverage of a relatively large area is greatest among the lower invertebrate forms from the Diptera on down the phylogenetic scale. The invertebrates observed to have been killed by DDT poisoning belong in the following group:

Amphipoda	Ephermerida	Odonata
Arachnida	Gastropoda	Decapoda
Belastomidae	Gerridae	Polychaeta
Corixidae	Grilliade	Stratiomyidae
Culicidae	Gyrinidae	Tabanidae
Dytiscidae	Notonectidae	

2. Higher vertebrate and invertebrate forms appear to have suffered little toxic effect. There was some noticeable mortality among the smaller fish, notably *Cyprinodon variegatus, Fundulus heteroclitus* and *Menidia berylina,* but this was relatively unimportant in comparison with the population densities of these species.

3. The toxic effect of DDT is greatest on quiet shallow restricted waters such as tidal pools on marshes and beaches.

JAPANESE BEETLE INFESTATION IN CONNECTICUT, 1946

J. C. Schread

The following report is of some interest in regard to the rate of dispersion and intensity of infestation of this insect. The Japanese beetle was first found in Connecticut at Stamford in 1926. In 1927 beetles were found in Bridgeport, and in 1928 in the cities of New Haven, Hartford and New London. Inasmuch as only 58 beetles were found in the last three cities in 1928, it is reasonable to assume that the infestation was found in the year of its first occurrence or the year after. In spite of the fact that quarantines were in force for several years following the original discovery in Connecticut, the insect spread to the East fairly rapidly, presumably carried by man in some cases. Yet it took about 20 years after the establishment in Bridgeport for the insect to spread to Waterbury and become a serious pest there, a distance of only 25 miles. This phenomenon has also been evidenced in other parts of the State. The dispersion of the Japanese beetle and its establishment in large numbers in any locality depend a great deal upon the climate, means of transportation, the abundance of suitable turf in which to lay eggs, and of host plants upon the foliage of which the adults feed, as well as upon the power of flight of the beetle itself. It is obviously very difficult either to predict the rate of spread or to determine precisely what is responsible for it.

The general level of the Japanese beetle in Connecticut in 1946 was noticeably higher than for several years. This was due to some extent to a comparatively wet summer in 1945 preceding a decidedly wet season in 1946.

Infestation in Southwestern Part of State

Extensive feeding occurred in the towns comprising the Naugatuck Valley, including Waterbury, especially so in the northwestern part of the town and continuing over the town line into Watertown. Foliage injury was very light at the Wolcott-Waterbury town line which is northeast of Waterbury center. Wolcott proper showed virtually no damage by beetles, but beyond Wolcott in the town of Bristol a sudden rise in beetle population resulted in heavy to moderate injury in most of the latter town with the exception of the northern part where damage was much less. Eastwardly from Bristol the infestation was light until in the town of Farmington it became heavy again.

Infestation from New Haven westwardly through Orange to Milford and Derby was heavy; 50-75 per cent stripping of host trees was noticeable in some sections, whereas in other parts of the area grapevines seemed to be more severely attacked. Through west and northwest Shelton the infestation was heavy. In this area stripping of many host trees was estimated to be as high as 90 per cent. From Shelton into the town of Huntington foliage injury was moderately heavy to light. Defoliation of grape in this section varied from 20 to 100 per cent. In the Huntington, Monroe and Stepney area infestation was generally light to moderate with a definite rise in damage in Stepney where feeding was considerably heavier than in 1945. In these towns stripping was as high as 50 per cent in fruit and ornamental shade trees.

In the vicinity of Highland Golf Course in the northwestern part of the town of Shelton, foliage injury was extensive and heavy on shade trees. Sassafras trees were 75-90 per cent defoliated; oak 10-20 per cent, and sour gum 20 per cent. Between Shelton and Bridgeport extensive beetle feeding occurred throughout the entire area. Grape was stripped 50-75 per cent and five-leaf ivy (Virginia creeper) virtually 100 per cent. Feeding in host trees was light to moderate with an occasional specimen tree seriously damaged.

At the Monroe-Seymour town line Japanese beetle injury was moderate. From thence into Newtown feeding was very light with a slight increase in Newtown and variable beyond to east Danbury where damage became intensified. The Danbury to Bethel infestation on the east side of the towns was continuously heavy, becoming lighter through the center of Bethel and Redding. At Easton a rise in beetle population was noticeable as measured by damage to vegetation. In most of the town of Easton and across the Fairfield town line damage was observed to be from moderate to heavy. On the north side of the town of Fairfield the infestation was very heavy, dropping away to light towards the center of the town, where a much reduced infestation over 1945 was observed.

The infestation in the City of Bridgeport was greatly reduced below that of 1945. Decline in foliage injury was especially noticeable in the city parks. Virtually no widespread feeding occurred on horse chestnut and linden, what little existed was not perceptible at a distance and could be seen only on close examination. This was the first time since the late 1930's that extensive injury to these two species of trees has not occurred here. A decline in beetle infestation in Bridgeport and near vicinity has been reasonably rapid during the last three to four years.

The Merritt Parkway, serving as a cross section of Fairfield County which it traverses, showed the Japanese beetle infestation to be generally light. Heaviest injury was seen in Darien with some sassafras 25 to 35 per cent defoliated. Most of the feeding on the Parkway was confined to grape, varying from 5 to 25 per cent. The Parkway infestation in 1946 was hardly noticeable on trees and somewhat lower than in 1945.

Infestation in Northwestern Part of State

In the western part of Connecticut near the New York State line and north of Danbury the Japanese beetle infestation was light and continued to be so until the town of Brookfield was reached where injury became more noticeable as the season advanced. By late August moderate to heavy foliage injury was observed in this town. From Brookfield to New Milford and including the latter, moderate to heavy feeding prevailed. North of New Milford and into the town of Gaylordsville the infestation was light to very light.

Beetle infestation in Salisbury, North Canaan, Canaan, Sharon, Cornwall and Kent was spotted and light to extremely light. In this part of Connecticut there are isolated infestations which may ultimately spread and close in the uninfested intervening areas.

Infestation in South-Central and Southeastern Part of State

Beetle infestation in New Haven was heavy and from light to moderate in nearby Branford. On the east side of Branford it was mostly light but built up rapidly to heavy in Guilford. From the town of Guilford to the western side of Madison the infestation varied from light to heavy. In the center of Madison damage to foliage was quite severe. From east Madison to the city of New London the infestation for the most part declined sharply. It was difficult to find beetles in the town of Westbrook. At the Connecticut River, however, beetles were seen in some abundance and a definite increase in population became evident in western and southwestern New London where damage was quite general on trees and readily seen at a distance in all directions.

Infestation in Central and Northern Part of State

A light to heavy infestation existed from New Haven to Hartford, with rapid increase in beetle abundance especially noticeable from Southington to Plainville, remaining heavy from there on and reaching a high degree of injury in West Hartford and Bloomfield. From the Hartford-Windsor town line to the Connecticut-Massachusetts State line observations indicated an increase in beetle abundance over 1945.

A heavy infestation is gradually moving eastward from the Connecticut River to and including Thompsonville. From thence it becomes less heavy to moderate at Somersville. Between the latter town and Stafford town line the beetle infestation is much lighter, injury to vegetation being much less noticeable. From Stafford to and including the town of Union, which is but a few miles from the Massachusetts State line, the infestation was light and remained light throughout the summer of 1946.

The infestation from New Haven to Middletown was generally heavy as measured by evidence of adult feeding. Favored food trees displayed varying degrees of foliage injury in the entire area. In the area comprising Middletown and Portland evidence of extensive beetle feeding could be seen on shade trees. From Portland to beyond the center of East Hampton foliage injury continued heavy. It varied from moderate to heavy in the center of the town of Marlborough. Beyond this point damage tapered off until at the Hebron town line it became light and continued as such to and including Willimantic.

Infestation in Northeastern Part of State

From Willimantic to north Windham and in Brooklyn virtually no evidence of feeding could be found. No beetles were seen over most of the area. At Putnam, however, a light infestation continues to persist as it has for a number of years. The Japanese beetle infestation at Storrs is gaining slowly. It is of several years' standing and shows promise of becoming a serious problem on the University campus and in the near vicinity.

JAPANESE BEETLE INVESTIGATIONS

J. C. Schread

Owing to unfavorable weather conditions parasites of the Japanese beetle were not as concentrated in the spring of 1946 as usual. Adults of *Tiphia vernalis*, a parasite of the larva, were found at only eight colonization sites and never in great enough abundance to permit collecting for recolonization. The so-called late summer or fall Tiphia, *T. popilliavora*, showed a marked tendency towards increase in numbers in the Bridgeport area where for several years past the species had been at a low population level. Failure of the parasite to multiply during several seasons prior to 1946 is attributed to a great extent to cutting of wild carrot flower stalks at the time the flowers began to open, thus depriving the adult wasps of the only food plant on which they are known to subsist.

Fourteen new colonizations of *T. vernalis*, of 200 females each, were made in scattered parts of the area of heaviest beetle infestation in Connecticut. All were provided by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture.

Centeter cinerea, a fly parasite of adult Japanese beetles, was recovered from several colonization sites in Hartford County. A total of 579 parasitized adult beetles were collected and redistributed in Waterbury and Orange. Potentially the parasite is an important natural factor in local reduction of adult beetle populations. Centeter has spread outwardly from a colonization site of nine years' standing at Riverside Park in Hartford in a radius of three miles, which includes natural migration eastwardly across the Connecticut River. The Bureau of Entomology released a colony of adult Centeter in the town of Greenwich in an area of extensive beetle feeding.

The "milky" disease of Japanese beetle grubs continues to show a high degree of effectiveness in experimental plots established six to eight years ago in Fairfield, New Haven and Hartford counties. A 70 per cent average incidence of disease was observed in June at a time when soil temperature conditions were most favorable for bacterial action. Accumulated evidence shows that generally there has been a decided decline in Japanese beetle population during the last three years in Fairfield County, where, in all but six towns, the "milky" disease organism was broadcast in 1941 and 1942. To what extent this may be attributed to the bacterium has not been determined, although the disease has been an obvious factor in control.

DDT was used experimentally to reduce Japanese beetle grub populations in golf course fairways and greens. It would appear from the results of the experiments that the material, when employed as a means of rapid elimination of grub infestations in turf, is very promising. In one instance when 10 per cent DDT dust was used at the rate of 250 pounds per acre, application made May 20, 75 per cent mortality was obtained in five weeks. At the time of the treatment the grubs averaged 65 per square foot of turf; 14 days later the population was down to 44 per square foot; 25 days from the time of treatment the grub count was 24 per square foot; and on June 26, 36 days from the day of treatment the grub population had been reduced to an average of 16 grubs per square foot of turf. In the succeeding Japanese beetle grub generation, laid down during July and August, the residual power of the DDT treatment reduced the grub population from a high of 72-75 average per square foot of turf to two by September 18. Concurrently, an average of 79 grubs per square foot of turf existed in the check plots.

Preliminary experiments in early August with benzene hexachloride as an insecticide for control of Japanese beetle grub infestations were for the most part negative in result. At 8, 16 and 24 pounds per acre of the crude compound, containing actually 5.75 per cent gamma isomer, the grub population in late September was virtually the same in the treated and check plots.

DDT used at the rate of 1-3/5 pounds of the actual material to the acre, when dissolved in kerosene and applied with a mist blower, gave complete protection of vegetation from attack by adult Japanese beetles for a period of three weeks. Subsequently, the insects returned to the area in greatly delayed and reduced numbers.

SULFATHIAZOLE AS A CONTROL FOR AMERICAN FOUL BROOD DISEASE OF HONEYBEES

J. Peter Johnson

The treatment of colonies of honeybees infected with American foul brood disease, using sulfathiazole (1) as a medication, has been under investigation at this Station since early in 1945. (2) Colonies treated in 1945 with sulfathiazole at the rate of 0.5 gram to one gallon of sugar and water (mixed at the rate of 1 to 1 by volume) and 0.5 gram of sulfathiazole to one gallon of water have been under observation for two complete seasons. Eight infested colonies, with hives containing two or more body sections, were used in the first experiment. Two colonies were fed the sulfathiazole-sugar-water mixture; four colonies were supplied with both the sulfathiazole-sugar-water and the sulfathiazole-water mixture; one colony was sprayed with the sulfathiazole-water mixture, and one colony served as an untreated control.

In 1946, 13 additional colonies were used. Two colonies were treated with sulfathiazole at the rate of 0.5 gram to one gallon of sugar and water. Three other infected hives, each of which received a three-pound package of bees with a laying queen, were treated with 0.5 gram, 1.0 gram and 2 grams of sulfathiazole per gallon of sugar syrup, respectively. Two colonies were treated with 0.5 gram furacin (5-nitro 2-furaldehyde semicarbazone) to one gallon of sugar syrup. As the furacin failed to show any ability to control the disease, this treatment was stopped and sodium sulfathiazole was then fed to the hives. Two hives, each consisting of a single brood body, and populated with a five-pound package of bees and a laying queen, were given six treated frames. The frames obtained from diseased hives had been treated previously by submerging them in two separate baths containing 0.5 gram and 1.0 gram of sulfathiazole per gallon of water respectively, for one week at room temperature. As these baths did not control the disease, the hives were later treated with sulfaguanidine. One hive, containing diseased frames which had been treated by deep therapy X-ray equipment for a total dosage of 2800 R units, into which a five-pound package of bees and a laying queen were placed, was under observation for a part of the season. The hive receiving the X-ray treatment continued to be diseased, and as a result sulfapyridine was fed at the rate of half a gram per gallon of sugar syrup. In addition, one other colony was also fed sulfapyridine. One colony was treated with penicillin, buffered with calcium carbonate, at the rate of 50,000 units to one quart of the sugar syrup. One diseased hive, the control, was fed sugar syrup throughout the season.

Formulation of Sugar Syrup and Feeding Procedure

The sugar syrup used in all the experiments contained one part of sugar to one part of water by volume. This heavy syrup was used to be certain the syrups containing the drugs would compete with nectar flows and the bees consume it regularly. The mixtures containing sugar were usually fed in an inverted honey pail, the top of which had been finely perforated, placed on and over the hole of the inner cover and protected with a shallow super and the top cover of the hive. The sulfathiazole-water mixture was supplied to the bees in a Boardman feeder. A continuous supply of the medicated syrups, replenished as required, was made available to each of the colonies. The treatment, in each case, was continued for an arbitrary period after all visual signs of the disease were eliminated or, if it was evident that no progress was being made, discontinued and the colony subjected to other treatment.

Results of Treatment

All the colonies receiving sulfathiazole, regardless of the method of application, responded more or less favorably. There was definite improvement in the colonies which received the sulfathiazole in water without sugar but it was evident that insufficient amounts of the drug were taken through this medium, as the disease persisted throughout the season. The colonies which received the sulfathiazole in the sugar and water mixture improved rapidly and all visual evidence of the disease in these hives disappeared before the fall season. It was very evident that the amount of the disease present, colony strength and old stores present were important factors in progress of the treatment. The improvement of the conditions within the hives was more rapid in the stronger colonies. Weak colonies were slower in recovering and did not improve at a rapid pace until young bees were sufficiently numerous to accelerate hive sanitation and brood rearing.

Scale Removal

The new brood continued to be more or less infected until all scales were removed by the bees, usually a period of several weeks and dependent on colony population and the rapidity with which the frames were used in brood rearing. Progress in scale removal was noticeable within the first two weeks of the treatment. New scales would be found in the hive during the first stages of the treatment if hive workers were not present in sufficient numbers to remove all the dead larvae. If the treatment was interrupted or neglected when old stores or diseased material were present, a resurgence of diseased brood followed with a resulting increase of scales.

Effect of Stores in Hive

It is possible to follow the trend of the effect of the sulfathiazole medication during the brood rearing season. Normally, in brood rearing, the queen deposits eggs in a particular section of the comb, then travels to the opposite side and deposits a smiliar number. She is consistent in this practice and moves from section to section and from comb to comb, being regulated mainly by hive conditions and nectar flow. In general, a number of diseased larvae (usually capped and dead) were found in the section first used by the queen for egg deposition after the treatment was begun. Diseased larvae often were found the second and third time the section was used for brood rearing, but usually in smaller numbers. This did not necessarily follow in each section, especially in the strong colonies, where brood rearing was proceeding at a rapid pace. In such colonies all scales might be removed from several adjacent frames within a week or two and all the cells polished by the bees for egg deposition. When this occurred very few, possibly one or two, diseased larvae might be found on each side of these frames upon the first examination and none thereafter.

In the multiple-bodied hives, usually consisting of brood and food chambers, a relationship apparently existed between the amount of the old untreated stores and the number of larvae that became infected during the first stages of the treatment. This was very evident when the colony population was small and the hive and field workers were relatively few in number. Under such conditions the consumption of medicated syrup was slow, permitting a much higher percentage of the old infected stores to be fed to the brood. This was reflected in a high incidence of disease among the more recent brood. However, as the hive population increased, more medicated syrup was consumed and became more competitive with the old stores. As the relationship of the old stores and the medicated food changed, the number of diseased individuals in the brood progressively lessened until all evidence of the disease vanished.

Relationship of Hive Equipment

It also became evident that the amount of diseased equipment involved in a hive was an important factor in the time required for eliminating the disease. One hive under treatment, fairly strong in bees, consisted of a standard hive body and a deep food chamber. Both sections were badly infected with the disease and nearly all the frames contained hundreds of scales. The brood chamber had been invaded by mice and the combs in three frames were partially destroyed. As the treatment progressed, the scales and diseased brood were eliminated rapidly from the food chamber. The colony persisted in rearing all brood in the food chamber and all signs of the disease were eliminated from it while the brood chamber remained unused and full of scales. It was not until the positions of the sections were reversed that the bees began to rear brood in the former brood chamber, and this necessitated the continuance of the treatment until the disease was eliminated from it.

Hive Inspection and Results

Seasonal hive conditions in respect to the progress of the treatments in 1945 were observed by thorough examinations of all frames in each hive at approximately two-week intervals. In 1946 the examinations were made at three-week intervals. Additional equipment was placed on each hive as needed. The hives were prepared for winter by reducing the entrance to one-fourth by three inches and placing a burlap sack partially filled with dry leaves or hay in a shallow super over the inner cover on the food chamber. No other packing was used.

The seven hives originally treated in 1945 were all free of scales by September 24 or earlier and of diseased brood by October 22. The control (untreated) hive was weakened to such an extent that it was fumigated with cyanide on October 8. In 1946, no signs of foul brood were observed in hives number 1, 5 and 6 during the entire season. A few scales which had been covered with stores were observed in hive No. 4 on April 30, 1946. These were removed by the bees before the next observation and the hive remained free of disease for the remainder of the season. A few diseased cells were found in hive No. 3 at three different intervals in the season of 1946, the last on August 26. The hive was in excellent condition all through the season. Hives No. 2 and 7 were found to be infected on May 31, 1946, and the disease increased as the season progressed. There were no scales observed in hive No. 2, but scales were found in hive No. 7 as early as July 16. At the end of the season both of these hives contained strong colonies with ample winter stores and both had made 50 or more pounds of surplus honey.

In 1946 several of the experiments using materials or methods other than sulfathiazole failed to show any promise as control for American foul brood. Results in colonies receiving treatments of penicillin, sulfapyridine or furacin in a sugar syrup did not show these materials to be of any particular promise. Frames containing scales and diseased (dead) brood submerged in baths of water containing 0.5 and 1.0 gram per gallon of water for one week at room temperature did not respond to the treatment. Deep therapy X-ray treatment of 2800 R units failed to control the foul brood.

The two colonies treated with sulfathiazole in 1946 recovered from the disease. The colonies treated with sulfaguanidine and sodium sulfathiazole responded favorably. These treatments were not conducted long enough to determine whether or not the disease was entirely eliminated, but the scale removal and diseased brood elimination closely followed the pattern of recovery as when using sulfathiazole.

Sulfa Drugs in Honey

In view of the fact that sugar syrup, like nectar, is taken by the bees, made into honey and fed to the brood or stored as surplus, it was believed that any drug fed in such a syrup, to be effective, must maintain its identity in passing through the honey-making process. This is characteristic of sulfathiazole, as the brood receiving the drug in its food remained healthy regardless of the amount of diseased material surrounding it. Further, chemical analyses indicated the presence of the drug in the honey stored during the treatment. The chemical analyses of the surplus honey obtained in 1945 and 1946 from the experimental hives are given in Table 20.

All supers containing surplus honey were extracted individually and a sample was taken from each to be analyzed for possible drug content. Sulfa in varying amounts was found in each case where surplus honey was made during treatment. The amounts of the drug found in the extractions varied from 1 p. p. m. to 130 p. p. m. The large amount of 130 p. p. m. found in one super from hive 15 was due to the treatment containing 1 gram of sulfathiazole to one gallon of sugar syrup (twice the usual concentration fed) and a poor nectar flow. Super 2 of hive 15 contained only 15 p. p. m.: This was due to the treatment being terminated shortly after the super was added and followed by a heavy nectar flow.

TABLE 20. TREATMENTS AND CHEMICAL ANALYSES[1] FOR DRUGS IN THE SURPLUS HONEY

Hive No.	Year	Drug used	Total amounts of material fed[2]	Total amount of drug fed	Super No.	Amt. of drug in surplus honey
			Pints	Grams		p.p.m.
1	1945	Sulfathiazole	23	1.4375		1
	1946	”	14 (spring feeding)	.875		0
2	1945	”	63.5	3.96875		No surplus
	1946	”	0	0		0
3	1945	”	21.5	1.34375		4
	1946	”	0	0		0
4	1945	”	21.5	1.34375		6
	1946	”	0	0		No surplus
5	1945	”	45	2.8125		18
	1946	”	0	0		No surplus
6	1945	”	39	2.4375		10
	1946	”	0	0		Faint trace or none
7	1945	”	33	2.0625		2.5
	1946	”	0	0		0
8	1946	”	55	3.44		8
9	1946	”	49	3.06		5
11	1946	Sodium sulfathiazole	16	1.0	1	Less than 1
					2	7
15	1946	Sulfathiazole	63	7.88	1	130
					2	15
16	1946	”	58	14.50		8

[1] Analyses by the Analytical Chemistry Department.

[2] Hives number 1, 2, 3, and 4 received the drug in a sugar syrup and in a water supply. Hive number 7 was sprayed at weekly intervals with a water solution of the drug and given the medicated syrup in the fall season. All other hives, when being treated, received 0.5 gram of the specified drug per gallon of sugar syrup, excepting 15 and 16 which received 1.0 and 2.0 grams per gallon.

The concentration of 130 p. p. m. is equivalent to .059 gram per pound of honey. This concentration in relation to an initial medicinal dose (3) of 4 grams for an adult, or 1.7 grams for a child weighing 25 pounds, cannot be considered significant. However, if it is determined medically that an individual, after continuous intake of sub-medicinal concentrations of sulfathiazole, may possibly become "drug-fast", then the small amounts found in honey may be significant.

Literature Cited

(1) HASMAN, L. AND CHILDERS, L. F., 1944. Controlling American Foul Brood with Sulfa Drugs. Univ. of Missouri Agr. Expt. Sta. Bul. 482.

(2) JOHNSON, J. PETER AND STADEL, ROY. Sulfathiazole as a Medication for American Foul Brood Disease of Honeybees. Jour. Econ. Ent., Vol. 39, No. 2, pp. 141-144, April 1946.

(3) LEDERLE Laboratories, Inc., N. Y., 1946. Sulfonamides. pp. 22-24.

WIREWORMS ON POTATOES

D. E. Greenwood

Wireworm (*Limonius ectypus* Say.) control investigations in 1946 consisted mainly of laboratory and field studies of dosages and methods of applications for benzene hexachloride together with a small field trial of D-D mixture[1] and Iscobrome D[2].

D-D Mixture

D-D mixture was applied in late April by a hand injector at dosages of 12, 25 and 40 gallons per acre for the purpose of determining how little crude chemical would be required for commercial control of wireworms on typical potato soils in Connecticut. The soil at the time of application was in a physical condition suitable for planting.

Tubers from these plots were dug in late September, two or three weeks earlier than the normal digging season, and wireworm injury did not develop to the greatest possible degree. Tubers harvested from both the 25 and 40 gallons per acre plots were completely free from out of grade tubers and showed only a trace of wireworm injury. Seedpieces examined from these plots earlier in the season showed no larval feeding. From those plots treated with 12 gallons per acre, there was approximately 16 per cent total injury, 10 per cent of the tubers were out of grade U. S. No. 1 and a small amount of larval feeding occurred on the seedpieces. On untreated plots there was approximately 30 per cent total injury, 20 per cent of the tubers were out of grade and the seedpieces were fed on rather heavily.

The ideal dosage for our soils appears to lie somewhere between 12 and 25 gallons per acre, probably nearer 25 gallons in the more heavily infested soils.

Iscobrome D

A small field was treated in early May with a 10 per cent ethylene dibromide mixture applied at 15, 30 and 45 gallons per acre. This test was made especially to study the efficiency of a power applicator on our soils which contain a great many stones and considerable organic trash. Because of improper mechanical functioning and complete lack of sealing the soil after application, both attributable to our soil conditions, none of the treatments reduced injury to any degree in spite of the fact that all of them are capable of good control if properly applied.

Benzene Hexachloride

Preliminary greenhouse studies demonstrated that as little as one pound per acre of technical benzene hexachloride containing 10 per cent gamma isomer, if thoroughly mixed with soil to a depth of five inches and applied as a dilute dust, is sufficient to kill all wireworms confined in the treated soil. Incidental to this work, it was observed that larvae exposed to treated soil for less than two hours, and subsequently removed to fresh soil, did not develop symptoms of toxicity when kept under observation for several weeks. All exposures for a period of time longer than two hours resulted in definite symptoms of toxicity within the normal 24-48 hour period. All such affected

1 1,2-Dichloropropane—1,3-dichloropropylene.

2 Ethylene dibromide, 10 per cent in a naphtha carrier.

lavae died within 10 days to three weeks even when stored in fresh soil following exposure. Death appears to occur much sooner, usually in about eight to 10 days, when larvae are kept in treated soil continuously.

With one pound of technical benzene hexachloride per acre as a starting point, field dosages were scattered about this point so as to include a range of from one-third to six pounds technical benzene hexachloride per acre. Four methods of application were selected for this preliminary work: row treatment, broadcast, seedpiece treatment and poison baits.

Row Treatment

The most effective method of application was row treatment in which dilute dusts were placed in the open furrow by means of a rotary hand duster prior to dropping the seedpieces. Dosages ranged from one-third to six pounds of benzene hexachloride per acre. All treatments containing 1.3 or more pounds of material per acre resulted in almost perfect commercial

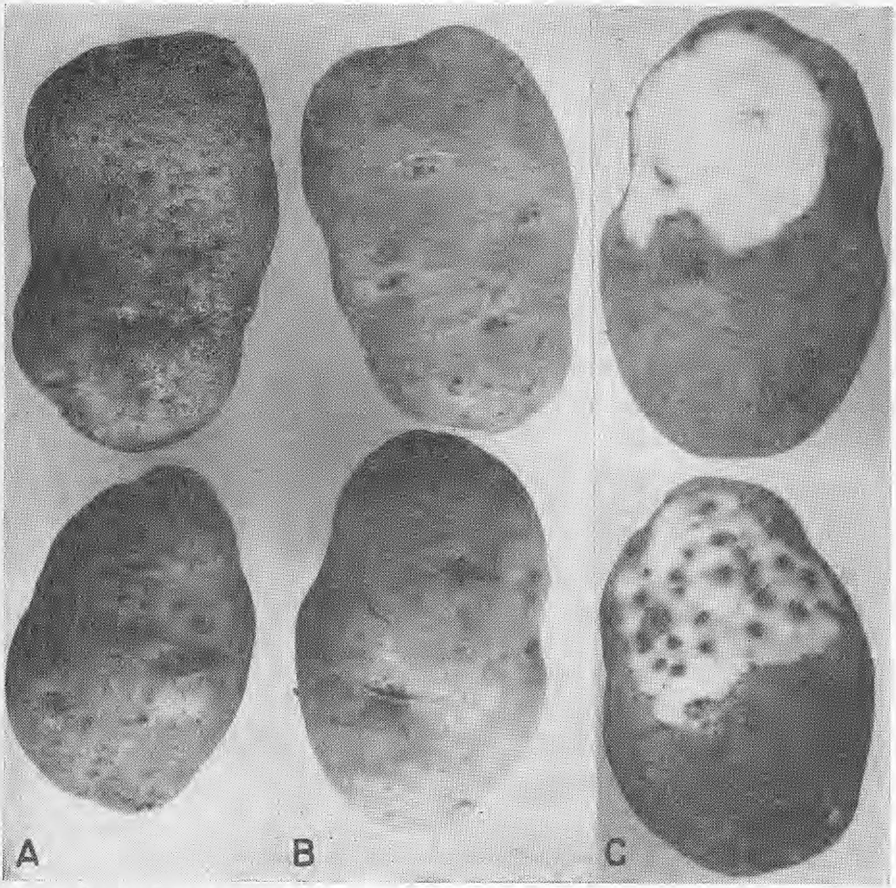


Figure 2. A. Typical tubers from untreated soil.
B. Tubers grown on soil treated with approximately three pounds of benzene hexachloride, applied in the row.
C. Peeled tubers from treated and untreated plots, showing the feeding channels in the tuber flesh.

control in contrast with 71 per cent total injury and over 50 per cent out of grade tubers in untreated soils. Treatments containing less than 1.3 pounds of benzene hexachloride per acre gave less control, in proportion to the amount of material applied, but in all cases were distinctly better than where no treatment was made. The field on which this test occurred was far more seriously infested than average so that under more normal conditions the lower dosages might be expected to result in commercial control; that is, on a crop in which not more than 6 per cent by weight of the tubers are injured to the point of being thrown out of grade U. S. No. 1.

Row treatment, though the most effective method of application tried, appears to be of limited use because of the fact that its success depends on the migration of a large percentage of the population to the seedpieces for the initial spring feeding period. Past handling of infested land should determine the use of this method. Where food other than the seedpieces is available, as is the case following a cover crop, the response of wireworms to the seedpieces is negligible and row treatment is not advised. Serious wireworm infestations often are not apparent until late in the season.

Broadcast

Broadcast treatments were made by applying dilute dusts to the soil, in this case with a grain drill, and thoroughly discing the soil immediately after application. Dosages ranged from approximately one-half to five pounds of technical benzene hexachloride per acre and treatments were often made the day of planting.

This method of application was found to be an effective way of incorporating benzene hexachloride into the soil to a depth of five or six inches. When two and one-half or more pounds of material per acre were applied in 200 to 250 pounds of bulk, the commercial control obtained was good. The total injury to tubers grown on soils treated in this manner and at this minimum dosage was slightly higher than on the more effective row treated plots but the percentage of out of grade tubers was still safely below the percentage tolerance for total defects (6 per cent) allowed for grade U.S. No. 1. Untreated soils on the two fields used for these treatments showed, respectively, 70 and 79 per cent total injury and 46 and 53 per cent out of grade. The reduction of injury to a point where the field run of tubers was within the tolerance for total defects testifies to the wide variety of instances in which this method of application can be generally useful.

Seedpiece Treatment

Seedpiece treatments consisted of a deposit of crude benzene hexachloride, on cut and calloused seed, either from a 50 per cent concentrate dust or a dip made from a wettable 50 per cent concentrate. The amount of material per unit area of surface was not determined. The reduction in wireworm injury obtained under the conditions of such a severe infestation was not sufficient for good commercial control but seedpiece treatment materially reduced the losses which would have occurred had no treatment been made, especially in the number of tubers showing extreme wireworm feeding. It is believed that seedpiece treatment will be cheap insurance against undue losses from wireworms and future build-up of large populations in those instances in which the present populations are moderate to low.

Poison Baits

Benzene hexachloride was incorporated into wheat bran at the ratio of 1:1000 by weight and individual baits placed alongside the seedpieces. This method of application involves considerable work and results in control about comparable to seedpiece treatment. It was found to be the least desirable method of application and will probably find little use.

Odor and Taste

The benzene hexachloride formulations used in this work all possessed a strong, musty odor. Tubers grown in either row or broadcast treatment are subjected to this odor. The work thus far indicates that the material will impart a taste, described as medicinal or earthy, to tubers grown in soils treated so as to contain more than one pound per acre when applied in the row or more than two and one-half pounds per acre when applied broadcast. Until further data are available, soil treatments made with the intention of growing potatoes the same year should be on a limited scale. The insecticidal efficiency of benzene hexachloride in soil remains very high after many months so that fall application might be practical. Tobacco grown on heavily treated soils, 50 pounds technical benzene hexachloride per acre, has been shown to be affected in no way, either in burning qualities or taste.

CONTROL OF POTATO PESTS WITH NEW ORGANIC INSECTICIDES

Nancy Woodruff and Neely Turner

The following organic insecticides were tested in the field against two potato insects: two commercial 50 per cent DDT spray powders; a 25 per cent DDT emulsion; two DDT "mixed isomer" emulsions; two 50 per cent DDT-diatomaceous earth formulations, one of which contained 1 per cent wetting agent; benzene hexachloride, and dichloro-diphenyl-dichloroethane (Rhothane).

All mixtures were applied at the rate of 1, .5, .25, and .125 pounds of toxicant per 100 gallons of water. Green Mountain potatoes were planted in 15-foot plots, three rows in width, with three replicates for each treatment. All plots were randomized in blocks.

A power sprayer with a six-row boom, spraying three rows at a time, was used carrying three nozzles for each row. The spraying pressure averaged 400 pounds and delivery rate was 200 gallons per acre at a two mile per hour ground speed. The center row nozzles were equipped with quick-acting valves which shut off completely at the end of each plot to prevent drizzling in other treatments. All data and yields were taken from ten plants in the center row.

Table 21 shows the spray schedule for all treatments. The first two sprays were for flea beetles alone and a reading of flea beetle damage was taken on June 19. The third and fourth sprays were for leafhoppers alone, and the last two for both flea beetles and leafhoppers. Estimates of amount of tip burn were taken on July 17 and second generation flea beetle damage was read on July 25. Insect damage was estimated using a scoring system described by Horsfall (1945).

Results of insect control and yield by weight in pounds are recorded in Table 22.

Table 21. Spray Schedule

Treatment	6/4	6/11	6/25	7/10	7/16	7/30
Commercial A—50%	X	X	X	X	X	X
Commercial B—50%	X	X	X	X	X	X
25% Emulsion	X	X	X	X	X	X
70% "Mixed Isomer"				X	X	X
25% "Mixed Isomer"				X	X	X
Rhothane	X	X	X	X	X	X
Benzene Hexachloride			X	X	X	X
"67" DDT—50%	X	X	X	X	X	X
"67" DDT—50% + 1% Wetting Agent			X	X	X	X

Difference Between Spray Powders

Two commercial preparations of 50 per cent DDT were tested in the laboratory. Against the housefly, Commercial A showed greater toxicity than B although both are 50 per cent DDT wettable powders (Table 23, Figure 3).[1] Interpolation from the curve shows the dosage required for 70 per cent

[1] Variations in results of this type of residue test on houseflies have been large. A study of factors involved has failed to disclose the fundamental reason or reasons for these variations. In this case the two materials do differ statistically but the exact amount is difficult to determine with precision because of the variation.

control of flies to be about .066 per cent DDT for A and .25 per cent DDT for B. Commercial A was more than three times as toxic as B at the 70 per cent level. Because of this difference in toxicity, they were tested in the field on potatoes against flea beetles and leafhoppers (Table 22). Interpolation from Figure 4A at the 80 per cent control level, shows that A, in flea beetle control required .053 per cent DDT, while B needed almost four times as much, .195 per cent DDT. For 80 per cent control of tip burn A was about twice as effective as B, requiring .016 per cent DDT against .04 for B.

Both commercial preparations had identical DDT particle size and as far as is known, neither preparation contains any wetting agent. However, B foamed in the spray tank, indicating the possible presence of an additive.

TABLE 22. RESULTS OF FIELD TESTS OF ORGANIC INSECTICIDES ON POTATOES

		Per Cent Control				
		Flea Beetles				
Treatment	Per cent Conc.	1st Gen.	2nd Gen.	Tip Burn	Yield in lbs.	Total Yield
Commercial A	.12	78.5	89.3	96.3	63.9	
	.06	55.8	77.9	88.0	51.9	
	.03	47.0	72.8	83.3	39.2	
	.015	47.0	72.8	82.5	49.7	204.7
Commercial B	.12	55.8	76.2	85.2	57.4	
	.06	38.2	64.4	81.6	40.9	
	.03	29.4	57.6	82.5	51.2	
	.015	26.4	52.5	66.6	38.0	187.5
25% Emulsion	.12	64.7	71.1	93.4	53.2	
	.06	17.6	59.3	81.0	32.0[1]	
	.03	26.4	57.6	80.4	52.3	
	.015	17.6	50.8	83.2	31.2[1]	168.7
70% "Mixed Isomer"	.12		63.3	36.1	46.5	
	.06		59.3	52.7	51.3	
	.03		55.9	63.8	45.6	
	.015		44.0	69.4	46.0	189.4
25% "Mixed Isomer"	.12		61.0	25.0	48.3	
	.06		52.5	55.5	51.3	
	.03		40.6	52.5	31.6[1]	
	.015		40.6	55.5	42.7	173.9
Rhothane	.12	41.1	64.4	84.4	52.8	
	.06	20.5	52.5	72.2	49.0	
	.03	23.5	47.4	78.3	35.7[1]	
	.015	32.3	55.9	84.2	47.2	184.9
Benzene Hexachloride	.12		64.4	80.1	45.9	
	.06		52.5	67.2	41.0	
	.03		49.1	67.2	41.9	
	.015		40.6	60.1	40.6	169.4
"67"—DDT	.12		76.2	88.8	44.4	
	.06		67.7	83.3	50.4	
	.03		72.8	76.9	54.8	
	.015		67.7	78.3	41.5	191.1
"67"—DDT + 1% Wetting Agent	.12		61.0	76.9	50.3	
	.06		57.6	55.5	42.3	
	.03		52.5	66.6	34.8[1]	
	.015		49.1	72.2	43.8	171.2
Check		12.5[2]	61.0[2]	19.0[2]	36.7	

[1] Indicates tubers rotted in ground.
[2] Per cent damage to control.

TABLE 23. COMPARISON OF TWO COMMERCIAL DDT PREPARATIONS IN CONTROL OF HOUSEFLIES

Treatment	DDT Conc.	Per Cent Kill 1	2	3	4	Average Per cent kill
A	.25%	100	100	100	100	100
	.125	100	80.0	46.6	55.0	70.4
	.0625	95.2	56.5	45.8	10.0	51.9
	.0312	89.4	68.7	40.0	14.2	53.0
B	.25%	100	80.0	33.3	68.1	70.3
	.125	88.8	80.0	31.2	44.4	61.1
	.0625	72.7	60.0	16.6	18.1	41.8
	.0312	64.7	47.3	22.2	13.6	36.9

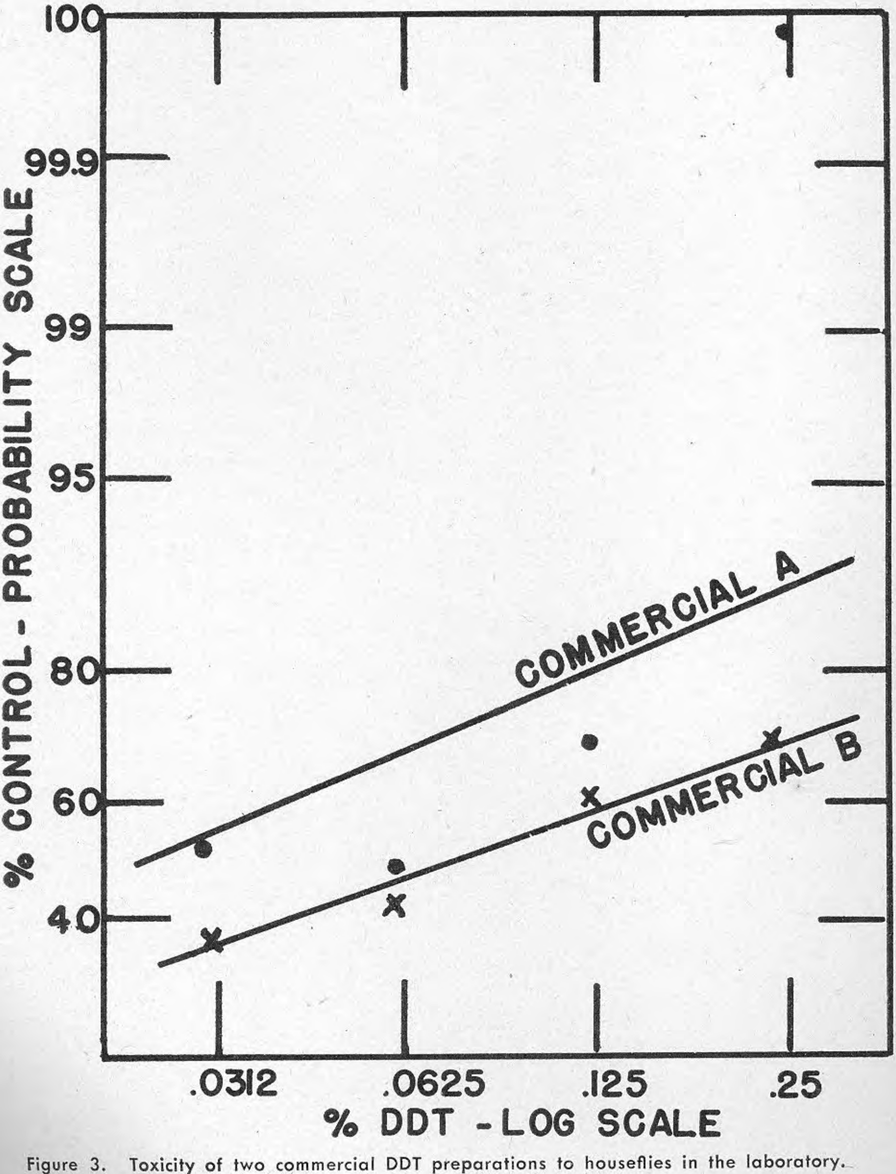


Figure 3. Toxicity of two commercial DDT preparations to houseflies in the laboratory.

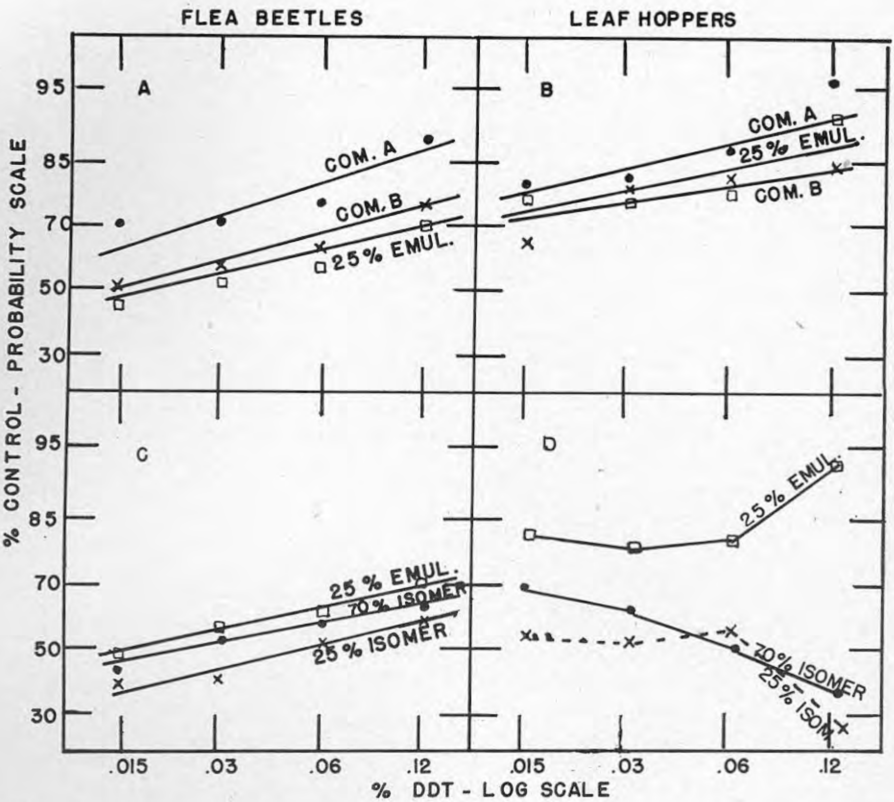


Figure 4. Toxicity of DDT water suspensions and emulsions to potato insects. A and B, two commercial wettable powders, and DDT emulsion used against the second generation of flea beetles and leafhoppers; C and D, DDT emulsion and two "mixed isomers" against the same potato insects.

TABLE 24. COMPARISON OF TWO "MIXED ISOMER" EMULSIONS AGAINST HOUSEFLIES

Treatment	Conc.	Per Cent Kill 1	Per Cent Kill 2	Average Per cent kill
70% "Mixed Isomer"	1%	100	95.8	97.9
	.5	75.0	100	87.4
	.25	69.5	72.2	71.0
	.125	66.6	90.0	78.3
25% "Mixed Isomer"	1%	92.0	81.2	86.6
	.5	73.3	89.4	81.3
	.25	55.5	100	77.7
	.125	44.4	100	72.2

The comparative low toxicity of B may be due to the effect of its diluent or additive. The effect of wetting agents will be discussed further along in this paper.

Spray Powder vs. Emulsion

In the literature, little information was found in direct comparison of spray powder and emulsion. In some cases, both emulsions and spray powders were tested in the same experiment but dosages were so high that no comparisons could be drawn. Gyrisko et al. (1946) in tests with DDT for control of potato aphids compared a DDT spray powder with an emulsion and found that the spray powder reduced the population of aphids by a greater margin than the emulsion.

In this study, the 25 per cent DDT emulsion gave less control of second generation flea beetles than either commercial spray powder. However, in control of tip burn caused by leafhoppers, the emulsion was more toxic than spray powder B, but less toxic than A. (Figure 4B).

Potatoes were dug in early October and yield is summarized in Table 22. Soil heterogeneity caused considerable variation in yield and tuber rot was serious in low portions of the field. Nevertheless, it is interesting to note that Commercial A outyielded both B and the emulsion by a wide margin, (not statistically significant).

Two DDT emulsions, one containing 70 per cent "mixed isomers", the other 25 per cent "mixed isomers" were applied three times in mid-season. Second generation flea beetle control showed that the 70 per cent isomer emulsion was more effective than the 25 per cent isomer at all concentrations (Table 22, Figure 4C). The curves for the 25 per cent emulsion are re-

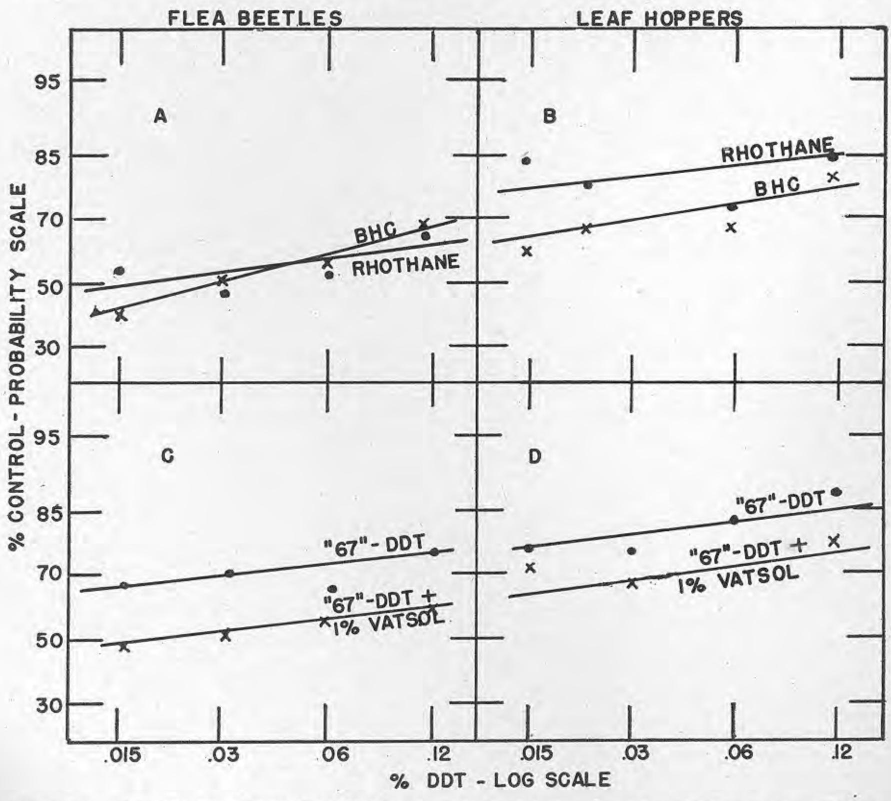


Figure 5. Toxicity of organic insecticides to potato insects. A and B, benzene hexachloride and Rhothane used against the second generation of flea beetles and leafhoppers; C and D, two 50 per cent DDT-diluent preparations, one containing 1 per cent wetting agent used against the same potato insects.

peated for comparison with the isomers. Interpolation from Figure 4C at the 60 per cent control level shows that .045 per cent DDT was required for the 25 per cent emulsion, .066 per cent for 70 per cent "mixed isomer", and .11 per cent DDT for the 25 per cent "mixed isomer". Curves for tip burn control were not drawn for the 70 per cent "mixed isomer" because of the wide scatter on the dosage-response curve (Figure 4D).

The 25 per cent emulsion was more effective than either of the mixed isomer materials. Actual curves for tip burn control (Figure 4D) were not drawn because of the wide scatter on the dosage-response curve. In at least two cases, those of the 70 and 25 per cent "mixed isomers", there is a reversal in the slope of the curve, and it appears that toxicity increases as concentration is decreased. Even the points for the 25 per cent emulsion do not justify a valid dosage-response curve because it could slope in either direction. There exists the possibility of an excessive amount of emulsifier present as the DDT concentration is increased. If so, it might interfere with the DDT toxicity which would decrease as more emulsifier is added. A reversal in slope might be due also to heterogeneity or the effect of contact action on leafhoppers. Tested in the laboratory against the housefly, the 25 per cent "mixed isomer" responded in accordance with the DDT dosage

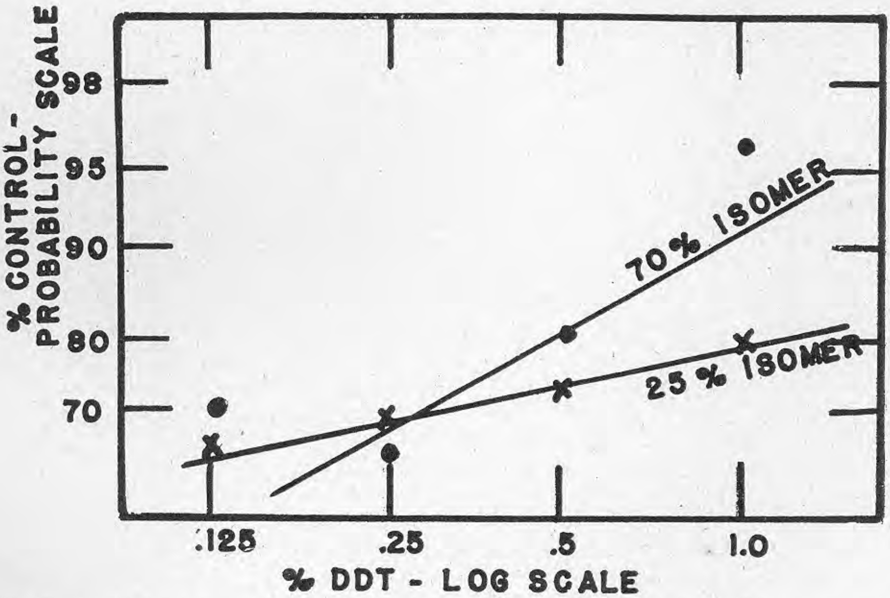


Figure 6. Toxicity of residues of two DDT "mixed isomers" to houseflies in the laboratory.

(Table 24, Figure 6). The dosage-response curve for the 70 per cent "mixed isomer" was not similar to the one for control of tip burn in the field. Therefore, it cannot be assumed with any accuracy that an excessive amount of emulsifier is present.

However, in the laboratory the residual action of the DDT is being tested, while in the field it is primarily contact action, so it is not surprising to get two different slopes.

Whatever caused this reversal in slope is not known at this time. Regardless of the slope of the curves, however, the 25 per cent emulsion, in both the field and laboratory, gave greater control of insects than either of the "mixed isomers".

Despite poor control of both flea beetles and leafhoppers, both isomers outyielded the 25 per cent emulsion. This can be explained by tuber rot in the emulsions, two plots of which suffered the heaviest loss in yield.

In summary, the DDT spray powder is more effective than the emulsion in controlling potato insects and in producing heavy yields, when used at the same DDT ratio. Two DDT "mixed isomers"[1] gave less control of potato insects than the straight emulsion, but yielded heavier because of less tuber rot caused by soil heterogeneity.

Benzene Hexachloride vs. Rothane

Benzene hexachloride and dichloro-diphenyl-dichloroethane (Rhothane) were sprayed on potatoes at the same rate as the DDT formulations. Both insecticides gave essentially the same control of flea beetles (Figure 5A). However, in control of tip burn, Rhothane was more than four times as effective as benzene hexachloride at the 80 per cent level (Figure 5B). Rhothane, with a serious amount of tuber rot, outyielded benzene hexachloride with no rot at all. It should be noted, however, that neither in insect control nor yield did either benzene hexachloride or Rhothane approach the high toxicity of DDT preparations.

In a spray experiment on Connecticut Valley farms,[2] Rhothane and benzene hexachloride were both tested on potatoes. Both were applied at the rate of two pounds per 100 gallons of water. On farm D, Rhothane equalled the yield of DDT, averaging 500 bushels per acre as compared with 497 for DDT.

On farm E, benzene hexachloride yielded less than DDT, averaging 470 bushels per acre as contrasted with 518 bushes for the DDT plots.

No precise comparison can be made between Rothane and benzene hexachloride since they were applied on different farms. From the figures above, however, Rhothane appears to outyield benzene hexachloride to some extent.

In this same valley experiment, at farm A two treatments of DDT were used, both at the same rate. One was sprayed continuously every week from July to September, and the other was used as needed. Dates of treatment were as follows:

A	7/11	7/18	7/26	8/5	8/12	8/16	8/26	8/30	9/6
B		7/18	7/26	8/5	8/12				

Previous to the first spray date, the farmer had made two applications of DDT on both plots. Thus, 11 applications of DDT were made on A, and six applications on B throughout the season. Final yields showed that A, which received DDT all season long, yielded 295 bushels per acre while B, which received DDT as needed, yielded 278 bushels, a difference of 17 bushels per acre. It appears therefore that DDT is needed at a continuous rate for high yield at the end of the season.

[1] The two "mixed isomers" are products of John Powell & Co., Inc. They are water miscible spray concentrates containing 25% and 70% by weight of DDT isomers and other chlorinated poymers of dichloro diphenyl trichloroethane combined with a hydrocarbon solvent (alkalated naphthelenes and anthracenes) plus 6% of a special emulsifying agent.

[2] All spraying on Connecticut Valley farms was done by Arthur Kellman and Raymond McLeod.

Effect of Wetting Agent

Steiner et al (1944), in tests of DDT mixtures against codling moth larvae, found that wetting agents would not improve the toxicity of DDT formulae, and in some cases they caused reduction in both toxicity and tenacity before and after washing.

Two preparations of 50 per cent DDT and diatomaceous earths were tested in the field on potatoes against both flea beetles and leafhoppers. They were identical in composition except that one contained 1 per cent Vatsol OT. Number 67 without a wetting agent was more effective than number 67 with 1 per cent Vatsol, in both insect control and yield. (Table 22, Figures 5C and D).

In the laboratory, a series of DDT-Fuller's Earth (Attaclay) mixtures were prepared with Vatsol OT in a dosage series. The preparation without Vatsol was at least as toxic as that with .5 per cent (Table 25) against the housefly. Addition of more spreader reduced the toxicity chiefly because the spray deposit was reduced. Reduction of surface tension of water reduces the size of spray droplets, and in this case smaller droplets would not reach the sprayed surface. Addition of more spreader than necessary to wet the powder for suspension, therefore, is detrimental because it causes reduction in toxicity.

TABLE 25. ATTACLAY WITH VATSOL SPREADER

Treatment	Conc.	Deposit	Per Cent Kill 1	Per Cent Kill 2	Av. Per cent kill
Attaclay 75g	.25%	.0007	13.6	7.6	10.6
+ 25g DDT	.5	.0011	19.0	75.0	47.0
	1.0	.0020	96.4	30.0	63.2
	2.0	.0040	100.	87.5	93.7
Attaclay +	.25%	.0006	29.4	36.8	33.1
.5g Vatsol	.5	.0009	41.1	15.7	28.4
	1.0	.0024	33.3	100.	66.6
	2.0	.0042	94.1	90.9	92.5
Attaclay	.25%	.0005	31.0	42.1	36.5
1g Vatsol	.5	.0008	58.6	66.6	62.6
	1.0	.0018	69.5	40.0	54.7
	2.0	.0041	55.5	92.3	73.9
Attaclay	.25%	.0002	12.5	23.8	18.1
2g Vatsol	.5	.0006	52.6	57.8	55.2
	1.0	.0012	48.0	90.4	69.2
	2.0	.0026	68.4	93.3	80.8
Attaclay	.25%	.0001	45.4	28.5	36.9
4g Vatsol	.5	.0007	56.0	53.3	54.9
	1.0	.0011	38.0	50.0	44.0
	2.0	.0028	89.4	60.7	75.0

Literature Cited

GYRISKO, C. C., C. P. WENE AND W. A. RAWLINS, 1946. DDT to Control Potato Aphids. Jour. Econ. Ent. 39:205-208.

HORSFALL, J. G., 1945. Fungicides and Their Action. Waltham, Mass. Chronica Botanica Co.

STEINER, L. F., S. A. SUMMERLAND, C. H. ARNOLD, AND J. E. FAHEY, 1944. Tests of DDT Mixtures against Codling Moth Larvae. U.S.D.A. Bur. Ent. & Pl. Quar. E 628.

ORGANIC INSECTICIDES FOR CONTROL OF THE MEXICAN BEAN BEETLE

NEELY TURNER

The toxicity of DDT to the Mexican bean beetle is relatively low, as noted by Weigel (1944), Harriess (1944), Nelson (1944) and others. Related materials, however, were reported by manufacturers as having much higher toxicity for this insect. Accordingly DDT, *Rhothane* (dichloro-diphenyl dichloroethane), and dimethoxy diphenyl trichloroethane (methoxy DDT) were applied to beans for control of larvae of the Mexican bean beetle. As a standard of comparison, pure ground cube root, as a source of rotenone, was used. In addition, hydroxy pentamethyl flavan was tested. All dusts were mixed with pyrophyllite diluent except DDT, which was used as mixed at the factory. Dusts were applied on August 15 and 23, 1945, to 10 row plots, in three randomized blocks. Applications were made using a small plunger duster. Results were determined August 29 by taking 10 plants at random from each plot and counting the surviving larvae. The results have been summarized in Table 26, and dosage response curves for the more effective materials are given in Figure 7.

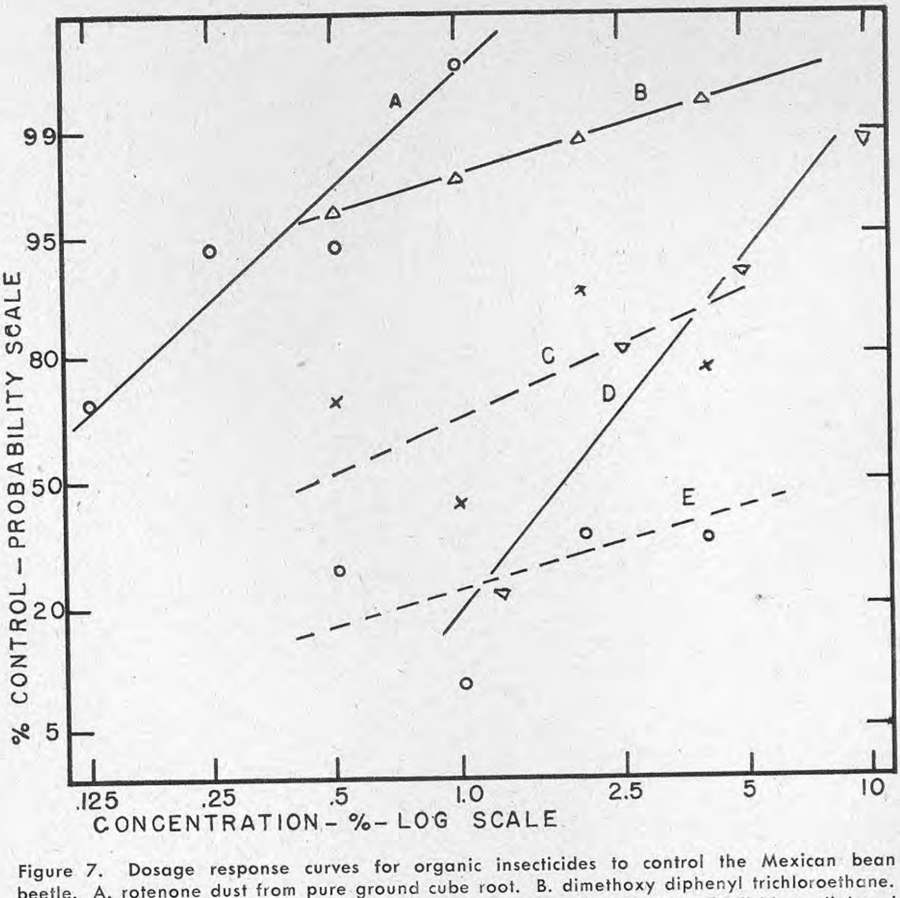


Figure 7. Dosage response curves for organic insecticides to control the Mexican bean beetle. A. rotenone dust from pure ground cube root. B. dimethoxy diphenyl trichloroethane. C. dichloro diphenyl trichloroethane. D. hydroxy pentamethyl flavan. E. dichloro diphenyl dichloroethane.

Table 26. Control of Mexican Bean Beetle with Organic Insecticides

Material	Conc. per cent	No. larvae	Per cent reduction
Cube	.125[1]	99	69.7
	.25	21	93.6
	.5	20	93.9
	1.0	1	99.7
DDT	.5	101	69.1
	1.0	187	42.8
	2.0	36	88.9
	4.0	78	76.1
Methoxy DDT	.5	12	96.3
	1.0	7	97.8
	2.0	4	98.8
	4.0	2	99.4
Rhothane	.5	238	27.2
	1.0	300	8.3
	2.0	214	34.6
	4.0	216	33.9
Hydroxy pentamethyl flavan	1.25	260	20.5
	2.5	64	80.4
	5.0	25	92.4
	10.0	4	98.8
No treatment	......	327	......

[1] rotenone

As was expected, DDT was much less effective than rotenone in cube. None of the concentrations used killed as many larvae as .25 per cent rotenone. *Rhothane* was even less effective than DDT, and all concentrations up to 4 per cent were less effective than .125 per cent rotenone. Methoxy DDT was relatively effective. At the 98 per cent level of control about 1 per cent Methoxy DDT equalled .5 per cent rotenone in cube. At the 99 per cent level 2.5 per cent Methoxy DDT was required as compared with .7 per cent rotenone in cube. The curve for Methoxy DDT was much flatter than for cube.

Hydroxy pentamethyl flavan was also a relatively effective material. At the 99 per cent level of control 10 per cent flavan was required to equal .7 per cent rotenone in cube. The dosage response curve for the flavan was parallel with that for cube.

The relationship between the three related compounds DDT, Methoxy DDT, and *Rhothane* was very interesting. The methoxy compound and *Rhothane* were not very toxic to the European corn borer (Turner, 1946). Apparently the test insect sometimes determines the order of toxicity of a series of compounds. Obviously Methoxy DDT is of great interest as a chemical to control the Mexican bean beetle.

Literature Cited

Harriess, F. H., 1944. Laboratory Tests with DDT against the Pea Aphid and the Mexican Bean Beetle. Jour. Econ. Ent. 37:151.

Nelson, R. H., 1944. Field Experiments on DDT for Control of the Mexican Bean Beetle. Jour. Econ. Ent. 37:151.

Turner, N. 1946. Some Fundamental Aspects of Control of the European Corn Borer. Conn. Agr. Expt. Sta. Bul. 495.

Weigel, C. A., 1944. DDT against Some Pests of Vegetable Crops. Jour. Econ. Ent. 37:150.

REPORT ON FRUIT INSECTS FOR 1946

Philip Garman

Work during 1946 included further studies of reduced schedules involving use of various supplements to handle scab in heavy infections and codling moth in difficult situations. Miticides for control of European red mites, and insecticides versus parasites for control of the Oriental fruit moth were also investigated. Laboratory and small scale field tests with the plum curculio and apple maggot yielded useful information in connection with new chemicals. A single field test in which lead arsenate was eliminated completely from the spray schedule, its place being taken early in the season with benzene hexachloride, and through mid-season with DDT and DN-111, was eminently successful. It shows that both mites and curculio and, possibly, apple maggot can be handled with such a schedule. Furthermore, a marked increase in the size of fruit was noted in the non-arsenical plot compared with the plot receiving a standard lead arsenate-wettable sulfur program. Absence of severe mite injury was probably responsible.

Acquisition of a new sprayer and truck greatly facilitated movement from place to place and tests were conducted in three out-lying orchards including the Plumb orchard in Westwoods, Hamden. A Niagara duster converted into a mist blower was placed at our disposal and used in the Burton orchard. Tests with it appeared promising inasmuch as complete control of insects and diseases was obtained with concentrates and a reduced number of applications. The main difficulty encountered so far has been trouble with the nozzles which clog frequently. Remedy of this should not be difficult. Trials of spreader nozzles for attachment to the end of the duster delivery tube appeared to offer advantages for uniform coverage. With dusts, alone, these were definitely better than the straight single tube. Advantages of the mist blower, if it continues to handle insects and diseases successfully, lie in a re-

Figure 8. Type of mist blower used in orchard experiments.

duction in the number of sprays necessary, less water cartage, and lower removal of previous spray deposits. There is considerable danger of excessive residues on the fruit unless care is taken to prevent it, and the nozzles used will of necessity have to be so constructed that they will deliver thick heavy mixtures with a minimum of trouble from clogging.

Experiments with Reduced Schedules

Burton Orchard

Results of tests in the Burton Orchard are given in Tables 27 and 28. Made after sampling and examination of the fruit, the following notes and conclusions give an idea of the results obtained.

McIntosh. A considerable amount of red mite damage was noted in the sulfur plots. Tersan (50 per cent tetra methyl thiuram disulfide) produced fruit of excellent quality and color but considerable roughness was observed in all Fermate plots, mainly enlarged lenticels. Some of the same was seen in the sulfur plots but was not quite so pronounced. Analysis by the Department of Analytical Chemistry indicates that the only plots under tolerance for lead arsenate were those receiving reduced spray schedules with Fermate as the fungicide, the last application on June 15.

(1) Tersan may be adapted to the reduced schedule with oil, bentonite and skim milk and appears to be superior to Fermate in the fruit quality produced.

(2) In seasons such as 1946[1], just as good McIntosh can be harvested with the reduced program in the Burton Orchard as with full schedules of wettable sulfur and lead arsenate.

(3) Concentrates used in mist blowers are effective for insect and disease control. With modified equipment they may be suitable for commercial orchards.

(4) Maggot control was satisfactory in the Burton Orchard with all treatments. Drop fruits are collected here each year and removed.

Baldwin. (1) Tersan is an excellent fungicide for Baldwins in the Burton Orchard. The amounts used could probably be reduced judging by the amount of disease developing.

(2) Fermate in reduced schedules is very close in effectiveness to Tersan, but while the figures do not show a statistically significant difference in russetting, that condition appeared to be more marked in the course of fruit examination than the figures indicate.

(3) More than five sprays on Baldwins are rarely, if ever, needed in this orchard provided satisfactory stickers are employed.

A general summary of the fruit counts is given in Table 29.

---

1 Heavy scab and red mite, light curculio and aphis year.

TABLE 27. SUMMARY McINTOSH—BURTON ORCHARD—1946
Averages of All Trees Scored in Several Randomized Plots

Treatment	Good deducting russet	Good including russet	Scab	Russet[1]
White[2]—Sulfur— lead arsenate 11 sprays	93.22%	96.64%	1.64%	3.42%
Black—Sulfur— lead arsenate 12 sprays	88.61	93.14	4.38	4.53
Yellow—Tersan— lead arsenate 6 sprays	91.34	92.66	6.28	1.32
Red and White—Fermate— lead arsenate 5 sprays	88.93	95.27	2.83	7.34
Black and White—Puratized— Fermate-lead arsenate 6 sprays	86.72	90.77	6.49	4.05
Red[3]—Sulfur-lead arsenate concentrate with blower 5 sprays	77.21	84.03	13.37	6.82
Without Tree D31	80.64	93.72	2.69	13.08
Green—Fermate—lead arsenate concentrate with blower 5 sprays, 1 dust	82.92	97.22	1.16	14.30

1 Russet includes net russetting and sulfur scald as well as enlarged lenticels conspicuous enough to reduce sale value. Scoring difficult because of hail-damaged fruit.

2 The colors indicate the plots as given in the spray program on page 73.

3 Only one tree D31 with severe scab infection at harvest.

TABLE 28. BALDWIN—BURTON ORCHARD—1946
Summary

	Good[1] deducting russet	Good including russet
1) Reduced Schedule + Fermate 5 sprays	89.95%	98.23%
2) Reduced Schedule + Tersan (TMTD) 6 sprays	91.73	96.63
3) Lead arsenate + "Mike" sulfur and lime—12 sprays	76.63	97.81
4) Same—11 sprays	77.64	96.90
5) Sulfur concentrates Mist blower 5 sprays	71.78	96.47
6) Fermate concentrates Mist blower 5 sprays, 1 dust	74.48	94.78
7) Zerlate reduced schedule	17.88	98.62

1 Free of external insect and disease blemishes.

TABLE 29. SPRAY PROGRAM FOR BURTON ORCHARD—1946
No Dormant Spray on This Orchard

Trees	Plot	Materials in 100 gals.		Dates applied	
B11-21 D7-10, 20-23 E4-7, 23-31 F14-17	White	Lead arsenate "Mike" sulfur Lime ——— Extra fertilizer "Esminel" Applied June 4	2,3 lbs. 3,4 lbs. 2,3 lbs. 10 lbs./tree	Apr. 17, Sulfur only Apr. 24 May 10, 17, 23, 30 June 7, 17, 25 July 5, 25	11 sprays
C5-8 D25-27 E32-35 F6-9 G14-7, 34-31	Black	Same as above ——— No extra fertilizer		Apr. 17 (Sulfur only) Apr. 23 (Sulfur only) Apr. 24 May 10 (Sulfur only) May 17, 23, 30-31 June 7, 17, 25 July 5, 25	12 sprays
C9-12 D29-31 E19-27 F3-5 G27-29	Red[1]	Lead arsenate "Mike" sulfur Oil ——— Applied as a concentrate 1/2 gal/tree with blower		April 29 May 14, 30-31 June 15 July 15 (no oil)	5 sprays
C21-25 D4-6 F18-21, 26, 27 G2-5	Green[1]	Lead arsenate Fermate "Daxad" disperser Skim milk ——— Applied as a concentrate with blower 1/2 gal/tree		Apr. 23 (Fermate dust only) Apr. 29 May 14, 30-31 June 15 July 15 (no oil)	5 sprays 1 dust
C24-6 D15-18 E15-19 F32-35 G10-13	Red and White	Lead arsenate Fermate Bentonite Skim milk Oil	6 lbs. 2 lbs. 1½ lbs. ½ lb. ½ gal.	Apr. 17 (Fermate only) Apr. 24 May 10, 30-31 June 15	5 sprays
C32-35 D15-19 F22-25 G18-21	Yellow	Lead arsenate Tersan Bentonite Skim milk Oil	6 lbs. 2 lbs. 1½ lbs. ½ lb. ½ gal.	Apr. 17 (Fermate only) Apr. 24 May 10, 30-31 June 12 July 15 (Tersan and lead arsenate)	6 sprays
C18-20 D8-15 F19-31 G6-9	Black and White	Fermate ——— Puratized ——— Lead arsenate Soy bean oil	2 lbs. 1 pint 6 lbs. 1 pint	Apr. 17 (Fermate only) May 10 (Puratized only) May 17 (Puratized, lead ars. & oil) May 31 (Lead ars. & oil) June 12 (Lead ars. & oil) July 15 (Fermate only)	6 sprays

[1] See following page for exact formula for concentrates.

Formulae for concentrates:

Sulfur formula (Red)
- 10 lbs. "Mike" wettable sulfur
- 6 lbs. standard acid arsenate of lead
- 8 gallons water
- 1 pint white mineral oil (summer oil)
- Equivalent to 2.0 lbs. total solids per gallon or 0.75 lb. lead arsenate

Fermate formula (Green)
- 4½ lbs. Fermate
- 18 lbs. lead arsenate
- 3 oz. Daxad disperser[1]
- 18 oz. skim milk powder
- 1½ gals, white mineral oil
- Water to 12 gallons
- Equivalent to 1.98 lbs. total solids per gallon or 1.5 lbs. lead arsenate

Plumb Orchard

In this orchard we attempted to obtain satisfactory disease and insect control with Fermate-oil-lead arsenate, etc., combinations, supplementing them with either additional Fermate or Puratized sprays. Puratized[2] supplements, the most successful, reduced scab to 10 per cent on both McIntosh and Rome. However, they were not any better than Fermate supplements in the amount of good fruit produced, probably because of better curculio control with the Fermate mixtures. These data are not shown in the tables. Scab control in the Plumb Orchard is extremely difficult because of its low damp situation.

TABLE 30. SUMMARY OF SCAB CONTROL AND CLEAN FRUIT
With Reduced Schedules—Plumb Orchard—1946
McIntosh

	Treatment	Tree	Per cent scab	Per cent good
	Reduced program with	K9	11.82	80.76
(1)	2 Fermate supplements for scab	K10	18.47	70.78
	7 sprays including dormant	K11	19.21	77.42
		K22	17.14	80.96
		J21	26.42	71.41
		G18	16.60	77.82
		Average	16.82	76.99
	Reduced program with	G8	14.05	80.25
(2)	1 Puratized plus 1 Fermate	O30	5.88	61.26
	supplement for scab	O32	10.35	66.99
	6 sprays including dormant	D3	8.88	62.32
	½ strength Puratized added	F4	2.78	81.42
	to 2 reduced formulae sprays	Average	10.14	72.55
	Reduced program	I12	24.13	72.32
(3)	with Tersan	M15	42.41	56.71
	No supplementary sprays for scab	P35	28.98	60.60
	7 sprays including dormant	P37	7.15	88.09
		I16	86.24	12.82
		Average	39.19	57.64
	Wettable sulfur	F33	6.18	54.60
(4)	Lime sulfur (1 Spray)	F34	10.43	16.00
	Lead arsenate	O16	8.71	84.62
	reduced program	O24	29.36	53.78
	7 sprays including dormant	P15	23.58	52.04
		Average	13.90	63.35

1 Synthetic wetting and dispersing agent.
2 "Puratized" is a trade name for phenyl mercuri triethanol ammonium lactate.

Table 31. Summary of Scab Control and Clean Fruit With Reduced Schedules—Plumb Orchard—1946

Romes

	Treatment	Tree	Per cent scab	Per cent good
(1)	Reduced program with 2 Fermate supplements 5 sprays including dormant	I20	18.02	78.61
		J21	9.36	89.11
		J22	13.71	83.06
		Average	14.10	83.03
(2)	Reduced program with Puratized 5 sprays including dormant No supplements as for McIntosh	F7	16.23	79.29
		F11	12.42	85.55
		H5	6.99	85.22
		H11	12.60	83.67
		P26	7.02	91.23
		P29	2.98	93.37
		Average	10.79	84.35
(3)	Reduced program with Tersan No supplementary sprays 6 sprays including dormant	H13	68.61	27.21
		H17	54.33	43.46
		J18	49.22	49.22
		P33	25.20	61.89
		P37	16.34	70.67
		Average	53.45	41.54
(4)	Wettable sulfur Lime sulfur (1 spray) Reduced program 6 sprays including dormant	P13	8.38	84.68
		P19	5.53	86.85
		P22	30.54	58.84
		Average	12.11	80.21

Summer Spray Program (2 Per Cent Delayed Dormant Oil Applied to All Blocks)

Amounts are for 100 gallons

(1)	a.	Fermate 2 lbs.	April 18
	b.	Reduced formula[1] plus 1 lb. Fermate and 1 pint nicotine sulfate	April 25
	c.	Same	May 14
	d.	Fermate 2 lbs.	May 25
	e.	Reduced formula plus 1 lb. Fermate	May 29
	f.	Same	June 12
(2)	a.	Fermate 2 lbs.	April 18
	b.	Reduced formula plus ½ pint "Puratized"	April 25
	c.	Same	May 14
	d.	1 pint Puratized only	May 25
	e.	Reduced formula—no Puratized	June 12
(3)	a.	Fermate 2 lbs.	April 18
	b.	Reduced formula (with 2 lbs. Tersan) plus 1 pint nicotine sulfate	April 25
	c.	Same, no nicotine	May 14
	d.	Same	May 25
	e.	Same	June 12
	f.	Lead arsenate 1.5 lbs., lime 1.5 lbs., sulfur 2.6 lbs.—150 gals	Aug. 6
(4)	a.	"Mike" sulfur only 8 lbs.	April 18
	b.	Lead arsenate 3 lbs., sulfur 4 lbs., lime 1 lb., nicotine sulfate 1 pint	April 25
	c.	Lime sulfur 2 gals., lead arsenate 3 lbs., soybean flour ½ lb., manganese sulfate 2-4 oz.	May 15
	d.	Lead arsenate 3 lbs., "Mike" sulfur 4 lbs.	May 31
	e.	Same	June 25
	f.	Lead arsenate 1½ lbs., lime 1½ lbs., sulfur 2 lbs.	Aug. 6

[1] Reduced formula

Lead arsenate	6 lbs.
Wyoming bentonite	1½ lbs.
Skim milk	½ lb.
Fermate	2 lbs.

Mixed dry and used at the rate of 10 lbs. to 100 gallons, plus ½ gal. white mineral oil.

MITE CONTROL IN CONNECTION WITH DDT EXPERIMENTS

PHILIP GARMAN AND J. F. TOWNSEND

Field tests in the Plumb Orchard in Hamden, Henry Orchard in Wallingford, and the Cook Orchard in Branford provided the following information (Tables 32, 33, 34).

(1) *Hydroxy methyl flavan* combined with DDT was unsuccessful in holding down mites in both Hamden and Wallingford. Compared directly with DN-111 at Branford, it did not reduce the mites nearly as well as DN-111.

(2) *Genicide* (Xanthone) combined with the usual flocculator and spreader and with DDT added, gave satisfactory control of red mites. Several sprays are apparently needed to accomplish this.

(3) *Syndeet* (alkyl ester of beta naphthol plus DDT) did not equal results obtained in 1945 and was unsatisfactory in the Westwoods Orchard where it also did not compare in effectiveness with Xanthone. Comparison at Branford with 1 per cent summer oil showed that it was likewise inferior to the latter and killed more of the natural enemies.

(4) *DN-111* as already reported, gave satisfactory mite control in the Mount Carmel Orchard where it was combined with DDT. It is compatible with DDT and the combination is apparently safe on apples. Preliminary tests in late season gave no injury on peaches.

Laboratory and small scale field tests utilizing the greenhouse red spider *(Tetranychus bimaculatus)* and European red mite *(Paratetranychus pilosus)* indicate that hexaethyl tetraphosphate has considerable promise as a killing agent for eggs and adults (Tables 35, 36). "Spydertox", a rotenone formulation (3 per cent rotenone), also appeared promising both in the field and laboratory. The latter also kills a good percentage of eggs and adults and approaches the kill obtained with DN-111 about as closely as any material encountered so far.

TABLE 32. EUROPEAN RED MITE CONTROL
Plumb Orchard—1946

Treatment[1]	Tree No.	No. adult females per leaf 20 leaves per tree			
		Aug. 6	Aug. 9	Aug. 15	Aug. 22
A. DDT plus Miticide	C6	43.4	16.35	20.6	37.9
	C8	1.3	0.1	0.35	2.5
B. DDT plus Genicide	C10	.4	0.3	0.20	1.8
	C12	.3	0.5	1.25	4.0
	C14	28.4	5.8	11.1	31.9
C. "Syndeet" (with DDT)	C16	40.4	11.2	18.6	40.5
	C18	23.4	9.8	13.2	31.2

[1] SPRAY SCHEDULE:

All plots received a delayed dormant spray of oil and four early season sprays of lead arsenate and sulfur, prior to start of mite control tests.

Plot A. DDT plus hydroxy methyl flavan—formulation containing 25% DDT—5 lbs.-100 June 11. Same plus 4 lbs. "Mike" sulfur-100 June 25, July 8, 26, Aug. 8, (sulfur omitted).

Plot B. 25% DDT, 6 lbs. "Genicide", 2 lbs. (with flocculant and spreader) and 3 pints kerosene—June 11. Same without kerosene but 4-100 "Mike" sulfur June 25, July 8, 26, Aug. 8 (sulfur omitted).

Plot C. "Syndeet" 1 qt. to 100 June 11. Same plus 4 lbs. "Mike" sulfur June 25, July 8, 26, August 8, (sulfur omitted).

Table 33. European Red Mite Control—1946
A. T. Henry Orchard, Wallingford
Variety McIntosh

Treatment	Number adult females per leaf 25 leaves per tree[1]			
	July 11	July 20	July 29	Aug. 5
Lead arsenate. plus Fermate-sulfur (no DDT)	1.02	1.8	4.9	17.0
DDT, plus "Miticide" plus Fermate-sulfur (Hydroxy, 5-100)	2.0	2.7	5.3	24.3
DDT, no "Miticide" plus Fermate-sulfur	2.5	3.7	8.4	26.8

Three applications made by grower; June 15, July 2 and about Aug. 1.
Natural enemies scarce in all plots.
[1] Average of four trees.

Table 34. Comparison of "Syndeet"[1] and Tank Mix Summer Oil Emulsion
Sprays Applied July 16

Treatment	Adult female mites per leaf (20 leaves per tree)					Notes
	July 8	July 18	July 26	Aug. 2	Aug. 8	
"Syndeet" 1 qt.-100 gals.	19.9	8.6	6.1	10.1	4.5	Natural enemies eliminated
	16.9	3.8	8.2	7.7	8.7	
	16.7	5.6	8.2	9.7	9.6	
1% White oil, tank mix with skim milk 1 lb.-100	16.4	2.5	2.3	2.5	4.45	
	15.1	2.7	1.4	.9	.2	
1% White oil, tank mix with blood albumin ¼ lb.-100	10.7	6.6	6.6	4.1	2.1	Natural enemies present on Aug. 8
	11.4	9.3	6.0	2.8	1.1	
	8.1	5.5	4.0	3.8	1.4	

[1] Alkyl Ester of beta-naphthol—formulation prepared by U.S. Rubber Co. 1946; contains DDT.

Table 35. European Red Mite Control
Plumb Orchard 1946
Sprayed August 6, after count

Treatment	Tree No.	Number adult female mites per leaf (25 leaves per tree)			
		Aug. 6	Aug. 9	Aug. 15	Aug. 22
"Spydertox"[1] 1 pint-100 gals.	F27	26.7	0.15	0.55	2.0
	E24	23.6	0.55	1.9	9.6
Hexa ethyl tetra phosphate 1 qt.-100 gals.	F30	15.7	0.25	0.25	7.9
	F34	14.9	0.15	0.65	9.7
Check No treatment	F36	10.1	4.1	1.2	0.15
	F32	2.1	1.05	3.7	9.5

[1] 3 per cent rotenone formulation prepared by Bonide Chemical Co.

TABLE 36. RED SPIDER CONTROL. LABORATORY TESTS. 1946
(Figures are percentages killed)

Concentration	50%[1] Hexa ethyl tetra phosphate	1068[2] 25%	Benzene[3] hexachloride 30%	"Spydertox"[4] 3% rotenone	DN-111[5]
		Eggs			
1.00%	62	100	90	100	97
0.5	54	89	74	98	100
0.25	55	62	22	94	95
0.125	37	17	20	78	81
		Adult—females			
1.00	98	12	47	100	100
0.5	80	9	22	100	98
0.25	71	6	26	64	100
0.125	71	5	22	32	98

1 Formulation of California Spray Chemical Co. 1946.
2 Chlorinated hydrocarbon $C_{10} H_6 Cl_8$.
3 Benzene hexachloride 30%—3% gamma isomer.
4 "Spydertox"—formulation of Bonide Chemical Co., containing 3% rotenone.
5 DN-111—dicyclohexylamine salt of dinitro-o-cyclo hexyl phenol.
Dilutions on basis of original materials, not on active ingredients.

OBSERVATIONS ON THE EUROPEAN APPLE SAWFLY IN 1946

J. F. Townsend

In view of the potentialities of this insect as a serious orchard pest, it seemed important to get some definite information at the first opportunity on practical control measures under Connecticut orchard conditions. Efforts to find an infestation suitable for experimental spraying were not successful.

Records of emergence of adults were made from over-wintered stock in ground cages at the Experiment Station, and some pilot spray experiments were made with the adult flies obtained. Infested material was gathered for the insect collection, for further observations on seasonal life history and for stock to carry over winter. Observations were made on the course of infestations in orchards previously known to be infested and in newly reported infestations.

Weather and seasonal life history. The pattern of spring weather undoubtedly had an important effect on the seasonal history and abundance of the insect. There was an abnormally early blossoming period, but with temperatures below normal during bloom and for most of the remainder of the spring. The weather was somewhat similar to that of 1945, but was cooler during bloom, with only two days of temperature reaching 70 degrees or over in a 12 day period (as recorded at the Hartford weather station). This is in contrast with seven such days in 1940, eight in 1943, and 5.8 days as the average of the last 10 years. As the apple sawflies are reported to oviposit chiefly on quiet, warm, sunny days during full bloom, the season of 1946 should be regarded as relatively unfavorable. The restraining influence of low temperatures was illustrated with sawfly adults confined in outdoor cages or shaken from trees, where they appeared almost inactive at 60 degrees F. Even in this season with temperatures apparently unfavorable for oviposition, the insect was able to cause severe damage in trees not thoroughly sprayed. It is well to be on the lookout for increased damage in seasons with temperatures normal or above during bloom.

In 1946 the emergence of adult flies from over-wintered stock in ground cages under apple trees began 10 days later in relation to bloom than in 1945, which was nearer the stage commonly reported. The first observation of egg laying in the trees was similarly delayed. Mating activities by the flies in cages on the day of emergence, together with evidence of egg-laying in the trees, suggest that the preoviposition period may be negligible under certain conditions. Larval development was apparently slowed down by the cool weather that followed.

The accompanying chart shows some of the main features of seasonal life history for 1945 and 1946.

Distribution. The apple sawfly is now known to be distributed throughout Fairfield County and the southern part of New Haven County. Many of the new locations reported are obviously not new infestations, but were merely recognized in the more widespread knowledge of the characteristic damage of the insect. In the Mount Carmel orchard a definite spread of infestation on a small scale has been noted by Garman.

Types of Orchards Infested. In relating the infestations to orchard practices, the heavier infestations have been chiefly in individual trees of odd varieties not receiving full spray treatments, or in orchard blocks where the insecticide coverage was apparently inadequate as indicated by damage from

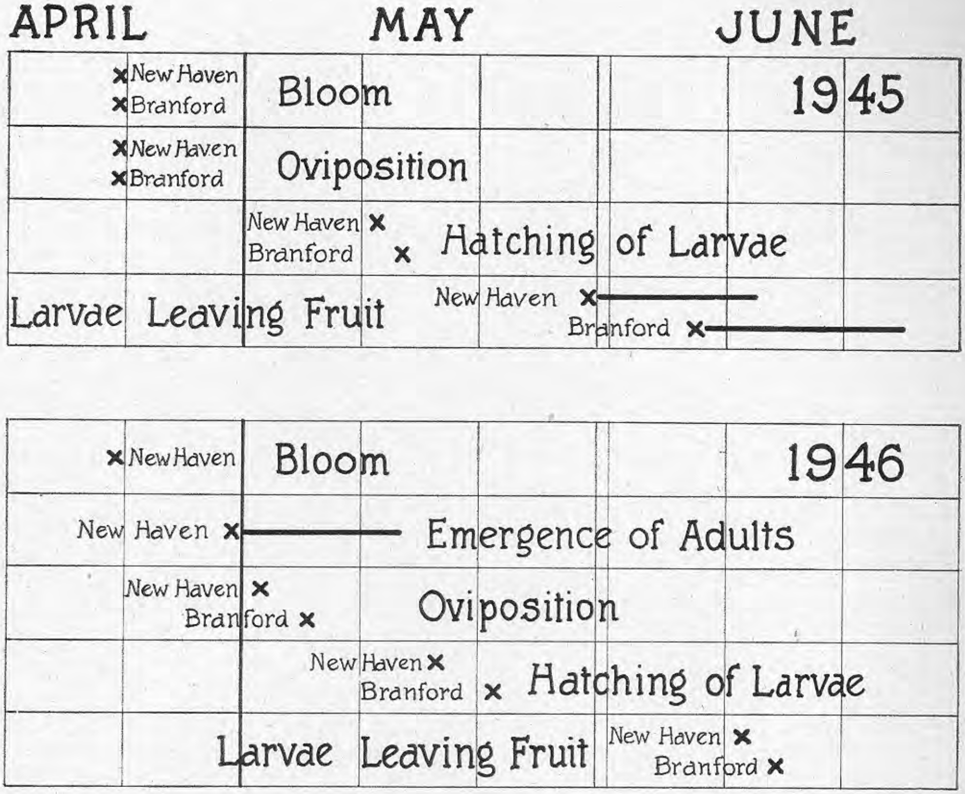


Figure 9. European apple sawfly: seasonal history for 1945 and 1946. The symbol "X" indicates the first observation of a stage, and a heavy bar in addition indicates the duration of the stage where known. In 1945 oviposition was noted at the time in relation to bloom commonly reported in the literature, while in 1946 both the emergence of adults and the first evidence of egg-laying were about 10 days late. There appears to be practically no preoviposition period.

miscellaneous orchard pests. In one case the trees were obviously too overgrown to allow thorough coverage. In another the insecticide coverage appeared ample as examined in early June, but the timing of applications was questionable. Considerable sawfly damage was also reported in one block in an orchard where thorough spraying is the routine practice. In addition to differences in timing and thoroughness of applications in the orchards involved there may have been wide differences in intensity of the insect attack, related to the number of sawflies present and their activity under influence of the weather during bloom. An insect as responsive to temperatures as the European apple sawfly might prove particularly difficult to control under the stimulus of favorable high temperatures, as is the case with the codling moth and the plum curculio.

Varieties Infested. It is widely mentioned in the literature that early varieties are particularly subject to attack, but one English writer has also pointed out that it depends partly on the variety in bloom when the adults are present and the weather favorable. In 1944, in one orchard, the infestation was chiefly in Gravensteins and a few Redbirds that had not received the full schedule of sprays. In 1945, it was chiefly in varieties with a long blooming period and a heavy set of fruit—Wealthy, Early McIntosh and Golden Delicious at Branford, and Wealthy at Greenwich. In 1946, in the more thoroughly sprayed orchards that were infested, the damage appeared to be thinly scattered through the orchard blocks in general. In the only orchards with substantial infestations, some varieties, including Wealthy and Golden Delicious, were more heavily damaged than others.

In a season such as 1946 with very few days apparently suitable for oviposition, the time of blossoming would probably have a strong influence on the chances of infestation. Varieties that have a long blossom period, and that also set fruit heavily, may be particularly suitable for both oviposition and full development of the larvae in view of their habit of migrating to new fruit when partly grown. Apples in clusters, being more difficult to spray thoroughly than individual apples, may also be more readily infested by the migrating larvae. As migration occurs before the normal time for the hand-thinning of apples, blossom-thinning sprays may prove useful where infestation is expected in varieties that set heavily.

Control. Information on the practical control of the insect has advanced very little since the previous discussion in the 1944 report. While there has been very little economic loss from the insect in the past three years in orchards well sprayed with standard schedules, the insect has been able to persist under such conditions, even with relatively unfavorable temperatures at bloom, and apparently to spread somewhat.

A factor that may help the insect to persist in sprayed trees was noted in the habit of some of the larvae of tunnelling directly under the skin of the apple from the oviposition slit, and thus not being exposed to contact with insecticide residue during the first part of larval development. This definitely appeared to be the means of entrance in at least 12% of 124 infested apples examined, and was suspected in more cases. Whether any large proportion of the larvae find enough food to complete development in the original apples entered has not been determined, but migration has appeared to be rather general.

With the irregularity of occurrence of infestation as exhibited in the past two seasons, diagnosis of an infestation in time to take action against it has been difficult. Collecting the emerging adults in cages placed at random under trees heavily infested the previous year has yielded surprisingly little information, as has also been the case with soil sampling for hibernating puparia. Shaking adults from the foliage on cool mornings and catching them on cloth on the ground has given useful information in the case of the dwarf trees at the Experiment Station, but it does not seem practicable in a light infestation on large trees in a commercial orchard. Examination for oviposition scars in a heavy bloom is obviously time-consuming, particularly over a large area, and might not yield much information except in a heavy infestation. Examination of the small fruits for the first signs of larval tunnelling has also proved difficult because the scars do not show clearly until the tissues have dried out.

Frass is not usually deposited in quantity on the outside until the larvae start tunnelling deeply. The appearance of frass is perhaps the first practicable indication for diagnosing a current infestation in a commercial orchard. The frass shows up more distinctly when it is damp in the early morning, or throughout a damp day, than when it has dried out and lost much of its brick-red color. Frass may be found not only on the fruit, but spattered on lower parts of the foliage from infested apples above. When frass appears there may still be time to take measures against the migrating larvae, which are an especially destructive feature of this pest. An extra spray on the infested area may be useful with the regular insecticide at a stronger concentration, or with some more promising insecticide if by then available. The effectiveness of derris dust against sawfly larvae in experiments elsewhere suggests that some practical control method may be found for use at this stage. Besides preventing damage to additional apples, it would seem worth while to try to reduce the number of larvae that can reach maturity and carry over to the following year.

Ground treatments to kill the hibernating larvae in the soil may be worth investigating, but very little information is available as a basis. Puparia in the soil in ground cages were found to be in the upper three inches, with the majority between one and two inches. Depths as low as nine inches have been reported in England.

Spraying the orchard ground cover with a material such as DDT might be effective against the newly emerged adults, which exhibited a habit—at least in cages—of spending a good deal of time in the grass during cool days and of returning to the sod at night. Similar sprays directed against the mature larvae as they leave the fruit and go into hibernation in the soil might also be worth investigating.

Spraying the apple foliage before bloom offers interesting possibilities for killing the adult flies. DDT may prove effective against flies that come in contact with it on the foliage. Poisoning the adults through the digestive tract seems also a possibility in view of the observation by Miles (3) of the sawflies running over the foliage in bright, warm weather, sipping up droplets of moisture, and licking or scraping the surfaces of the leaves with their mouthparts. A quick-acting poison would seem necessary for effectiveness, as there may be only a relatively short interval between emergence and oviposition under certain conditions. The risk of poisoning bees should be investigated, but from casual observation it appears that bees spend comparatively little time during bloom on any part of the foliage except the opened blossoms.

In some preliminary cage tests with adult sawflies, foliage that had been previously sprayed with either DDT or benzene hexachloride proved lethal. A fumigating action was suspected with the latter in the type of cage used.

Literature Cited

(1) Hey, G. L. and W. Steer, 1934. Experiments on the control of the apple sawfly *(Hoplocampa testudinea* Klug). Rep. E. Malling Res. Sta. 1933, 21:197-216, 3 figs. Abstr. in R. A. E., XXII:583, 1935.

(2) Kearns, H. G. H., 1934. Control of the apple sawfly. Fruit Grower, No. 9, 1933. Abstr. in R. A. E., XXII:425-426, 1935.

(3) Miles, H. W., 1932. On the biology of the apple sawfly, *Hoplocampa testudinea* Klug. Ann. Appl. Biology, XIX (3) :420-431, 3 pls. Abstr. in R. A. E., XX:579-580, 1933.

(4) Pyenson, Louis, 1943. A destructive apple sawfly in North America. Jour. Econ. Ent., 36(2) :218-221.

CODLING MOTH OBSERVATIONS IN 1946

J. F. Townsend

With spring temperatures somewhat similar to those of 1945, conditions were similarly unfavorable for oviposition by the early-emerging moths, and the latter part of the first brood moths was delayed even later than in 1945. Severe damage in several orchards might have occurred, as in 1945, but for the sprays timed to combat it. Severe damage did occur in one commercial orchard in which the trees were obviously too overgrown for effective spraying. For the eastern seaboard states in general, codling moth damage was less severe than in recent years, with lower summer temperatures apparently acting as the main factor in the decline.

In infested orchards previously under observation, infestations were kept at low levels or reduced under improved control practices, and with sprays of either arsenate of lead or DDT.

DDT in direct comparison with arsenate of lead proved definitely superior in codling moth control. The presence of "resistant" strains of the insect is suspected in two or three orchards, but it has not yet been demonstrated that control cannot be obtained with arsenate of lead accompanied by good general control practices.

The benefits of good general control practices in both orchard and packing shed have been emphasized, particularly in Illinois and Ohio. Experience in Connecticut also indicates such measures as major rather than minor factors in the control of this pest.

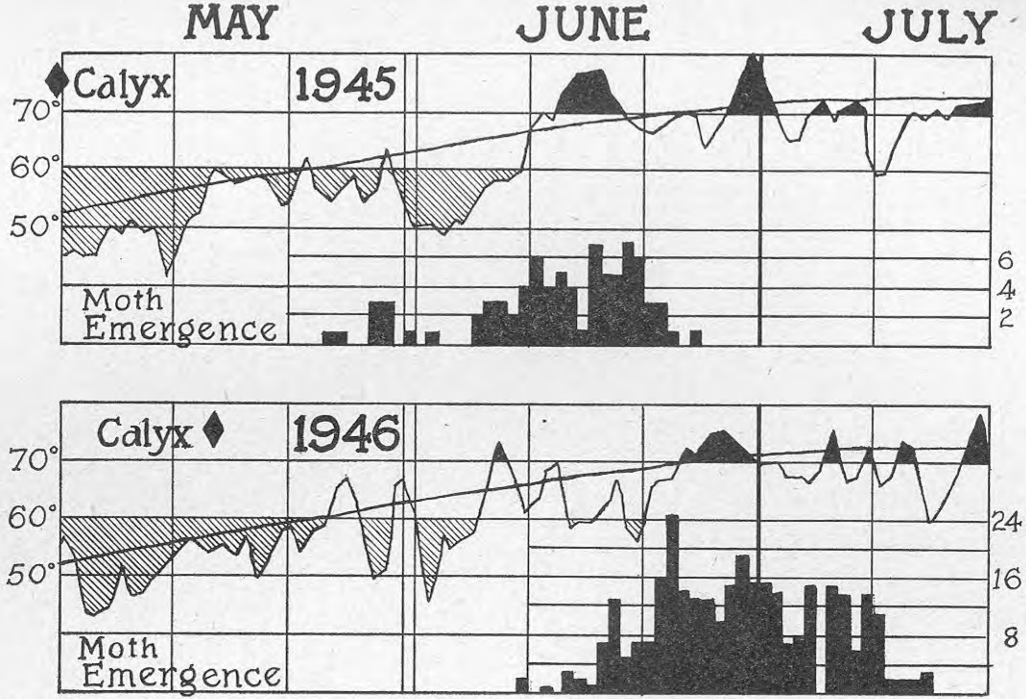


Figure 10. Codling moth: showing delayed moth emergence in 1945 and 1946 from the over-wintered larvae in the shade at the Experiment Station, the numbers of moths being indicated by the scale at the right. Also shown in jagged lines are daily mean temperatures, degrees F., at the Experimental Farm in Mount Carmel, and in smooth curves the normal mean temperatures on a long-time basis (from the U. S. Weather Bureau at Hartford). Cross hatching indicates temperature conditions regarded as unfavorable for oviposition by early moths, and as tending to retard emergence from larvae in cool locations. Black areas over 70 deg. indicate temperature conditions considered stimulating to egg laying. The chief damage in 1945 occurred after the 23rd of June, and in 1946 after the 1st of July. The damage was mainly in orchards where there was a substantial carry-over of the insect, and where the insecticide coverage was allowed to decline between the intense program of early spring and the later sprays against apple maggot.

CONTROL OF CODLING MOTH WITH REDUCED SCHEDULES

PHILIP GARMAN

Lyman Orchard

Mr. John Lyman of Middlefield kindly placed at our disposal a block of McIntosh, which was treated in part by his crew and partly with the Experiment Station outfit. Altogether a total of six complete treatments was given this plot. A portion was treated with DDT twice, once on June 19 and again on July 11. A second portion was sprayed June 19-22, and a third only on July 11, after codling moth damage appeared on the fruit.

Codling moth damage was much reduced following the June 19 treatment and there was very little difference between this plot and the plot receiving two treatments. On the other hand, the portion receiving DDT on July 11 showed a much greater infestation although in none of the subplots was the damage as severe as in 1945. Results are given in some detail in Table 37. It would appear from these experiments that DDT added to the last reduced schedule treatment, applied about the middle of June or shortly thereafter, might be sufficient for light infestations of codling moth in Connecticut.

TABLE 37. RESULT OF FRUIT EXAMINATION
Lyman Orchard. 1946
(In connection with reduced schedule treatments)
Variety McIntosh

Tree	Total fruits examined	Per cent good[1]	Per cent curculio	Per cent scab	Per cent codling moth	Per cent others[2]	Notes on applications
C2[3]	181	88.40	.00	4.97	2.20	4.97	Sprayed in part by Exp. Station outfit. Remainder by Lyman including Sulfur dust supplements and one DDT spray July 11 after codling moth damage appeared on fruit.
C4	212	94.33	.47	2.83	.94	1.41	
C6	239	89.96	.41	4.19	.84	4.60	
C8	195	87.18	.51	4.62	2.05	6.15	
C10	230	86.95	.43	.87	6.96	4.78	
C12	237	84.39	.00	4.22	4.22	7.17	
Total & Averages	1294	88.48	.31	3.55	2.94	4.87	
C13	316	82.28	.00	6.64	1.26	9.81	Sprayed and dusted entirely by Lyman outfit and crews. One DDT spray only—June 19-22 combined with reduced schedule formula.
C14	256	80.08	.39	13.28	1.17	5.47	
B13	286	90.90	.00	5.59	.35	3.14	
B14	279	82.44	.36	13.98	1.08	2.15	
B15	256	85.94	.39	12.11	.00	1.56	
B16	278	82.73	.36	15.83	.00	1.08	
Total & Averages	1671	84.08	.24	11.07	.66	4.01	
B18	317	78.86	.00	17.67	.32	3.15	Sprayed and dusted entirely by Lyman outfit and crews. Two DDT sprays—June 19-22 and July 11. Combined with reduced schedule formula.
B20	328	89.93	.00	6.10	.91	3.35	
B22	287	92.33	.00	4.88	.00	2.79	
B24	277	84.84	.00	7.94	.36	7.22	
B26	320	75.00	.00	18.13	.63	6.56	
B28	247	74.90	.40	17.00	.00	7.69	
Total & Averages	1776	82.77	.06	11.94	.39	5.01	

1 "Good"—Free of external insect injury.
2 "Others"—Mostly bud moth—a few red banded leaf-roller.
3 Trees numbered beginning at north end of plot.

Formula Lead arsenate 6 lbs. Skim milk powder ½ lb.
Wyoming bentonite 1½ lbs. Fermate 2 lbs.
Mixed dry and used at rate of 10 lbs. to 100 gallons: ½ gal. white mineral oil added.
DDT—2 pounds 50 per cent wettable to 100 gallons.

TABLE 38. RESULT OF FRUIT EXAMINATION
Lyman Orchard
Examination of two trees at foot of hill southwest of water tank.
Intensive Schedule: Lead Arsenate, DDT, Sulfur, Fermate. Supplemented with sulfur dust.
Variety McIntosh

Tree	Total examined	Per cent good	Per cent curculio	Per cent scab	Per cent codling moth	Per cent others[1]
1	184	95.11	.00	.00	.00	4.89
2	352	96.59	.00	.56	.00	2.84
Total & Averages	536	96.08	.00	.37	.00	3.54

1 Mostly red-banded leaf-roller damage.

EXPERIMENT IN CONTROL OF INSECTS WITHOUT ARSENIC

Philip Garman

Experiment Station Farm Orchard

Here the trees were divided and one-half were sprayed with lead arsenate and wettable sulfur, the other half with benzene hexachloride, DDT and DN-111. Results are given in Tables 39, 40, 41.

Foliage and fruit in the non-arsenical plot appeared to be in excellent condition at harvest. In the sulfur-lead arsenate plot many leaves dropped by the time the fruit was harvested.

No odor was noticeable in or on Gravenstein apples picked between August 20 and September 1, two months after the last application of benzene hexachloride. Odor disappeared from the trees themselves in about one month.

Conclusions. Curculio control by the use of benzene hexachloride was certainly good but could be improved to advantage. Other insects and diseases were handled successfully and mites were kept at a low level of abundance all season. This was a very promising experiment but one that needs repeating on a more extensive scale.

Table 39. Comparison of Curculio Control with Sulfur-Lead Arsenate and Sulfur and DDT-Benzene Hexachloride-DN-111 Spray Program

Experiment Station Farm, Mount Carmel. 1946

	A Lead Arsenate—Sulfur			B DDT, etc.			
Variety	Tree	No. Apples	% Curculio	Tree	No. Apples	% Curculio	Difference
Wealthy	A5	626	44.56	C13	332	18.98	−25.58
	A8	263	55.51	B13	311	37.62	−17.89
	A10	122	25.14	A13	751	10.51	−14.90
Baldwin	L6	5229	3.61	L7	3481	6.94	+ 3.33
	M6	2683	2.98	M7	2965	1.96	− 1.02
Hurlburt	N6	6611	2.78	N7	5117	13.81	+11.03
		Mean difference in favor of DDT, etc. (Not significant by statistical analysis)					7.46%

Table 40. European Red Mite Control

Experiment Station Farm. 1946

	A Lead Arsenate—Sulfur			B DDT, etc.		
		Adult females per leaf			Adult females per leaf	
Variety	Tree	Aug. 14	Aug. 22	Tree	Aug. 14	Aug. 22
Baldwin	L6	13.4	38.7	L7	3.26	5.0
Baldwin	M6	18.5	59.0	M7	1.92	4.2
Hurlbut	N6	24.4	59.2	N7	2.58	8.2

Note: Leaves on treatment "B" remained green to end of season.

TABLE 41. FRUIT SIZE COMPARISONS OF THE TWO ABOVE SCHEDULES

	A				B			
Variety	Tree	Below 2½ inches %	2½ to 3 inches %	Above 3 inches %	Tree	Below 2½ inches %	2½ to 3 inches %	Above 3 inches %
Baldwin	L6	53.53	44.37	2.10	L7	19.17	68.86	11.97
	M6	18.49	72.15	9.35	M7	7.52	65.97	26.51

Treatment and Dates (Amounts are for 100 gals.)

A. April 6 Delayed dormant DN[1] solution (Krenite)
April 24 Lead arsenate 3 lbs. "Mike" sulfur 4 lbs., lime 3 lbs.
May 14 Same
May 21 Same
June 6 Same
June 17 Same
July 3 Same but lead arsenate reduced to 2 lbs.
Aug. 5 Same as July 3

B. April 6 Delayed dormant with DN solution
April 24 Benzene hexachloride (50% of 10% gamma isomer) 2 lbs., "Mike" sulfur 4 lbs.
May 14 Same plus 1 lb. Mississippi bentonite
May 21 Same plus 2 lbs. Mississippi bentonite
June 6 Benzene hexachloride 1 lb., "Mike" sulfur 4 lbs.
June 17 Benzene hexachloride 2 lbs., DN-111[2] 1 lb., 25% DDT 4 lbs., sulfur 4 lbs.
July 3 25% DDT 4 lbs., DN-111 1 lb., sulfur 4 lbs.
Aug. 5 Same as July 3 but without DN-111

1 Formulation containing sodium salt of dinitro-o-cresol.
2 Di cyclo hexyl amine salt of Di-nitro-cyclo-hexyl-phenate.

EXPERIMENTS IN CONTROL OF THE ORIENTAL FRUIT MOTH

PHILIP GARMAN AND W. T. BRIGHAM

Experiments in control of the Oriental fruit moth with DDT-sulfur dusts were conducted at Mount Carmel, Meriden, and Far Mill River (Nichols). In addition very close checks were made in the Scott orchard at Niantic where the owner applied one DDT spray and several DDT-sulfur dusts. Parasites *(Macrocentrus ancylivorus)* were released in considerable numbers in all the orchards mentioned. In the Mount Carmel Farm orchard and in the Scott orchard at Niantic, results from the DDT treatments were much better than were obtained from release of parasites. In the Watrous orchard in Meriden, the control appeared to be the same or slightly better, while in the Far Mill River orchard fewer infested fruits were found in the parasite section (possibly an error in handling the baskets). Bait pans hung in the parasitized and unparasitized treated plots caught fewer moths in all DDT treated plots (Table 44). The record from Mount Carmel is complicated somewhat because of the inclusion of zinc nicotine thiocyanate in the plots where bait pans were placed. Zinc nicotine thiocyanate, a new chemical from the U. S. Eastern Regional Research Laboratory was tried for the first time in the field against the Oriental fruit moth. Reduction in percentage of damaged fruit was considerable but no more than with DDT dusts. When sulfur was mixed with the thiocyanate there appeared to be considerable loss of efficiency.

Injury to foliage was noted from DDT-sulfur dusts and zinc nicotine thiocyanate. In the latter case, the injury took the form of marginal chlorosis of a more or less temporary nature. The injury from DDT sulfur dusts consisted of pin holes in the leaves and, later, leaf drop. This type of injury is considered to have been caused by a small amount of bentonite included in the original mix, since dusts used at Niantic containing no bentonite and dusts used at Mount Carmel in 1945 produced little or none.

The tests this year indicate that three 2.5 per cent DDT-sulfur dusts will reduce a level of 20-30 per cent infested fruit to about 4 per cent. Mites did not become troublesome in any of the plots but increases were reported from at least one commercial orchard where sprays were used entirely.

TABLE 42. ORIENTAL FRUIT MOTH CONTROL ON ELBERTA PEACHES
Mount Carmel—1946

Treatment	No. trees included in examination	Percentage damaged by Oriental fruit moth
3215 Parasites released among 144 trees.	6	21.21
DDT. Three 2½ per cent DDT-sulfur dusts.	6	4.01
Zinc nicotine thiocyanate 3 lbs. plus wettable sulfur 4 lbs. in 100 gals. Two sprays.	2	13.98
Same, no wettable sulfur.	2	7.30
Zinc nicotine thiocyanate 1.5 lbs. plus wettable sulfur 4 lbs. in 100. Two sprays.	2	19.23
Same, but no sulfur.	2	7.92

Applications—Dust July 5, 27, Aug. 5; Spray July 5, Aug. 5.
Samples—Picked fruit from all trees sampled systematically to two 16 quart baskets. Samples cut open to determine degree of infestation. All drops collected at harvest cut open—not sampled.
Percentages in last column are combined picked and drop counts.

TABLE 43. EXPERIMENTS IN CONTROL OF THE ORIENTAL FRUIT MOTH
Scott Orchard—Niantic—1946

Per Cent Infested Peaches	
DDT plot	Plot in which parasites were released
7.9	27.0
8.5	13.6
4.4	43.2
4.6	21.7
Average 6.85	28.14

Result of fruit examination. Samples cut open.
Spray 1 lb. actual DDT per 100 gallons and four 5 per cent DDT dusts.
Parasites released June 8, 20, July 6, July 18. Total 3215, females 1565.
Sprayed section 300 trees; parasite section 700 trees.

TABLE 44. BAIT PAN COLLECTION OF MOTHS
(Figures are number of moths per pail)

	DDT plot		Parasite plot	
Mount Carmel				
July 13	1		9	
July 30	1		2	
August 1	2		6	
August 7	5		6	
August 20	15		14	
August 27	15		12	
September 3	15		7	
Totals[1]	54		56	
Niantic				
July 11	86	134	145	
July 19	41	87	159	
August 1	14	35	30	
August 6	15	52	74	
August 9	21	16	55	
August 23	139	294	295	
August 28	43	139	198	
September 3	134	249	209	
September 10	52	211	203	
Totals	545	1217	1368	Av. 1292
Meriden				
July 30	1		7	
August 5	5		10	
August 12	2		23	
August 19	7		18	
September 3	13		30	
September 11	9		17	
Totals	37		105	
Far Mill River (Nichols)				
August 23	22		63	
August 28	1		5	
Totals	23		68	
Grand Total	659		1521	

1 Bait pans in section treated with zinc nicotine thiocyanate as well as DDT.

The only orchard from which large enough numbers of parasites were recovered to draw any conclusions was the Scott orchard in Niantic. It should be noted that 1946 was the first year in which DDT had been used, but there was considerable parasitism in the DDT sprayed and dusted section (Table 45). There was a conspicuous decline in percentage parasitism in both treated and untreated sections as the season advanced.

Although not large, the recoveries seem to indicate that the elimination of Macrocentrus was far from complete in the DDT plot. Likewise, the difference is not nearly as great as might be expected considering the number of parasites released in the untreated section (see Table 43 for the number released in this orchard).

TABLE 45. PERCENTAGE PARASITIZATION IN DDT AND PARASITE TREATED PORTIONS OF THE SCOTT ORCHARD IN 1947. DETERMINED FROM TWIG COLLECTIONS

Dates	DDT sprayed and dusted per cent parasitized	No. larvae	Parasite treated per cent parasitized	No. larvae
July 11	26.6	16	45.6	46
July 18	11.8	34	2.9	39
August 9	0.0	2	8.1	12

Spray and dust treatments were begun in July and continued through early August.

INCREASE IN RED-BANDED LEAF ROLLER DAMAGE FOLLOWING USE OF DDT

Philip Garman

Mount Carmel and Plumb Orchards, 1946

In regard to the general agitation concerning insect increases following DDT applications, it was noted during examination of fruit following harvest that there was a noticeable increase in red-banded leaf roller damage where DDT was used, the average increase being 3.9 per cent (Table 46). While this is not an alarming increase, it is something which will bear watching and possibly will need future investigation, especially since the differences are significant by statistical analysis.

Table 46. Control of Red-Banded Leaf Rollers

Comparison of DDT Schedules with Arsenical Spray Programs, 1946

Baldwin

DDT Program[1]		Arsenical Program[1]		
Tree	Per cent injured	Tree	Per cent injured	Difference
C6	3.52	E6	1.43	+2.09
C10	5.84	E10	.36	+5.48
C12	8.01	G18	.00	+8.01
M25	1.11	O28	.24	+ .87
L7	3.03	L6	.25	+2.78
M7	4.25	M6	.07	+4.18

Mean difference 3.90 per cent
Significant by statistical analysis

Explanation of treatments.

Trees C6, 10, and M25—lead arsenate early in the season to May 31 (4 sprays). Sulfur-DDT beginning June 11. (5 sprays).

Trees E6, 10 Reduced schedule 4 sprays.
G18 Reduced schedule 5 sprays.
O28 Lead arsenate wettable sulfur 6 sprays.

Trees L7, M7 DDT-Benzene hexachloride to June 17. DDT to August 5.
L6, M6 Lead arsenate wettable sulfur throughout the season.

[1] Note—Trees paired by proximity and variety.

FACTORS AFFECTING THE TOXICITY OF DDT RESIDUES

Neely Turner and Nancy Woodruff

The effectiveness of residues of DDT in controlling insects has been noted by Lauger, Martin and Müller (1944) and by Annand et al. (1944). Lindquist et al. (1944) reported differences in the toxicity of residues from different solvents and from different emulsions. Barnes (1945) studied the toxicity of residues of DDT to bedbugs on the surface of materials commonly used in the construction of buildings. She found that the residue on glass remained most toxic, followed in order by unpainted wood, cement, old painted wood and freshly painted wood. The toxicity of residues of DDT dissolved in deodorized kerosene was greater than residues from acetone solutions. Spraying rubbed deposits of DDT on wood with kerosene also increased their toxicity.

The importance of DDT residues in controlling pests of plants as well as household insects suggested a study of the factors affecting the toxicity of DDT residues. The following is a brief summary of the results to date.

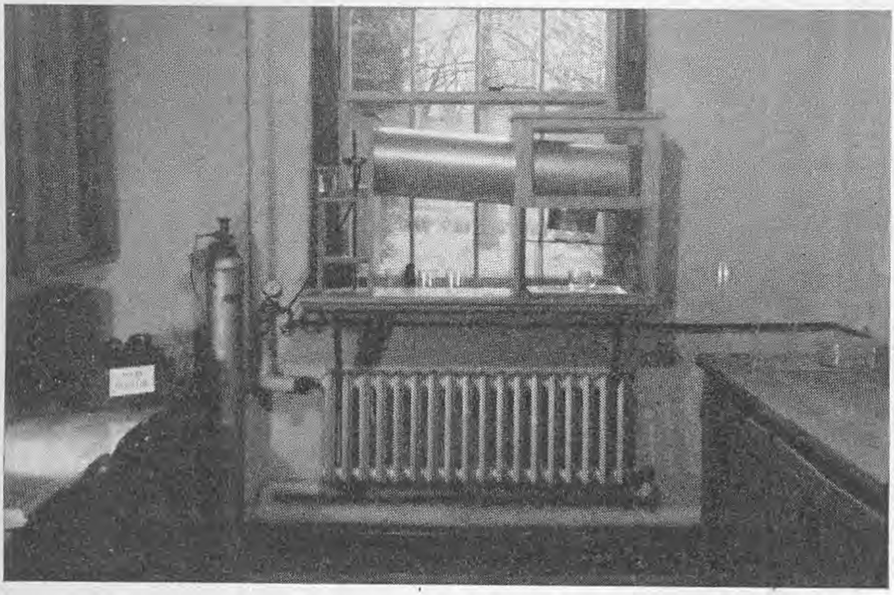


Figure 11. Laboratory sprayer modified from the design of Hoskins. The spray is delivered by the atomizer at the left and the right end of the tube is closed. Spray drifts down through the outlet pipe at lower right.

Methods

DDT was applied to glass lantern slides and to other surfaces of similar size by means of a precision laboratory sprayer designed after the apparatus of Hoskins as described by Richardson (Campbell and Moulton, 1943). The sprayed surfaces were dried for 24 hours and then exposed to 25 to 30 five-day old houseflies. The exposure cage was designed by Garman (1943). An exposure period of two hours was adopted after preliminary tests. When glass plates or wire screens were used as the sprayed surfaces, light attracted the flies. Wood blocks were sprinkled lightly with diluted honey to attract the flies. After the exposure period, the flies were held for 24 hours before mortality was determined.

Flies were reared on bran mash, and no effort was made to separate the sexes or to determine sex of the flies used.

Effect of Vehicle on Deposit

Glass slides were sprayed with water, with kerosene and with a chlorinated solvent[1] to determine the deposition of each of these materials. Slides were weighed immediately after spraying, and three replicates were sprayed. The deposit was varied by varying the time of spraying. The results have been summarized in Table 47. The deposit of water was much greater than for the other two materials. Since droplet size and therefore surface tension is involved, it seems likely that the deposition is a reflection of size of the droplets of the various vehicles. Those producing the smallest particle size would be expected to produce the smallest deposit.

TABLE 47. EFFECT OF VEHICLE ON SPRAY DEPOSIT

Amount Deposit, Grams

Vehicle	Spray time, seconds	1	2	3	Average
Water	2.5	.0629	.0686	.0645	.0653
	5.0	.1328	.1365	.1338	.1344
	10.0	.2708	.2513	.2675	.2632
	20.0	.5669	.5517	.5444	.5543
Kerosene	2.5	.0267	.0224	.0243	.0245
	5.0	.0656	.0616	.0634	.0635
	10.0	.1369	.1366	.1383	.1373
	20.0	.2534	.2528	.2435	.2499
Chlorinated solvent[1]	2.5	.0337	.0306	.0351	.0331
	5.0	.0950	.0931	.0924	.0935
	10.0	.1892	.1823	.1863	.1859
	20.0	.3253	.3503	.3380	.3379

1 Velsicol AR 50.

These same three vehicles were used with DDT for toxicity tests. Technical DDT was mixed with an equal quantity of pyrophyllite in a ball mill for use in water. It was suspended at the rate of .25 gram DDT in 100 ml. of water. A similar quantity was dissolved in each of the two solvents. Sets of galvanized wire screens were sprayed, dried 24 hours, and tested for toxicity to houseflies twice on succeeding days. The experiment was repeated, and the results are summarized in Table 48. It is evident that the toxicity of the deposit from the water suspension was highest. However, toxicity of residues from the two solvents was not in the order of the deposition as shown in Table 47. Lindquist et al (1944) noted similar differences between solvents using the time for complete knock-down of flies as the criterion of effectiveness. More than one factor is acting to produce these results. It seems probable that the nature of the crystalline deposit as noted by Barnes (1945) may more than offset the lighter deposit from the kerosene spray.

1 Velsicol AR 50.

TABLE 48. EFFECT OF VEHICLE ON TOXICITY OF DEPOSIT

Spray time, seconds	Average mortality (per cent)		
	Water	Kerosene	Chlorinated solvent[1]
2.5	31	12	5
5.0	51	33	38
10.0	70	68	56
20.0	91	65	51

[1] Velsicol AR 50.

Effect of a Wetting Agent

One part of DDT was ball-milled with three parts fuller's earth *(Attaclay)* to form a powder for suspension in water. The wetting agent *Vatsol* was added to a series of samples at the rates of .5, 1, 2 and 4 per cent of the total mixture. Deposits were varied by changing the concentration of DDT in the suspension with spraying time constant. Four sets of glass slides were sprayed, the weight of deposit recorded, and two exposures of each slide made to houseflies. The numerical averages of the deposits and of the percentage of the flies killed are given in Table 49. There is no doubt that the addition of the wetting agent reduced the size of the deposit. The toxicity tests showed, however, that the smaller deposits were about as toxic as the larger deposits without a wetting agent.

Loss of Toxicity of Deposits

Lindquist et al (1944) and Barnes (1945) presented data showing loss of toxicity of residues of DDT. Barnes indicated that the losses might be attributed to physical changes in the DDT. Sweetman (1945) has suggested that insects may carry residue away with them, thus reducing the toxicity of the residue. In order to test this possibility, sets of glass slides were sprayed with four types of materials: (1) a spray powder of the suspension type prepared in the laboratory, (2) a commercial spray powder, (3) a commercial emulsion and (4) a kerosene solution. One set of the slides was tested on houseflies every other day for four exposures, at which time the toxicity had definitely decreased. The other set was stored and tested on the last day of the series of tests. The results are given in Table 50. There was obviously a marked loss in toxicity of the residues as they were exposed to the flies. However, in three of the four tests the unexposed surfaces of the same cages were also very low in toxicity. Only in the case of the commercial spray powder was there any evidence that the flies may have been responsible for the loss. It must be concluded that this test did not show that removal of DDT by the test insects was responsible for the losses in toxicity.

Effect of Particle Size of DDT

In a study of the effect of diluents on the toxicity of DDT applied in water suspension, it was shown that the finer the particle size the more toxic the residues, other things being equal (Woodruff and Turner, 1947).

Summary

The amount of DDT deposited from sprays was affected by the vehicle used. Water deposited most, a chlorinated solvent *(Velsicol AR 50)* next and

TABLE 49. AMOUNT AND TOXICITY OF DEPOSITS OF DDT WITH SPREADER ADDED

Per cent Vatsol	Concentration DDT %	Mean deposit[1] (grams)	Mean mortality toxicity[2]
None	.125	.0008	30.3%
	.25	.0013	54.8
	.5	.0028	57.8
	1.0	.0045	55.1
.5	.125	.0007	56.1
	.25	.0011	46.8
	.5	.0027	55.1
	1.0	.0043	72.8
1.0	.125	.0008	22.8
	.25	.0012	33.0
	.5	.0022	46.6
	1.0	.0042	73.9
2.0	.125	.0006	41.5
	.25	.0010	42.2
	.5	.0018	57.7
	1.0	.0039	79.3
4.0	.125	.0004	20.7
	.25	.0009	27.4
	.5	.0020	54.3
	1.0	.0035	73.7

1 Average of 4 replicates.
2 Average of 8 tests on 4 slides.

TABLE 50. EFFECT OF EXPOSURE TO HOUSEFLIES ON THE TOXICITY OF DEPOSITS OF DDT

Material	Conc. DDT %	Spray time secs.	Mortality Surfaces exposed serially 1/22	1/24	1/26	1/28	New surfaces 1/28
Laboratory	.25	2.5	7	0	0	9	0
spray		5.0	46	20	0	0	0
powder		10.	60	39	10	16	0
		20.	80	75	58	8	59
Commercial	.125	2.5	22	60	0	0	21
spray		5.	45	93	45	0	0
powder		10.	97	92	54	11	59
		20.	94	100	85	77	100
Emulsion	.15	2.5	13	0	0	0	6
		5.	47	4	0	18	25
		10.	95	5	0	6	40
		20.	100	5	24	45	45
Kerosene	.25	2.5	64	0	0	8	0
solution		5.	60	13	0	0	0
		10.	60	16	0	0	10
		20.	92	16	0	43	18

kerosene the smallest amount of DDT. The toxicity of residues from the three vehicles was greatest in the case of water, next with kerosene and lowest with the solvent.

Addition of a wetting agent of DDT spray powder reduced the deposit but apparently did not affect toxicity of the deposit.

Deposits lost toxicity rather rapidly, and the loss could not be ascribed to removal of DDT by the test insects.

Literature Cited

ANNAND, P. N., *et al.* 1944. Tests conducted by the Bureau of Entomology and Plant Quarantine to appraise the usefulness of DDT as an insecticide. Jour. Econ. Ent.. 37:125-158.

BARNES, S., 1945. The residual toxicity of DDT to bed bugs. Bul. Ent. Res., 36:273-282.

CAMPBELL, F. L. AND F. R. MOULTON, 1943. Laboratory procedures in studies of the chemical control of insects. 206 pp. A.A.A.S., Washington, D. C.

GARMAN, P., 1943. Control of the apple maggot with rotenone dusts. Conn. Agr. Exp. Sta. Bul. 474.

LAUGER, P., H. MARTIN AND P. MULLER. 1944. The constitution and toxic effect of botanical and new synthetic insecticides. Translation from Helv. Chim. Act 27 by Geigy Co., Inc., New York, N. Y.

LINDQUIST, A. W., A. H. MADDEN, H. G. WILSON AND H. A. JONES. 1944. The effectiveness of DDT as a residual spray against houseflies. Jour. Econ. Ent. 37:132-133.

SWEETMAN, H. L. 1945. The residual toxicity of DDT. Soap and San. Chem. 21(12):141, 143, 145, 147, 149, 171.

WOODRUFF, N., AND N. TURNER. 1947. The effect of particle size on the toxicity of DDT in water suspension. Jour. Econ. Ent. 40:206-211.

THE RELATIVE TOXICITY OF NICOTINE SULFATE AND NICOTINIUM COMPOUNDS

NEELY TURNER, Conn. Agr. Expt. Sta., New Haven, Conn., and
D. H. SAUNDERS, Eastern Regional Research Laboratory, Phila., Pa.[1]

The toxicity of nicotine to insects has been investigated by many workers whose findings have been well summarized by Shepard (1939). As far as chemical structure and toxicity are concerned, only those compounds in which the nicotine molecule was changed very slightly approached nicotine in toxicity. The Eastern Regional Research Laboratory of the U. S. Department of Agriculture has prepared a series of nicotine compounds by addition of radicals to the nitrogen in both the pyrrolidine and pyridine rings. These compounds offered an opportunity to study the effect of such additions on the toxicity of nicotine, and further to correlate chemical structure with toxicity.

Preliminary tests reported by Mayer, Weil, Saunders and Woodward (1947) showed that several of these compounds were more toxic than nicotine in tests on several insects.

Materials

All chemicals used, with the exception of the nicotine sulfate standard, were prepared in the Eastern Regional Research Laboratory. Structural formulae, empirical formulae, molecular weight, percentage of nicotine and information on solubility were furnished for all the compounds.

Alkyl, aralkyl, dialkyl, and diaralkyl nicotinium salts were prepared by methods described by Mayer, Weil, Saunders and Woodward (1947). Mixed nicotinium and hydrogen iodide salts were prepared by neutralizing the pyrrolidine nitrogen of the nicotine with hydrogen iodide leaving the nitrogen in the pyridine ring free to react with alkyl or aralkyl halides to form the corresponding quaternary nicotinium salt.

Attempts were made to prepare 2,4-dinitrophenylnicotinium salts by reacting 2,4-dinitrophenyl halides with nicotine, but under the conditions employed the reaction product decomposed. The reaction of aliphatic acid esters of 2,4-dinitrophenol with nicotine yielded a product which on examination proved to be nicotine 2,4-dinitrophenolate. Toxicity data on the latter compound (ERL-100a) were obtained and are included with those of the nicotinium salts.

Methods

The nicotinium compounds were tested as contact insecticides by spraying on the aphid, *Aphis rumicis* Linn, reared on nasturtium in the greenhouse. All dilutions were made on the basis of nicotine content. The water-soluble nicotiniums were dissolved directly in distilled water and compared in toxicity with nicotine sulfate in the same medium. Compounds not soluble in water were dissolved in acetone (10 ml.) and the acetone solution added to distilled water to make up 150 ml. of spray solution. A similar proportion of acetone was added to the nicotine sulfate standard. Preliminary tests showed that many of the nicotiniums were much less toxic than nicotine sulfate. Therefore, the nicotine content of the sprays using nicotinium compounds was double that of nicotine sulfate in order to avoid extrapolation in

[1] The authors acknowledge the assistance of C. F. Woodward and L. Weil of the Eastern Regional Research Laboratory in preparing the chemicals and their suggestions, together with those of J. J. Willaman in the preparation of the manuscript.

comparisons of toxicity. No wetting or conditioning agents were added to any of the materials.

The sprayer was designed after Hoskins as described by Richardson (Campbell & Moulton, 1943). As described, this sprayer was built for testing petroleum sprays on houseflies. Addition of a hinged plate under the outlet made it possible to spray the lower sides of nasturtium leaves with the aphids in place. Stems of the sprayed leaves were placed in water and were kept 24 hours in a conditioned room at 80° F. and 60 per cent relative humidity. Counts were made on the basis of movement, that is, any aphid that moved when disturbed by a needle was counted as alive.

The dosage series was applied by varying the spray time. For this series spray times of 5, 10, 20 and 40 seconds were used. Two replicates of each material were made, and the average mortality determined by averaging the percentages killed. If for any reason the two replicates were not consistent, further tests were made of the same materials.

Because of variations in the susceptibility of test insects to spray materials, a nicotine sulfate standard was applied with each series of nicotinium compounds. In reporting the results, these standard sprays have been included with the series with which they were compared.

Results

A summary of the results is given in Table 51. Dosage-response curves were plotted from these data, using logarithmic probability paper and fitting the curves by eye. Since there was usually no question as to the relative toxicity of the nicotiniums and nicotine sulfate, no statistical analysis was made. The relative toxicity was interpolated from the dosage-response curves, using as a dosage unit the concentration times the spray time. Since this led to complex numbers, a dosage of 1 was assigned to .04 per cent nicotine sprayed for 40 seconds. An estimate of relative slope was made, again by observation. All these results have been summarized in Table 52. In general, the results were very consistent. The amount of nicotine in the form of nicotine sulfate required varied greatly in only a few cases. In the tests with *p*-nitrobenzylnicotinium thiocyanate, for instance, one spraying with nicotine sulfate was relatively ineffective. A similar instance occurred in one test with *p*-nitrobenzylnicotinium palmitate. The variation in effectiveness of the nicotiniums in these two series was much less than the variation in potency of nicotine sulfate. For this reason the tests in which large quantities of nicotine sulfate were required have been given very little emphasis.

It will be noted at the outset that only a few of the nicotinium compounds were as toxic as nicotine sulfate. The more effective were Nos. 100a, nicotine 2, 4-dinitrophenolate; and 104, 1 benzyl-3-[2-(1-methylpyrrolidylhydriodide)] pyridinium chloride. Three other materials were less toxic than nicotine sulfate at the levels used, but had steeper dosage-response curves and would be expected to be more toxic than nicotine sulfate at higher dosages. These were Nos. 79, dodecylnicotinium thiocyanate; 94, didodecylnicotinium dithiocyanate, and 138, ethylnicotinium iodide. With regard to slope, 100a also appeared to have a steeper slope than nicotine sulfate. In addition to these materials which approached the toxicity of nicotine sulfate, two others had slopes apparently steeper than nicotine sulfate: 116, dilaurylnicotinium dipicrate and 35, hexadecylnicotinium thiocyanate. However, these materials required so high a dose for equal control as compared with nicotine sulfate that the steeper slope was of little advantage.

TABLE 51. AVERAGE PER CENT KILLED—TWO REPLICATES—SPRAY TIME

Materials	% Nicotine	5 secs.	10 secs.	20 secs.	40 secs.
ERL 36	.08	33.7	39.6	69.5	66.3
37	.08	29.3	38.9	55.7	66.5
53	.08	29.8	27.3	54.7	68.0
55	.08	33.2	44.8	51.4	59.4
58	.08	48.1	54.4	61.1	67.7
90	.08	20.0	20.8	23.7	31.1
Nicotine sulfate	.04	45.5	64.4	75.2	82.4
ERL 99	.08	3.7	5.6	8.4	15.1
106	.08	6.7	8.1	10.8	15.2
107	.08	9.6	16.8	26.1	37.9
108	.08	34.3	35.9	49.2	55.9
109	.08	26.1	47.5	35.9	49.7
110	.08	25.3	44.6	44.4	52.5
Nicotine sulfate	.04	38.4	57.4	57.2	73.2
ERL 118	.08	3.4	4.0	12.4	28.0
121	.08	1.6	4.1	12.1	14.2
119	.08	2.7	8.2	16.5	24.1
122	.08	28.4	30.9	36.1	52.2
120	.08	22.2	32.0	37.8	41.0
143	.08	2.9	14.1	14.9	24.2
144	.08	3.8	6.1	7.8	15.7
Nicotine sulfate	.04	27.1	31.4	61.9	76.8
ERL 105	.08	12.3	18.6	17.9	34.3
103	.08	11.1	14.0	15.9	30.1
104	.08	41.9	61.3	60.0	69.3
102	.08	12.2	15.3	18.4	26.1
Nicotine sulfate	.04	37.6	40.1	51.9	62.8
ERL 100a	.08	63.1	68.8	81.1	90.0
79	.08	27.6	46.9	71.9	78.8
81	.08	30.0	61.5	67.9	77.4
36	.08	22.5	33.0	41.1	52.5
55	.08	41.1	44.5	52.8	61.6
Nicotine sulfate	.04	43.7	52.9	63.9	73.8
ERL 34	.08	39.9	50.0	43.3	66.6
35	.08	22.6	36.2	32.3	71.3
54	.08	31.9	28.7	52.3	57.8
93	.08	11.7	13.0	25.3	28.3
Nicotine sulfate	.04	57.7	66.0	81.9	82.7
ERL 96	.08	17.8	27.5	42.5	43.0
97	.08	14.9	24.9	48.7	69.0
Nicotine sulfate	.04	49.7	52.7	68.2	83.9
ERL 75	.08	35.0	46.4	50.3	61.9
84	.08	35.7	45.7	53.6	58.7
85	.08	13.5	12.2	19.6	17.4
86	.08	40.9	44.5	52.8	57.8
87	.08	12.9	25.4	34.4	41.5
Nicotine sulfate	.04	52.1	64.9	72.9	78.2
ERL 73	.08	14.0	22.5	26.3	25.9
76	.08	48.2	67.3	70.8	76.5
31	.08	33.9	45.2	58.6	64.5
72	.08	57.1	58.8	57.5	69.0
Nicotine sulfate	.04	61.1	61.2	71.1	79.4

TABLE 51. AVERAGE PER CENT KILLED—TWO REPLICATES—SPRAY TIME (cont'd)

Materials	% Nicotine	5 secs.	10 secs.	20 secs.	40 secs.
ERL 79	.08	19.5	24.5	56.3	68.8
Nicotine sulfate	.04	76.7	75.6	77.7	79.3
ERL 30	.08	12.0	10.9	14.4	17.5
52	.08	43.9	52.1	60.6	74.6
74	.08	35.3	57.9	43.0	83.7
Nicotine sulfate	.04	37.6	32.3	41.8	68.6
ERL 30	.08	23.9	31.9	28.6	40.6
52	.08	68.2	65.5	80.2	81.3
74	.08	27.3	47.2	45.2	62.6
88	.08	57.3	70.7	73.8	82.9
89	.08	31.8	37.9	42.5	51.0
Nicotine sulfate	.04	65.6	81.0	78.6	81.4
ERL 79	.08	27.3	30.9	37.9	73.9
81	.08	23.1	53.2	57.5	65.0
82	.08	47.8	57.2	57.3	71.4
83	.08	48.1	72.7	74.0	80.8
98	.08	38.6	45.3	64.5	68.9
Nicotine sulfate	.04	65.7	65.5	74.6	82.5
ERL 29	.08	44.2	41.6	56.7	52.5
51	.08	34.8	35.8	64.7	67.5
56	.08	38.1	57.7	60.7	76.5
57	.08	46.0	65.1	74.0	84.0
Nioctine sulfate	.04	55.7	65.0	76.8	77.9
ERL 91	.08	11.0	15.5	12.8	39.6
94	.08	28.9	42.6	57.8	76.9
115	.08	28.5	48.8	32.7	29.7
116	.08	11.6	19.0	47.1	55.6
117	.08	15.3	27.3	29.4	35.1
Nicotine sulfate	.04	42.5	61.1	61.5	73.4
ERL 91	.08	14.4	14.2	22.9	43.1
94	.08	16.4	30.4	63.0	84.9
74	.08	25.5	36.3	45.0	59.5
51	.08	42.3	45.6	41.1	57.6
56	.08	25.0	32.6	45.7	63.1
57	.08	34.6	39.9	50.0	64.8
Nicotine sulfate	.04	36.0	45.2	58.1	76.2
ERL 80	.08	15.8	28.6	35.4	43.9
92	.08	5.6	9.9	14.3	16.7
139	.08	13.1	11.5	23.2	39.8
141	.08	11.4	17.0	15.1	22.1
77	.08	9.2	20.4	23.0	33.7
78	.08	21.8	31.9	35.3	54.0
140	.08	11.5	11.8	12.8	15.9
142	.08	12.3	13.4	25.8	27.7
Nicotine sulfate	.04	24.6	38.2	46.2	65.6
ERL 111	.08	24.7	37.4	42.6	59.2
112	.08	53.3	50.4	55.5	63.4
113	.08	40.1	39.4	43.7	52.2
114	.08	25.6	46.7	50.8	56.0
137	.08	11.7	9.9	21.2	28.0
138	.08	27.9	36.2	51.7	76.1
Nicotine sulfate	.04	39.4	56.5	60.3	73.7

TABLE 52. COMPARISON OF TOXICITY OF NICOTINIUM COMPOUNDS AND NICOTINE SULFATE

ERL No.	Compound	Per cent killed at level of comparison	Dosage required		Toxicity of ERL[1]	Slope[2]
			ERL	Nicotine sulfate		
107	methylnicotinium bromide	40	1.7	.13	8	parallel
108	ethylnicotinium bromide	50	1.0	.2	20	flat
80	butylnicotinium bromide	40	.9	.2	22	parallel
81	dodecylnicotinium bromide	70	1.0	.6	60	parallel
			2.0	.2	10	parallel
34	hexadecylnicotinium bromide	70	2.1	.2	10	parallel
36	octadecylnicotinium bromide	50	1.4	.15	10	parallel
			1.5	.3	20	parallel
72	benzylnicotinium bromide	60	.7	.11	16	flat
31	o-chlorobenzylnicotinium bromide	70	2.0	.2	10	parallel
30	*p*-nitrobenzylnicotinium bromide	50	5.0	.1	2	flat
			6.0	.1	1.7	flat
111	1,2-ethylene-bis (nicotinium bromide)	60	1.9	.3	16	parallel
112	poly(2-bromoethylnicotinium bromide)	60	1.0	.3	33	flat
106	dimethylnicotinium dibromide	Less than			1	flat
109	diethylnicotinium dibromide	50	1.0	.2	20	flat
92	dibutylnicotinium dibromide	40	9.0	.2	2	parallel
91	didodecylnicotinium dibromide	40	3.0	.15	5	parallel
73	dibenzylnicotinium dibromide	60	>10.0	.1	<1	flat
93	methylnicotinium iodide	60	15.0	.1	.6	parallel
138	ethylnicotinium iodide	60	.8	.27	34	steep
139	butylnicotinium iodide	40	1.7	.22	13	parallel
140	octylnicotinium iodide	40	3.0	.22	7	flat
141	dodecylnicotinium iodide	40	1.0	.22	22	parallel
142	octadecylnicotinium iodide	40	>100	.22	< .1	parallel
90	dimethylnicotinium diiodide	50	> 10	.1	<1	flat
105	1-methyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium iodide	40	2.8	.15	5	parallel
137	diethylnicotinium diiodide	50	10	.13	1.3	parallel

TABLE 52. COMPARISON OF TOXICITY OF NICOTINIUM COMPOUNDS AND NICOTINE SULFATE (cont'd)

ERL No.	Compound	Per cent killed at level of comparison	Dosage required		Toxicity of ERL[1]	Slope[2]
			ERL	Nicotine sulfate		
98	dodecylnicotinium chloride	70	1.4	.2	16	parallel
29	benzylnicotinium chloride	60	3.0	.13	4	flat
84	*p*-chlorobenzylnicotinium chloride	60	2.5	.15	6	flat
86	2,4-dichlorobenzylnicotinium chloride	60	2.5	.15	6	flat
88	3,4-dichlorobenzylnicotinium chloride	80	1.0	.45	45	flat
113	2,2/-bis(nicotinium chloride) ethyl ether	50	1.5	.15	10	flat
114	poly[2-(2-chloroethoxy) ethylnicotinium chloride]	60	2.0	.27	13	parallel
104	1-benzyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride	70	1.2	1.5	125	parallel
103	1-*p*-chlorobenzyl-3[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride	40	7.0	.15	2	parallel
102	1-*p*-nitrobenzyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride	40	10.0	.15	1.5	flat
96	didodecylnicotinium dichloride	60	2.4	.2	8	parallel
85	di-*p*-chlorobenzylnicotinium dichloride	60	>100	.15	<1	flat
87	di-2,4-dichlorobenzylnicotinium dichloride	60	4.0	.15	4	parallel
89	di-3,4-dichlorobenzylnicotinium dichloride	50	1.5	.1	6	flat
78	butylnicotinium thiocyanate	40	.7	.2	30	parallel
77	octylnicotinium thiocyanate	40	1.8	.2	11	parallel
35	hexadecylnicotinium thiocyanate	70	2.1	.2	10	steep
37	octadecylnicotinium thiocyanate	70	1.5	.3	20	parallel
79	dodecylnicotinium thiocyanate	70	.8	.6	75	steep
		60	1.0	.1	10	steep
76	benzylnicotinium thiocyanate	70	.7	.3	43	parallel
75	o-chlorobenzylnicotinium thiocyanate	60	1.5	.15	10	flat
74	*p*-nitrobenzylnicotinium thiocyanate	60	1.5	.35	23	parallel
		60	1.3	.15	11	parallel
94	didodecylnicotinium dithiocyanate	60	.75	.35	46	steep
143	butylnicotinium *p*-toluenesulfonate	30	2.7	.13	5	flat
121	2-methyl-2-propen-1-ylnicotinium *p*-toluenesulfonate	30	3.5	.13	4	flat
120	allylnicotinium *p*-toluenesulfonate	30	.3	.13	43	flat

TABLE 52. COMPARISON OF TOXICITY OF NICOTINIUM COMPOUNDS AND NICOTINE SULFATE (cont'd)

ERL No.	Compound	Per cent killed at level of comparison	Dosage required		Toxicity of ERL[1]	Slope[2]
			ERL	Nicotine sulfate		
122	2-chloro-2-propen-1-ylnicotinium *p*-toluenesulfonate	30	.25	.13	52	flat
118	2,2′-bis(nicotinium *p*-toluenesulfonate) ethyl ether	30	1.5	.13	9	parallel
119	2-nicotinium *p*-toluenesulfonate-2′-(2-nicotinium *p*-toluenesulfonate ethoxy) ethyl ether	30	1.9	.13	7	parallel
144	2-(2-butoxy-ethoxy) ethylnicotinium *p*-toluenesulfonate	30	6.0	.13	2	flat
56	benzylnicotinium palmitate	70	1.3	.3	23	parallel
52	*p*-nitrobenzylnicotinium palmitate	70	2.0	.3	15	parallel
		80	1.0	.45	45	flat
		70	1.4	1.2	90	parallel
82	dodecylnicotinium propionate	70	2.0	.2	10	parallel
100a	nicotine 2,4-dinitrophenolate	80	.9	1.5	167	steep
83	dodecylnicotinium oleate	70	.6	.2	30	parallel
		60	2.0	.15	7	parallel
51	benzylnicotinium oleate	60	4.5	.45	10	flat
97	didodecylnicotinium dioleate	60	1.7	.2	12	parallel
54	methylnicotinium stearate	60	2.0	.1	5	
57	benzylnicotinium stearate	70	.7	.3	43	parallel
115	dodecylnicotinium picrate	50	2.5	.13	5	flat
117	3-[2-(1-dodecyl-1-methylpyrrolidyl bromide)] pyridine picrate	50	3.5	.13	4	parallel
116	didodecylnicotininum dipicrate	50	1.1	.13	12	steep
53	octadecylnicotinium acetate	70	2.0	.3	15	flat
99	dioctadecylnicotinium diacetate	Less than			1	flat
55	octadecylnicotinium laurate	60	2.2	.17	8	flat
58	octadecylnicotinium valerate	70	2.0	.3	15	parallel
110	methylnicotinium methylsulfate	50	1.0	.2	20	flat

1 On the basis of dosage of nicotine sulfate equalling 100 per cent.
2 Slope of dosage-response curve in relation to nicotine sulfate.

Dimond et al. (1941) have shown that slope may be affected (1) by the organism used (2) by the age and nutrition of the organism (3) by the toxicant and (4) by coverage. The same organism was used in all these tests and since the aphids were selected at random the age and nutrition should not be a factor. The method used in these tests did not control coverage, since there was no attempt to control the surface tension of the spray mixtures. It is, therefore, impossible to determine whether the differences in slope were caused by changes in the toxicant or by coverage. Probably both were involved. It does seem worth noting that all of the highly toxic nicotiniums had slopes apparently steeper than the slope of the nicotine sulfate standard.

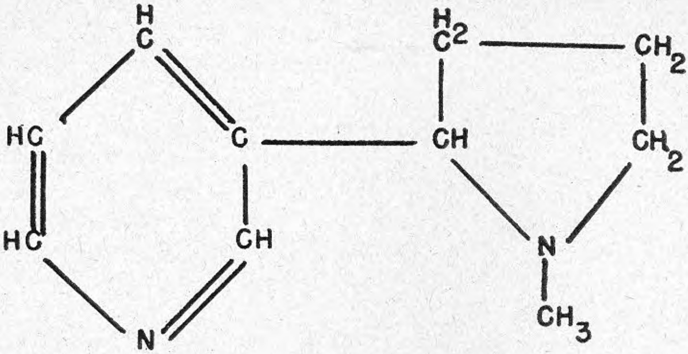
A large group of compounds had dosage-response curves with slopes definitely flatter than for nicotine sulfate. Few of these compounds were very toxic, and obviously the toxicity in comparison with nicotine sulfate decreased as the dosage was increased. If these slopes are any definite indication of changes in the mode of action of the nicotiniums, there are not enough correlations to establish any relationship between chemical structure and slope. Likewise, there appears to be no definite relationship between wetting properties and slope. For instance, octadecylnicotinium thiocyanate, with a contact angle of 50, had a much flatter slope than the cetylnicotinium thiocyanate with a contact angle of 52.

In spite of the fact that none of these compounds was promising as a replacement for nicotine sulfate, it is of interest to examine the data critically in an attempt to determine reasons for differences in toxicity between nicotine sulfate and the nicotinium compounds, and between the various nicotiniums.

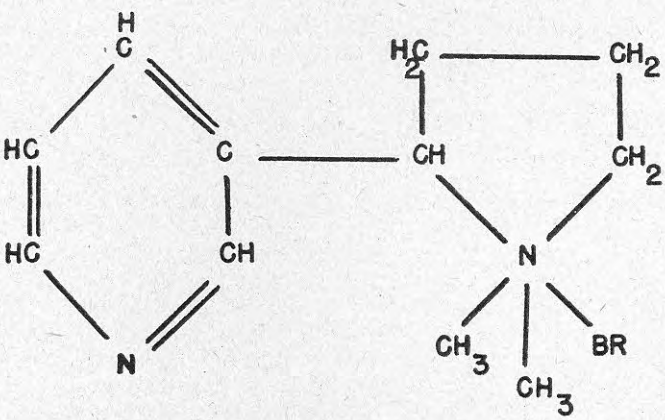
Richardson, Craig and Hansberry (1936) have shown that the substitution of a hydrogen atom for the methyl group on the nitrogen of the pyrrolidine ring did not change the toxicity of the compound. The substitution of a piperidine ring (in anabasine) for the pyrrolidine ring increased toxicity sharply. Campbell, Sullivan and Smith (1933) have reported that the substitution of a methyl group for the hydrogen in the piperidine ring of anabasine reduces the toxicity slightly. Richardson and Shepard (1930) showed that breaking the pyrrolidine ring reduced the toxicity sharply.

In the present study the modification in the nicotine molecule was additive on the nitrogen in the two rings. The simplest change made was the direct addition of an alkyl halide to the trivalent nitrogen in the pyrrolidine ring, forming a quaternary ammonium salt. (See Fig. 12). When such an addition was made, the toxicity of the compound was reduced sharply. Thus No. 107, methylnicotinium bromide was only 8 per cent as toxic as nicotine. When an additional alkyl halide was added to the nitrogen in the pyridine ring (See Fig. 12), the toxicity was still further reduced, as in No. 106, dimethylnicotinium dibromide, which was less than 1 per cent as toxic as nicotine sulfate. Within this series of compounds there were 11 comparisons between mono- and di-substituted nicotiniums. In nine instances the di-substituted compounds were definitely less toxic than the mono-. Dodecyl nicotinium thiocyanate was tested twice—in one test it was more toxic than didodecyl nicotinium dithiocyanate and in the other test less toxic. Dodecyl nicotinium picrate was also less toxic than dilaurylnicotinium dipicrate.

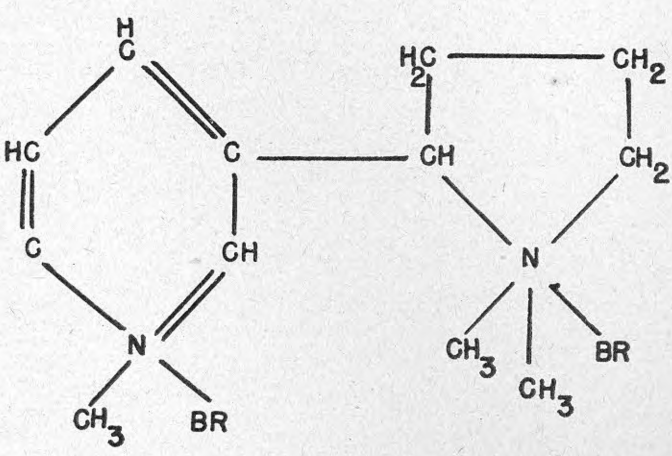
The combination of nicotinium and hydrogen iodide salts in the same molecule in general fails to produce any substantial toxicity. Thus 1-methyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium iodide shows only a slight increase in toxicity over either the methylnicotinium iodide or dimethylnico-



NICOTINE



METHYL NICOTINIUM BROMIDE



DIMETHYL NICOTINIUM DIBROMIDE

Figure 12

tinium diiodide. Similarly 1-*p*-nitrobenzyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride and the *p*-chlorobenzyl form of the same compound show relatively low toxicity.

On the other hand, 1-benzyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride, which differs from the latter two compounds only in the absence of a substituent on the benzyl group, was more toxic than nicotine sulfate.

Since in most cases addition of radicals to the pyrrolidyl nitrogen reduced toxicity and addition to the pyridine nitrogen reduced toxicity still more, it seems logical to conclude that the two nitrogens are very important to the toxicity of nicotine.

In spite of the fact that additions to nicotine reduced toxicity, the compounds varied in potency. In the bromides, toxicity increased from methyl to dodecyl, and then decreased as the length of the radical was increased further. In the iodides there was a less regular increase in potency and the ethyl nicotinium iodide was the most toxic of the series. In the thiocyanates dodecyl was again the most toxic of the series. This relationship agrees well with the results of Siegler and Popenoe (1942) and Tattersfield and Gimingham (1927). In other words the toxicity of these nicotiniums seemed to be controlled more by the nature of the added radicals than by the fact that the nicotine molecule was present.

Substitution of the benzyl radical for a straight chain had a variable effect. In the thiocyanates the benzyl was slightly more toxic than dodecyl. In the chlorides, bromides and oleates the benzyl was much less toxic than the dodecyl compounds. Substitution on the benzene ring also affected toxicity. O-chlorobenzylnicotinium thiocyanate was less toxic than benzylnicotinium thiocyanate, and the same was true of the bromides. *p*-Chlorobenzylnicotinium chloride was less toxic than the benzyl compound. 2,4-dichlorobenzylnicotinium chloride was also less toxic than benzyl. The 3,4 compound was one of the most toxic chlorides tested, however.

p-Nitrobenzylnicotinium bromide was less toxic than the benzyl bromide. In the thiocyanates and palmitates, *p*-nitrobenzyl was more toxic than benzyl.

Nicotine 2,4-dinitrophenolate (not a nicotinium) was the most toxic compound tested. Tattersfield et al. (1925) have shown that 2,4-dinitro compounds are highly toxic to insects.

Synthesis of compounds containing two molecules of nicotine such as 2,2′-Bis(nicotinium chloride) ethyl ether did not produce high toxicity. In fact, these molecules were less toxic than some of the smaller and simpler compounds.

Although the series of compounds available for comparison is not large, it seems that in general the iodides were less toxic than the corresponding bromides. Two of the chlorides were less toxic than the similar bromides, while one was slightly more toxic. The thiocyanates were much more toxic than the halogen compounds. The propionates, oleates, stearates, palmitates, laurates, valerates and *p*-toluene sulfonates were certainly not outstanding in toxicity. The acetates, picrates and sulfates were also mediocre.

The toxicity of the nicotine molecule was certainly not dominant in the nicotiniums. It did influence toxicity, however, as illustrated by comparing dodecylnicotinium thiocyanate with dodecylisoquinolinium thiocyanate, with the following results:

Material	Mortality at spray time—seconds			
	5	10	20	40
Dodecylnicotinium thiocyanate	19.5	24.5	56.3	68.8
Dodecylisoquinolinium thiocyanate	13.7	13.3	17.0	17.4

Obviously the dodecyl and thiocyanate radicals on these two compounds did not produce equal toxicity. Equally obviously one striking difference between nicotine and isoquinoline is the single nitrogen in isoquinoline. This seems to offer additional evidence of the importance of the two nitrogens in the toxicity of nicotine.

Relation Between Physical Properties and Toxicity

The nicotinium compounds differ from nicotine sulfate in physical properties as well as in chemistry. The physical properties are, of course, established by the components of the molecule. It is of interest to examine the more obvious physical properties for their relationship to toxicity.

Solubility

Most of the nicotinium compounds were soluble in water at the concentrations used in this series of tests. In a few cases it was possible to compare the toxicity of water-insoluble compounds with closely related water-soluble materials. Water-insoluble benzyl nicotinium thiocyanate was more toxic than soluble butyl, octyl, cetyl and octadecyl thiocyanates, and probably more toxic than dodecylnicotinium thiocyanate. On the other hand, the two most toxic nicotiniums were water soluble. While solubility in water may have some bearing on toxicity, it appears to be considerably less important than structure of the molecule.

Wetting Properties and Toxicity

Unquestionably the wetting properties of a spray have much to do with its toxicity as a contact insecticide. Contact angles of several nicotiniums

TABLE 53. CONTACT ANGLE AND TOXICITY OF NICOTINIUM COMPOUNDS

ERL No.	Material	Contact angle degrees[1]	Toxicity rating (Table 52)
75	o-chlorobenzylnicotinium thiocyanate	100	10
77	octylnicotinium thiocyanate	100	11
78	butylnicotinium thiocyanate	97	30
74	*p*-nitrobenzylnicotinium thiocyanate	99	23
			11
			109
76	benzylnicotinium thiocyanate	100	43
79	dodecylnicotinium thiocyanate	41	75
			6
37	octadecylnicotinium thiocyanate	50	20
52	hexadecylnicotinium thiocyanate	52	10
72	benzylnicotinium bromide	100	16
73	dibenzylnicotinium dibromide	100	>1
31	o-chlorobenzylnicotinium bromide	90	10
80	butylnicotinium bromide	96	22
30	*p*-nitrobenzylnicotinium bromide	67	2
81	dodecylnicotinium bromide	59	60
			10

[1] water = 100, angles given as per cent of the angle of water.

dissolved in water have been made available by Howard[1]. The comparative toxicity and contact angle are given in Table 53. It is obvious that there was no correlation between contact angle of these materials and their toxicity. Possibly poor wetting properties may have been responsible for the low toxicity of some compounds. However, closely related materials which did reduce the contact angle were not substantially more toxic.

Summary

The toxicity of a group of nicotinium compounds as contact insecticides has been determined by spraying on *Aphis rumicis* using nicotine sulfate as a standard.

Only 1-benzyl-3-[2-(1-methylpyrrolidyl-hydriodide)] pyridinium chloride exceeded the toxicity of nicotine sulfate.

Reduction of toxicity by addition of radicals to the nitrogen in the pyrrolidine ring, and further reduction by addition to the nitrogen in the pyridine ring suggests that these nitrogens are very important in the toxicity of nicotine. Adding radicals to them reduced the toxicity of nicotine as much as breaking the pyrrolidine ring as reported by Richardson and Shepard (1930).

The most toxic nicotinium compound (No. 104) produced a dosage-response curve parallel to the curve for nicotine sulfate. Two compounds producing steeper slopes were not highly toxic. The changes in slope could not be correlated with wetting properties.

The relative toxicity of the nicotinium compounds was influenced by the structure of the added radicals. Dodecyl compounds were outstanding in this respect. Substitution of the benzyl radical reduced toxicity and addition of halogens to the benzyl radical reduced toxicity still further.

The nicotine structure had an effect on toxicity, since dodecylnicotinium thiocyanate was much more toxic than dodecylisoquinolinium thiocyanate.

Degree of toxicity was not correlated with solubility in water.

There was no correlation between contact angle and toxicity.

Literature Cited

Campbell, F. L. and F. R. Moulton, 1943. Laboratory Procedures in Studies of the Chemical Control of Insects. A. A. A. S., Washington, D. C.

Campbell, F. L., W. N. Sullivan and C. R. Smith, 1933. The Relative Toxicity of Nicotine, Anabasine, Methyl Anabasine and Lupinine for Culicine Mosquito Larvae. Jour. Econ. Ent. 26:500-509.

Dimond, A. E., J. G. Horsfall, J. W. Heuberger and E. M. Stoddard, 1941. Role of the Dosage-response Curve in the Evaluation of Fungicides. Conn. Agr. Expt. Sta. Bul. 451.

Mayer, E. L., L. Weil, D. H. Saunders and C. F. Woodward, (1947). Nicotine Insecticides. IV. Preliminary Toxicity Tests with Nicotinium Salts. U. S. D. A. Bur. Ent. & Pl. Qu. E 725.

Richardson, C. H., L. C. Craig and T. R. Hansberry, 1936. Toxic Action of Nicotines, Nornicotines, and Anabasine upon *Aphis rumicis* Linn. Jour. Econ. Ent. 29:850-855.

Richardson, C. H. and H. H. Shepard, 1930. The Insecticidal Action of Some Derivatives of Pyridine and Pyrrolidine and of Some Aliphatic Amines. Jour. Agr. Res. 40:1007-1015.

[1] For permission to use these data, thanks are due to Dr. Frank L. Howard, Plant Pathologist of the Rhode Island Agricultural Experiment Station, Kingston, R. I.

SHEPARD, H. H., 1939. The Chemistry and Toxicology of Insecticides. Burgess Publishing Co., Minneapolis, Minn.

SIEGLER, E. H. AND C. H. POPENOE, 1924. Some Insecticidal Properties of the Fatty Acid Series. Jour. Agr. Res. 29:259-261.

TATTERSFIELD, F. AND C. T. GIMINGHAM, 1927. Studies on Contact Insecticides. VI. The Insecticidal Action of the Fatty Acids, Their Methyl Esters and Sodium and Ammonium Salts. Ann. Appl. Biol. 14:331-358.

TATTERSFIELD, F., C. T. GIMINGHAM AND H. M. MORRIS, 1925. Contact Insecticides. III. A Quantitative Examination of the Insecticidal Action of the Chlor-, Nitro- and Hydroxyl Derivatives of Benzene and Naphthalene. Ann. Appl. Biol. 12:218-262.

MISCELLANEOUS INSECT NOTES

Fly Control with DDT

An experimental spraying project was conducted on property located at Brooklyn, Conn., and owned by the Windham County Agricultural Society on September 12, 1946. The day prior to the day on which the spraying was accomplished, the area in the vicinity of a food dispensing booth on the Agricultural Society Fair Grounds at Brooklyn was visited during the late morning hours and in the evening. During the morning visit, an abundance of flies were noted; during the evening visit, numerous mosquitoes were present. The area was sprayed at approximately 9:00 A.M. on September 12 with an emulsion of DDT. The stock emulsion contained two pounds of DDT in one gallon of water and this was diluted to 300 gallons before application. The outside of the food dispensing booth and the ground around the booth (approximately one-half acre) were drenched with the emulsion. On the afternoon of the same day, a visit was made to the area to observe conditions. It was immediately apparent that the fly population was nil. Members of the Department were unable to make further observations themselves, but from information received by the writer from members of the group that operated the food dispensing booth, at no time during the three-day period that the booth was in operation were flies or mosquitoes plentiful enough to cause discomfort or annoyance, even on the third day, at which time the grounds around the food booth had become littered with fragments of foodstuffs.

O. B. Cooke

Control of Carpenter Ants in Telephone Poles

Mr. A. B. Carlson of the Southern New England Telephone Company very kindly has sent us an excerpt from the SNETC pole inspection summary for 1946 by Mr. C. C. Potter.

"Treatment for the control of carpenter ants[1] was administered to 738 poles, (this includes 88 poles which had been treated previously and were retreated this year). This compares with other years since the control measure was adopted as follows:

1938 —	642	1943 —	818
1940 —	807	1944 —	520
1941 —	1,321	1945 —	786
1942 —	1,498	1946 —	738

"Ant activity in 119 other poles was found too serious to control by treatment and they were condemned (this includes 21 poles which had been previously but ineffectually treated).

"A total of 883 poles previously treated for the control of ants was reinspected this year. There were no ants found in 665 or 75 per cent. In the 218 where ants were still present 21 were condemned because of ant damage, 109 condemned for some other defect and 88 retreated."

The above means that only 21 poles (2.4 per cent) out of 883 failed to respond to this treatment.

[1] See Friend and Carlson 1937, Conn. Agr. Exp. Sta. Bul. 403, for a description of this treatment.

PUBLICATIONS, 1946[1]

R. L. Beard

Competition between Two Entomogenous Bacteria. Science, Vol. 103, No. 2673, pp. 371-372. Mar. 22, 1946.

W. T. Brigham

Oriental Fruit Moth and Comstock's Mealybug Control Program. Proc. 56th Annual Meeting, Conn. Pom. Soc., pp. 93-94. 1946.

Oriental Fruit Moth Control. Pomological Pointers for Conn. Fruit Growers, No. 184 (1 column). Feb., 1946.

R. B. Friend

Entomology. The American Year Book, 1945. pp. 848-852. July, 1946.

The Insecticide DDT. Yale Scientific Magazine. Vol. 20, No. 3, pp. 12-13. Dec., 1945.

Philip. Garman

New Materials for Control of European Red Mite, Curculio and Oriental Fruit Moth. Proc. 56th Annual Meeting, Conn. Pom. Soc., pp. 21-30. 1946.

J. P. Johnson

A New Pest—The Long-Horned Weevil. Rural New Yorker, p. 392. May 18, 1946.

Sulfa Drug Promising. New England Homestead, p. 6. Aug. 24, 1946.

J. P. Johnson and R. Stadel

Sulfathiazole as a Medication for American Foul Brood Disease of Honeybees. Jour. Econ. Ent., Vol. 39, No. 2, pp. 141-4. Apr., 1946.

Neely Turner

Diatomaceous Diluents for Dusts. Jour. Econ. Ent., Vol. 39, No. 2, pp. 149-158. Apr., 1946.

---

1 Inasmuch as the articles in this Report written by members of the Department all bear the authors' names, they are not listed here.

INDEX