Investigations with the use of systemic insecticides for the control of spruce gall aphid, aborvitae soft scale, birch leaf miner, oystershell scale, and oak mite.

James Harold David
University of Massachusetts Amherst
INVESTIGATIONS WITH THE USE OF SYSTEMIC INSECTICIDES FOR THE CONTROL OF SPRUCE GALL APHID, ARBORVITAE SOFT SCALE, BIRCH LEAF MINER, OYSTERSHELL SCALE, AND OAK MITE

JAMES H. DAVID
Investigations With The Use of Systemic Insecticides
For The Control of Spruce Gall Aphid, Arborvitae
Soft Scale, Birch Leaf Miner, Oystershell
Scale, and Oak Mite

James H. David

Thesis Submitted in partial fulfillment
of the requirements for degree of
Master of Science

University of Massachusetts
Amherst, Massachusetts
June, 1957
# Table of Contents

Introduction ................................................. 3
Literature Review ............................................ 4
Action of Systemics .......................................... 12
  Absorption .................................................. 13
  Translocation ............................................... 16
  Detoxification ............................................. 18
Insecticide Tests ............................................ 23
  Procedure .................................................. 23
  Spruce Gall Aphid ......................................... 26
  Arborvitae Soft Scale ..................................... 34
  Birch Leaf Miner ........................................... 37
  Oystershell Scale .......................................... 54
  Oak Mite ................................................... 57
Summary ....................................................... 59
Conclusion .................................................... 62
Technical Data ................................................ 63
  Systox ....................................................... 63
  Thimet ....................................................... 65
  Isolan ....................................................... 67
  Schradan .................................................... 69
  Dimefox ..................................................... 71
  Parazoxon ................................................... 72
Illustrations .................................................. 74
Literature Cited .............................................. 75
Acknowledgements ............................................ 85
Introduction

A systemic insecticide may be defined as a compound which is rapidly absorbed and translocated by a living organism in an amount sufficient to render it generally toxic to insects and their allies.

Systemic materials have been widely tested against pests of orchard and field crops. The effectiveness of some systemic materials as pesticides on small potted trees and shrubs has been determined but little is known about their effectiveness when applied to trees and shrubs in the field.

This paper presents the results of field applications of the more promising systemic materials, Systox, Thimet, parazoxon, Isolan, dimefox, and schradan. They were applied as soil drenches, granules, trunk injections, bark paints, band treatments, and sprays, to determine their effectiveness in controlling spruce gall aphid, arborvitae soft scale, birch leaf miner, oystershell scale, and oak mite.
Literature Review

In 1938, Gerhard Schrader, a chemist for the I. S. Farben Industries of Germany, found that certain derivatives of \( \text{B-fluorethyl alcohol} \) had systemic and insecticidal action. This work is believed to be the first discovery of systemic action by an organic material and the beginning of effective systemic insecticidal treatment.

Before 1938, numerous workers had attempted to inject chemicals into the sap stream for the control of parasites, but with very limited success. Craighead and St. George (1938) stated that Magnol in 1707 discovered the flow of sap in living plants and its ability to carry chemicals throughout the plant system. They further stated that De la Boisse (1733), Bennet (1754) and Buffan (1755) published papers dealing with the rise of sap in plants.

In 1804 Sanosure introduced toxic solutions including copper sulfate into the sap stream of trees. During the next few years Boucherie succeeded in putting the idea of his predecessors into practical use and obtained in 1838 and 1844 patents for the preservation of wood by impregnation.

Rumbold (1914) demonstrated that injections of dilute solutions of lithium carbonate checked but did not kill the chestnut blight disease \textit{Endothia parasitica} (Murr.) P. J. & H. W. Anders.
Surface (1914), Sanford (1914), Shattuck (1915), and Flint (1915) reported that potassium cyanide tree injections did not control tree pests.

Von Muller (1926) screened many materials for systemic properties and found that 5 per cent pyridine solution controlled aphids under laboratory conditions but field tests were unsuccessful.

In 1927, Peirson reported that aloes injected into birch trees did not control the bronze birch borer.

Injections of arsenic trioxide, Black Leaf 40 and strychnine sulfate into birch trees for birch borer control by Scherer (1929) were ineffective as was the screening test of 26 preparations by Jacobs (1928). Bedard (1938) reported that injections of copper sulfate were only partially successful in controlling southern pine beetles in western white pine.

Neiswander and Morris (1940) reported that sodium selenite applied to the soil in greenhouse benches protected carnations from red spider mites. However, selenium compounds have not been recommended because of their extreme toxicity to mammals.

Since Schrader's discovery in 1938 that derivatives of B-fluorethyl alcohol had systemic insecticidal properties, many organic materials have been synthesized and screened for systemic action. Of the materials tested, a few were found to have outstanding qualities and received extensive
laboratory and field tests. The more promising of these materials have been schradan, demeton, dimefox, parazoxon, Isolan, Thimet and Phosdrin.

Schradan, bis (dimethylamino-phosphonous anhydride), was discovered to have systemic insecticidal properties in 1939 by Schrader and his colleagues. This compound was not released for commercial usage by Farbenfabriken Bayer because it was considered to be too toxic for safe usage. However, it has since been commercially developed by Pest Control Ltd. and Monsanto Chemical Company.

Schradan received little notice until it was used experimentally as a systemic in the late 1940's to control aphids and mites. Ripper et al (1949) found it to be toxic as a systemic material to several species of aphids, mites, leafhoppers and a species of mealybug. Ivy et al (1950) found that foliar spray, soil drench and seed treatment gave effective control of aphids and mites attacking cotton. However, at the concentration used, schradan was found to be ineffective against the following cotton insects: the boll weevil, cotton leaf worm, salt marsh caterpillar, boll worm, grasshopper, leafhopper, and white fly. Anthon (1951) reported that aphids on cherry tree limbs were controlled within nine days after treatment by a foliar spray applied only at the base of the infested terminal. Bronson & Dudley (1951) found that pea plants, the seeds of which had been
treated with schradan, were protected from the pea aphid for approximately six weeks.

Jeppson et al (1952) reported that trunk application of schradan was fairly effective in the control of citrus red mite.

Systox, demeton, was first synthesized by Schrader in 1948. Von Rumpler (1955). It is presently being used commercially in the United States.

Jeppson et al (1952) applied Systox to trunks of citrus trees and found a high mortality of citrus red mite on the leaves and fruit. Reynolds et al (1953) reported excellent mite and aphid control on cotton with a dosage of Systox as low as three ounces per acre. Ortega (1953) effectively controlled the European red mite on walnut for a complete season with Systox at one pint per 100 gallons of water. At lower dosages, it was not effective in the control of the mites, but gave adequate aphid control for about 8 weeks. Outright (1953) reported that a spray treatment gave 100 per cent control of rosy apple aphid on curled apple leaves. Hofmaster and Greenwood (1953) obtained early season control of strawberry mites with a foliar spray. Gaines et al (1952) found Systox gave effective mite control on cotton for three to four weeks when applied as a foliar spray. Dowdy et al (1954) recommended Systox for control of potato leafhopper and potato mites and aphids. Howe & Miller (1954) reported
that soil drench treatments controlled thrips, leafhoppers, southern corn rootworm and root-knot nematode on peanut plants. However, necrotic spotting of the leaves also occurred. 

Sherrer and Argent (1954) found that a soil drench treatment gave 90 per cent control for four weeks of southern red mite infesting camellias. Matthysse and Naegele (1952) reported that foliar sprays produced 100 per cent mortality of the birch leaf miner and 94.6 per cent mortality of the elm leaf miner within seven days from treatment. However, holly leaf miner was not controlled. Michelbacher & Bacon (1953) reported that foliar spray treatments gave excellent control of aphids on walnuts for the entire season. Ames (1954) reported that 0.10 per cent soil application controlled Taxus mealybug on taxus and soft brown scale on holly, and that 0.0031 per cent soil application controlled two-spotted mite on roses. Patterson (1955) reported that soil drench treatments controlled eriophyid rust mite on lilac, two spotted mite on Talisman roses and citrus mealybug on roses and gardenias. Schread (1956) reported that Systox soil drench controlled mealybug on nephthytis.

Dimefox, bis(dimethylamino) fluorophosphine oxide, has shown promise as a systemic insecticide. In a symposium on pesticides in tropical agriculture, it was stated that
dimefox showed outstanding success, where Schradan had failed to control the mealybugs which spread the swollen shoot disease of cocoa trees. Bond (1950) reported that dimefox applied as a soil drench and tree injection, controlled for 8 weeks the coffee mealy bug on coffee trees in Kenya, Africa.

Isolan, Isopropylmethylpyrazolyl dimethyl carbamate, was first synthesized by H. Gysin and introduced by the Geigy Co., as an experimental insecticide in 1952. Martin (1953) Patterson (1955) reported that 0.05 per cent soil drench gave excellent control of the rust mite on lilac. He also found that 0.0062 per cent soil drench gave control of the two spotted mite and citrus mealybug on roses. Scott (1956) stated that Isolan had been very effective against aphids but had not been found to be very effective on other pests.

During 1953 and 1954, American Cyanamid Company evaluated a series of dithiophosphates for systemic activity and reported Thimet, O,O diethyl (S-ethylmercaptomethyl dithiophosphate), to be the most promising.

Field tests have demonstrated Thimet to be very effective against early season cotton pests when applied as a seed treatment. Hanna (1956) reported that Thimet seed treatments gave good control of thrips, aphids, spider mites and leaf miners on cotton for a period of four to six weeks following plant emergence.

Patterson (1955) reported that 0.0062 per cent soil
drench gave effective control of two spotted mite on Talisman roses and citrus mealybug on roses.

Schread (1950) found that Thimet soil drench on potted plants gave control of mealybug on nephthytis and euonymus scale on euonymus. Also it was effective as a control of aphids on chrysanthemum and cyclamen mite on cyclamen.

Reports of experiments with Thimet in 1955 (American Cyanamid Company, compilation of experimental reports for 1955) indicate that it is effective as a systemic against mites and aphids on vegetables, citrus fruits and ornamentals.

Phosdrin, 2-carbomethoxy-1-methylvinyl dimethyl phosphate, was reported by Corey et al (1953) to have a high biological activity with a short residual action.

Carey (1953) reported that Phosdrin applied as a spray entered the plant in the early minutes after application and was rapidly transplanted throughout the plant.

Casida et al (1956) found that foliar application of Phosdrin to vegetable crops resulted in a 90 per cent residual loss in two days and over 99 per cent in four days.

Burkart et al (1955) reported that Phosdrin gave 100 per cent control of corn ear worm in sorghum heads within 96 hours following treatment, with slight phytotoxicity also occurring.

Shell Chemical Company (1956) has recommended its use as a short residual systemic for the control of various
sucking insects on many vegetables.

Since 1938 many materials have been tested for systemic insecticidal activity. A few of them have shown promise, and these have been tested more fully. Of these, three, Thimet, Systox and Phosdrin are presently being commercially produced in the United States. Data obtained from experimental and field testing of these materials have been very promising. Whether or not they become major insecticides will depend upon results of wide scale field testing.
Action of Systemics

It is believed that organic phosphorus insecticides are toxic to animals because of their ability to interfere in the normal mechanism of nerve impulse transmission. Metcalf (1955) states that their common mode of toxic action is the inhibition of cholinesterase and other esterase enzymes. This is said to be accomplished by the firm binding of the central phosphorus atom to the surface of the esterase enzyme in a manner which blocks the access of the normal enzyme substrates such as acetyl chloride. Therefore the effectiveness of phosphoric insecticides is largely dependent upon their effectiveness as cholinesterase inhibitors.

Ripper (1952) classifies systemic insecticides into three groups according to their decomposition within the plant; (1) stable compounds such as sodium selenite and sodium fluoroacetate where the toxicity is attributable to the unchanged selenite ion, (2) endolytic compounds which are present in their original form until decomposed by the plant, and (3) endometatoxic compounds which are transformed or metabolized partly or wholly in the plants into other toxicants.

The efficiency of systemic insecticides as cholinesterase inhibitors is dependent largely upon their absorption, translocation and detoxification by the plant.
Absorption refers to the penetration of the cell membranes by the insecticide; translocation, to movements from cell to cell; and detoxification, to all methods encountered in the removal of toxic material from the plant.

Absorption

Systemics have been reported as being absorbed by all plant surfaces under certain conditions. Seeds have been shown to absorb insecticides, thereby protecting them from insect attack during seedling stage. Chao (1950) reported that plants of cotton, pea, and nasturtium grown from seeds soaked in schradan solution were apparently protected from aphids and red spider for up to 50 days, with there being a possible relationship between the period of protection and weight of the seed. Ashdown & Cordner (1952) obtained similar results with the seeds of cotton and eggplants.

David & Gardiner (1955) found that broad bean seeds after soaking for four hours in the thiol isomer of demeton, contained more toxic material in the seed coat than the cotyledon, but this was reversed after 24 hours. They also found that there was no preferential absorption of water or of the thiol isomer from the solution. Chao (1950) on the other hand, reported selective absorption of water from a solution of schradan by broad bean plants.
Experiments have demonstrated that the absorption of systemics by roots from various media is greatest from solution, less from sand and least from soil. David (1952) stated that more schradan and dimefox are absorbed from sand than from soil. Tietz (1954) reported that demeton was absorbed from solution but from soils absorption was slower and occurred only up to a certain limited concentration. Bennett (1956) stated that this difference in absorption could be on a physical basis, either as a result of the varying contact between insecticides and roots or of the greater affinity of the material for some particle in the soil or solid media.

Apparently some materials may be absorbed more than others. David (1952) found that the roots of broad bean plants selectively absorbed dimefox from a water solution of the insecticide, but rejected schradan from a similar solution. Casida, Chapman and Allen (1952) reported that in pea plants there was a correlation between the absorption of schradan and the available inorganic phosphorus.

Foliar sprays have been the most important means of applying systemic materials to plants and even though leaves are not normally considered absorptive areas, absorption does occur. The amount of absorption which will occur has been found to vary with a large number of factors, including
physical factors such as temperature and radiation, plant factors such as leaf condition and period of growth, and properties of the applied material.

Materials have been reported to enter through the cuticla and the stomata. Knight and Cleveland (1934) reported liquid penetration of stomata by a petroleum oil. Bennett (1951) stated that Zattler (1951) suggested the stomatal entry of demeton in hop leaves. Fogg (1948) reported that Dinitro-O-Cresol entered the leaves of Sinapas arvensis through the epidermis. Bennett & Thomas (1954) suggested that cuticular entrance of schradan occurred in broad bean leaves. Bennett (1957) stated that cuticular penetration is the most likely path of entry of all systemic insecticides.

Various workers have reported on their observation of the effect of certain factors on leaf absorption. Bennett and Thomas (1954) demonstrated a variation in absorption of schradan by bean and chrysanthemum leaves of different ages, reporting that the young leaves absorbed the most and the middle aged leaves the least.

Bennett (1957) stated that permeability of the plasma membrane to the materials, varies with the acidity of the membrane, therefore concluding that an increase in liquid acidity may increase membrane permeability.
The effectiveness of the upper and lower leaf surfaces as absorptive areas has been shown to vary, but in nearly all cases more absorption has been obtained through the lower than through the upper surfaces. Bennett and Thomas (1954) reported that coleus and broad bean plants showed similar absorption of schradan through upper and lower leaf surfaces, whereas chrysanthemum and apple absorbed more through the lower leaf surface. Tietz (1954) found that actual penetration was four times more through the lower surface than through the upper. Bennett (1957) stated that the lower leaf surface is generally more absorptive than the upper, probably because of differences in cuticular absorption.

The effects of temperature, humidity and other environmental factors on leaf absorption have been reported in many cases, but because of varying results no conclusions have been drawn. Apparently a large number of closely interrelated factors are involved.

Translocation

Most of the published work dealing with translocation of systemic insecticides is from biological observations with only a small amount of quantitative work using radioactive isotopes having been done.

Bennett (1949) found that translocation of dimefox
after absorption by roots of willows to be about 11 cm/hr. and suggested that translocation occurred in the xylem. Wedding and Metcalf (1952) suggested that the rate of translocation of schradan in lemon plant slips was approximately the same as that determined for the movement of organic materials of various types in the phloem.

Bennett (1957) stated that Tietz (1954) studying root absorption and translocation of demeton in *Vicia faba* and *Salix viminalis*, found that the insecticide moved primarily in the xylem of the shoot axis and of the leaves and that there was slow diffusion from the xylem to the phloem.

The amount of translocation which occurs after leaf absorption has generally been found to be small and variable. Metcalf and March (1952) reported that between 0.1 and 1.0 per cent of the total dosage of schradan applied to a single lemon leaf appeared in other leaves after 17 days.

Thomas and Bennett (1954) reported that more movement of schradan occurred from the older to younger leaves than vice versa in coleus, chrysanthemum and apple. They also suggested, from results obtained by ringing apple rootstocks above and below treated leaves, that limited movement of schradan occurred in an upward direction in xylem but the majority of the movement was in the phloem and downward movement was exclusively in this tissue.

Ames (1953) reported that demeton foliar applications
to grey birch did not protect new growth, which indicated either no absorption or translocation.

After bark absorption, translocation has been shown to occur quite rapidly. Wedding (1953) found that after absorption of demeton in lemon plants, initial translocation occurred in the phloem with xylem transport occurring later. Hanna et al (1955) reported that little lateral movement of dimefox occurred following its implantation into the trunks of cocoa trees although upward movement in xylem occurred quite freely.

**Detoxification**

Detoxification may occur either by loss of the toxic agent from some plant surface or by decomposition of the toxic material by the plant into less or non-toxic metabolites. The specific processes seem to vary with the material and the method of absorption.

Stern et al (1952) found that the roots of peanut plants lost appreciable quantities of schradan after leaf application. However, Thomas and Bennett (1954) reported little loss of schradan or its metabolite from the roots of broad bean plants.

Bennett (1953) suggested that if the concentration of insecticide in the root is high such as occurs following root absorption, then a high loss of insecticide or its metabolite
may occur. However, he further stated that losses of translocated material from the roots will be generally small in amount.

Bennett (1949) reported vapor loss of dimefox from leaves and suggested that it was transpired with the water vapor. Tietz (1954) reported that insecticidal amounts of demeton were transpired from the leaves of lemon and beans following stem application.

Fukato et al (1955) reported in a series of articles on the action of systox within plants. They theorized that on the basis of an oxidation mechanism, 7 possible non ionic products can be realized from the thiol and thiono isomers of Systox. The breakdown is shown in the following schematic diagram:
They theorized that oxidation of the thioether linkage in the thionophosphate (I) occurred by steps 1 and 2, to respectively, the thionophosphate sulfoxide (II) and the thionophosphate sulfone (III). The thionophosphate could also be oxidized by step 3, to give the phosphate (IV) which in turn may be converted by steps 6 and 7, to the phosphate sulfoxide (V) and the phosphate sulfone (VI). These two products could also be obtained by steps 4 and 5, from the thionophosphate sulfoxide and sulfone. Oxidation of the thiolphosphate (VII) gives in sequence the thiolphosphate sulfoxide and sulfone.
sulfoxide (VIII) by step 8, and thiolphosphate (IX) by step 9.

They synthesized these 7 theoretical oxidation products and compared their properties by paper chromatography, cholinesterase activity, systemic activity and mammalian and insect toxicities with the metabolic properties of Systox isomers obtained after topical application to the base of the cotton plant. The comparison of the results indicated that the thiono isomer of systox is converted to the thionophosphate sulfoxide which is then converted to the thionophosphate sulfone or phosphate sulfoxide or both. The comparison of the thiol isomer indicated that it was converted to the thiolphosphate sulfoxide and then possibly to the thiolphosphate sulfone.

Hydrolysis of these oxidation products gives either 0-0-diethyl phosphoric acid and/or 0,0-diethyl thiophosphoric acid, both of which are non toxic. They reported that this occurs in plant tissues in 18 to 30 days with the thiol isomer and 8 to 20 days with the thiono isomer.

The breakdown of Thimet has been determined to be similar to that which is believed to occur with Systox. American Cyanamid Company (1956) reported Thimet when absorbed into plants is oxidized first to the dithiophosphate sulfoxide, then to the dithiophosphate sulfone, and finally to the monothiophosphate sulfone.
The oxidative metabolites of Thimet, dithiophosphate sulfoxide, dithiophosphate sulfone, and monothiophosphate sulfone, have been found to be more potent inhibitors of cholinesterase than is Thimet.

Later, the oxidative metabolites are hydrolyzed to form non-toxic diethylphosphoric acid or diethylthiophosphoric acid.
Tests of Systemic Insecticides

Procedure

The systemic insecticides used were Systox, Thimet, schradan, dimefox, Isolan and parazoxon. They were applied as soil drenches, granules, bark paints, injections, bands and sprays. Treatments were made on grey birch, Norway spruce, red oak, arborvitae and lilac, in an effort to obtain effective control of aphids, scale and mites.

All dosages were calculated as per cent of actual toxicant of the insecticide and were selected after evaluation of data from preliminary experiments, phytotoxicity tests, manufacturer's recommendations and from the results reported by Ames (1953) and Patterson (1955).

All treatments were replicated at least three times, except preliminary experiments, which were replicated twice.

Applications were made during the spring and summer of 1955 and 1956. The work was primarily performed at the Waltham Field Station, Waltham, Massachusetts, with supplementary field testing being done at Amherst and Woronoco, Massachusetts.

The soil drench treatments were made by pouring the liquid into a circular area around the tree trunk, which had been cleared of debris and walled with soil. Tap or
brook water was used as a diluent. The amount of solution applied was approximately one quart per cubic foot of root area. This volume was based on soil saturation tests which indicated it to be the average amount of liquid needed to wet one cubic foot of the soil types involved. The root area determinations were approximations calculated on the assumption that the majority of the roots are within the area covered by the leaf canopy and extend from a depth of one to two feet, depending upon the size of the tree.

Granular treatments were conducted by evenly broad-casting the material over the area around the tree trunk under the leaf canopy. The area was lightly raked before treatment, to remove the larger pieces of debris.

For injection treatments, two or more 500 ml. Bartlett injection bottles were used per tree. (Fig. I). One inch holes were drilled perpendicularly into the tree trunk, about two feet above the ground. If after three days, complete absorption had not occurred, the injection was transferred to a new hole drilled a few inches to the side of the original hole.

Foliar sprays were applied with a one quart capacity hand sprayer to small saplings, 8 to 10 feet high. The material was thoroughly applied to the foliage until it started to drip.
In the bark paint treatment, the systemic material was painted on the trunk with a two inch paint brush.

In the band treatments, the bands were composed of an absorbent portion consisting of synthetic cellulose sponge and a covering consisting of a double thickness, of aluminum foil. The band was held to the tree by a piece of string or copper wire (Fig. II). The size of the band varied according to tree size. In the larger trees, the trunk was prepared for treatment by cutting horizontal slits in the bark on which the band was to be placed.
Spruce Gall Aphid

The Eastern Spruce Gall Aphid, *Chermes abietis* L., attacks the twigs of Norway Spruce *Picea abies* (L.) Karst., causing the formation of a pineapple-shaped gall. In the forest the insect is not a serious pest, but on ornamentals the presence of the galls is often objectionable.

The species is parthenogenetic with two generations occurring per year, Plumb (1953). The winged females emerge from the gall in late summer and lay their eggs on the needles, usually on the same or adjacent trees. After oviposition, the female dies with her body remaining covering the eggs. The eggs hatch and the wingless nymphs migrate to the twig and after selecting a suitable site, insert their stylets at the base of the buds and then remain stationary over the winter. Those which survive resume feeding in the spring and later molt to become fundatrices or stem mothers. Eggs are laid by the stem mothers about the time the buds swell, and they hatch about the time the buds break. The nymphs then crawl into the opening buds. The gall develops from the cortical cells of the stem and leaf-stalklet, Plumb (1953). About the end of August, the galls open and the mature winged aphids emerge.

As a control for the pest, Becker (1954) recommended the spraying of trees in the early spring before the buds
open with a mixture of one pint of 40 per cent nicotine sulfate plus four pounds of soap per 100 gallons of water. This treatment kills the overwintering stage but does not kill aphids within galls. There is no practical method of killing the nymphs within the galls.

In 1953, Ames found that spruce gall aphid nymphs within galls formed on potted Norway spruce could be killed by a Systox soil drench. Patterson in 1954 repeated Ames's work and reported similar results.

To investigate whether or not systemic treatments applied early in the spring would kill the stem mothers on spruce twigs, and thus prevent gall formation, three soil drench, three injections, one granular and one band experiments were made.

Treatments were started April 14, as soon as the frost left the ground. The first soil drench experiment in the series was applied to ten Norway spruce trees, ten feet high, badly infested with spruce gall aphid. Systox treatments of 0.4 per cent, two gallons; 0.4 per cent, four gallons; were applied April 14. Twenty-three days later, on May 7, an application of 0.8 per cent, two gallons was applied to the first treatment and an application of 1.6 per cent, two gallons was applied to the second treatment, since at that time there was no visible effect of the first treatments. Each treatment was replicated twice, and the results are given in tables one and two.
Table 1. Soil Drench Treatments to Prevent Spruce Gall Formation (April 14). Aphids on foliage.

<table>
<thead>
<tr>
<th>April 14</th>
<th>May 14</th>
<th>Aphids*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Gals.</td>
<td>Per Gals.</td>
<td>(Ave. of 2 replicates)</td>
</tr>
<tr>
<td>Cent Per Tox.</td>
<td>Cent Per Tox.</td>
<td>Days after treatment</td>
</tr>
<tr>
<td>Tree</td>
<td>Tree</td>
<td>0</td>
</tr>
<tr>
<td>0.4</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>0.8</td>
<td>2</td>
<td>------</td>
</tr>
<tr>
<td>0.8</td>
<td>4</td>
<td>------</td>
</tr>
<tr>
<td>Control</td>
<td>------</td>
<td></td>
</tr>
</tbody>
</table>

*Ten twigs, three inches long, examined for aphids per replicate.
S=stem mother; E=egg mass.

Table 2. Systox Soil Drench Treatments to Prevent Spruce Gall Formation (April 14). Aphids in galls.

<table>
<thead>
<tr>
<th>April 14</th>
<th>May 14</th>
<th>Aphids - Per Cent Kill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Gals.</td>
<td>Per Gals.</td>
<td>(Ave. of 2 replicates)</td>
</tr>
<tr>
<td>Cent Per Tox.</td>
<td>Cent Per Tox.</td>
<td>Days after treatment</td>
</tr>
<tr>
<td>Tree</td>
<td>Tree</td>
<td>53</td>
</tr>
<tr>
<td>0.4</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>0.8</td>
<td>2</td>
<td>------</td>
</tr>
<tr>
<td>0.8</td>
<td>4</td>
<td>------</td>
</tr>
<tr>
<td>Control</td>
<td>------</td>
<td></td>
</tr>
</tbody>
</table>

*Five galls examined per replicate.
**Slight phytotoxicity observed.
These treatments did not kill the stem mothers or the developing nymphs in time to prevent cell stimulation and gall development. However, an examination 89 days after treatment (July 13) revealed that many of the aphids within the galls of the treated trees were dead and that gall development was arrested. No maturing galls were found on any of the treated trees on August 24. Besides the aphid mortality within the galls, there may have been an earlier reduction in aphid population.

Phytotoxicity consisting of a general yellowing of the needles occurred on all treated trees except those which received the 0.8 per cent, two gallon application. This may have been because of the smaller amount of actual toxicant applied, 60.8 ml. in the 0.8 per cent, two gallon treatment against 91.2 ml. or more in the other treatments.

The results could indicate that the absorption and/or the translocation of Systox is very slow in Norway Spruce, or that the aphid is more susceptible to the treatment while in the gall.

To determine why systemic action was slow in the earlier test, a soil drench treatment of 0.4 per cent was applied to saplings five feet high on July 13. The results are presented and summarized in table 3.
Table 3. Systox Soil Drench Treatment for Spruce Gall Aphid (July 13).

<table>
<thead>
<tr>
<th>Per Cent Tox.</th>
<th>Gals. Per Tree</th>
<th>Aphids in Galls - Per Cent Kill* (Ave. of 2 replicates) Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>---</td>
<td>0</td>
</tr>
</tbody>
</table>

*Five galls examined per replicate.
**Phytotoxicity was visible on treated trees at this time.

The treatment was phytotoxic. It killed interior needles and caused yellowing of all other needles.

Failure of the treatments to prevent development of galls was probably caused by slow absorption and/or translocation and not because of greater aphid susceptibility while within galls to insecticides.

On May 13, the third lot of soil drench treatments consisting of 0.4 per cent, two gallons and 0.8 per cent four gallons, were applied to trees 7 to 9 feet high. The results are summarized in table 4.

There was no prevention of gall formation. However, the examination after 55 days revealed 100 per cent kill of the aphids within the galls of the first replicates of both treatments. Also there was some phytotoxicity consisting of general needle yellowing in these replicates. In the second replicates of both treatments, there was no mortality and no phytotoxicity.
Table 4. Isolan Soil Drench Treatment to Prevent Spruce Gall Development (May 13).

<table>
<thead>
<tr>
<th>Tree Height</th>
<th>Per Cent Tox.</th>
<th>Per Gals.</th>
<th>0 Days</th>
<th>8 Days</th>
<th>39 Days</th>
<th>55 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 ft.</td>
<td>0.8</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>0</td>
<td>100*</td>
</tr>
<tr>
<td>9 ft.</td>
<td>0.8</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7 ft.</td>
<td>0.4</td>
<td>4</td>
<td>36</td>
<td>16</td>
<td>0**</td>
<td>100</td>
</tr>
<tr>
<td>9 ft.</td>
<td>0.4</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Aphids* (Ave. of 2 replicates)

Counts of stem mothers on foliage were taken on ten twigs, three inches long, per replicate. Counts of mortality of aphids in galls were made on five galls per replicate.

**Slight yellowing of older needles.

The differences in results obtained in the two replicates was probably due to differences in size of trees in the replicates. Mortality and phytotoxicity was obtained on the trees 7 feet high but not on those that were 9 feet high.

On May 3, four per cent Thimet granules were applied at the rate of 1000 and 2000 ml. to saplings 8 to 10 feet high. The results are summarized and presented in table 5.

The 2000 ml. treatment, like the soil drench treatments, killed aphids within the galls many days after treatment, but they did not prevent gall formations.
Table 5. Thimet Granular Treatment to Prevent Spruce Gall Development (May 4).

<table>
<thead>
<tr>
<th>Per Cent Tox.</th>
<th>ml. Per Tree</th>
<th>Stem Mothers on Foliage Days after treatment</th>
<th>Aphid Nymphs Within Galls - Per Cent Kill Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>2000</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Control</td>
<td>18</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

*Counts of stem mothers on foliage were taken on ten twigs, three inches long. Counts of mortality of aphids in galls were made on five galls per replicate.

In three injection experiments, it was found that absorption was slow and that it occurred over a period of two to three days after treatment and then ceased. In order to obtain complete absorption of 1000 ml. of solution, it was necessary to reinject in new holes.

Injections of 1000 ml. of 0.2, 0.4, and 0.6 per cent Systox were injected into trees 30 to 40 feet high on May 1. There was no apparent mortality of aphids.

In the second experiment, on May 3, 1000 ml. of 1.6 and 3.2 per cent Thimet and 1.6 per cent Systox were injected into trees 20 to 25 feet high. None of these treatments prevented gall formation. The 3.2 per cent Thimet treatment produced 40 per cent mortality of aphids within the galls many days after treatment. The 1.6 per cent Thimet and
Systox treatments produced no mortality. In all treatments the needles on the lower branches turned brown and eventually died.

In the third experiment, June 22, after galls had formed, 1000 ml. of 1.6 and 3.2 per cent Thimet and 1.6 per cent Systox were injected into trees 10 to 15 feet high. There was no visible effect on the aphids or the trees.

In a band experiment, treatments of 300 ml. of 0.4, 0.8 and 1.6 per cent Thimet were applied to trees 25 to 30 feet high. There was no visible effect on the aphids, or on the trees.

In some soil drench and granular treatments, aphids were killed within the galls many days after treatment, but gall formation was not prevented. Usually there was mild to severe phytotoxicity. With the injection treatments, it was very difficult to obtain translocation and at least two injections were required per 1000 ml. of solution. Failure to obtain any effects on the insects was probably due to poor absorption and/or translocation of the systemic materials.
Arborvitae Soft Scale

Arborvitae soft scale, *Lecanium fletcheri* Cockerell, until recently was found almost exclusively on Arborvitae. Now it is frequently found in large numbers on *Taxus hatfieldi* and *Taxus brevifolia*. On severely infested plants, the needles may lose color and dry prematurely, and the plant may be seriously weakened. The scales secrete honeydew in which sooty fungus grows causing an unsightly blackening of affected plants.

In the field in Massachusetts, there is only one brood a year. The eggs are deposited beneath the body of the female during late May and early June. Initial hatch varies from year to year with temperature conditions, but usually occurs in late June and continues for a few weeks. Development is almost negligible during the summer and fall. Overwintering occurs as a very small, soft scale on the stem branches and on the underside of the leaves. Feeding is resumed in April of the following year and the scales then mature rapidly.

Becker (1954) recommends as a control a spring dormant spray of two gallons of superior type oil or a late June spray of two pounds of 50 per cent DDT wettable powder per 100 gallons of water or a one pound, 15 per cent parathion wettable powder per 100 gallons of water. The late June sprays should be repeated in 10 days.
On August 24, treatments of 0.1 per cent, one gallon and 0.05 and 0.1 per cent, two gallons of Thimet and Systox were applied to arborvitae seedlings two to three feet high. Each treatment was replicated twice and the results are presented in Table 6.

Table 6. Soil Drench for Arborvitae Soft Scale Control on Arborvitae Seedlings (August 24).

<table>
<thead>
<tr>
<th>Materials</th>
<th>Per Cent Tox.</th>
<th>Gals. per Tree</th>
<th>Days after treatment (Ave. of 2 replicates)</th>
<th>Scales*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>1</td>
<td>20 DA</td>
<td>35 81</td>
</tr>
<tr>
<td>Systox</td>
<td>0.05</td>
<td>2</td>
<td>2-18 DA</td>
<td>0-20</td>
</tr>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>2</td>
<td>1-19 DA</td>
<td>2-18</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>1</td>
<td>1-19 DA</td>
<td>0-20</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.05</td>
<td>2</td>
<td>0-20 DA</td>
<td>1-19</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>2</td>
<td>0-20</td>
<td>0-20</td>
</tr>
<tr>
<td>Parazoxon</td>
<td>0.1</td>
<td>2</td>
<td>0-20</td>
<td>2-18</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td>1-19</td>
<td>0-20</td>
</tr>
</tbody>
</table>

*Twenty scales examined per replicate. 
A=alive; D=dead

None of the treatments were effective in killing arborvitae scale.

On June 24, treatments of 0.1 per cent Thimet and 0.1 per cent Systox were applied as soil drenches to shrubs three to four feet high. The results are given in Table 7.
Table 7. Soil Drench Treatments to Control Soft Scale on Arborvitae Shrubs (June 24).

<table>
<thead>
<tr>
<th>Materials</th>
<th>Per Cent</th>
<th>Gal.</th>
<th>Days after treatment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systox 0.4</td>
<td>18</td>
<td></td>
<td>Adult scales and egg masses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18 24 33</td>
</tr>
<tr>
<td>Thimet 0.4</td>
<td>18</td>
<td></td>
<td>7&amp;3E 1&amp;9E 10E</td>
</tr>
<tr>
<td>Control</td>
<td>-------</td>
<td></td>
<td>6&amp;4E 1&amp;9E 10E</td>
</tr>
</tbody>
</table>

*Average of counts taken on two replicates, ten, three inch twigs selected at random per replicate.

**Phytotoxicity consisting of a general yellowing of the entire foliage plus a browning of one-eighth to one-fourth of the leaf tips was apparent on all treated plants at this time.

E=egg mass; A=alive; D=dead

The development of the scale was not prevented, but phytotoxicity consisting of a general yellowing of the needles occurred. The 0.4 Thimet treatment may have caused a general population reduction. Failure of the treatments to prevent scale development was probably caused by slow absorption and/or translocation of the systemic materials.
Birch Leaf Miner

During recent years, the birch leaf miner *Fenusa pusilla* Lepeletier has been an abundant and serious pest in Massachusetts. It attacks grey birch, paper birch and European white birch throughout the state, causing unsightly foliage and leaf drop. The insect can be controlled with Malathion or Lindane sprays but timing and thorough treatment are all important. Hence a systemic treatment which could be applied before adult emergence in the spring and which would prevent miner development for a number of weeks would be desirable.

There are three, and sometimes four generations a year. The miners overwinter as prepupae within cocoons in the soil. They complete their development during the spring and emerge about the middle of May. Eggs are laid within the leaf tissues and hatch in 6 to 10 days. The larvae feed between the upper and lower epidermis of the leaves for one to two weeks then enter the ground to pupate. Adults emerge in about three weeks.

Becker (1952) recommends the spraying of trees, 10 to 15 days after egg laying with a 25 per cent lindane wettable powder.

To investigate the value of available systemic materials, application techniques, and toxicant-diluent ratios, 220 grey birch, *Betula populifolia*, were treated during the spring
and summer of 1955 and 1956. All treatments were replicated three times. Counts were made on ten leaves, selected at random from the first and second basal leaves of a growing tip.

To obtain information on the relative effectiveness of available systemic materials, two band experiments were performed during the summer of 1955. The treatments of the first experiment were applied June 30 to 45 seedlings, three to four feet high. Counts were made at 15 and 30 days after treatment and are summarized in table 8.

Table 8. Preliminary Band Treatments on Birch Saplings to Control Birch Leaf Miner (June 30).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent Tox</th>
<th>Miners (Ave. of 3 replicates)</th>
<th>15 Days</th>
<th>30 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A  D</td>
<td>A  D</td>
</tr>
<tr>
<td>Isolan 0.2</td>
<td>0</td>
<td>32</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Isolan 0.4</td>
<td>0</td>
<td>36</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Isolan 0.8</td>
<td>0</td>
<td>39</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Thimet 0.2</td>
<td>0</td>
<td>28</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Thimet 0.4</td>
<td>0</td>
<td>38</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Thimet 0.8</td>
<td>0</td>
<td>39</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>A. Cyan. 12008 0.2</td>
<td>11</td>
<td>26</td>
<td>15  0</td>
<td>0  0</td>
</tr>
<tr>
<td>A. Cyan. 12008 0.4</td>
<td>0</td>
<td>25</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>A. Cyan. 12008 0.8</td>
<td>0</td>
<td>34</td>
<td>0  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Dimefox 0.2</td>
<td>28</td>
<td>0</td>
<td>22  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Dimefox 0.4</td>
<td>24</td>
<td>8</td>
<td>18  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Dimefox 0.8</td>
<td>1</td>
<td>29</td>
<td>23  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Schradan 0.2</td>
<td>33</td>
<td>0</td>
<td>20  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Schradan 0.4</td>
<td>40</td>
<td>0</td>
<td>17  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Schradan 0.8</td>
<td>42</td>
<td>0</td>
<td>24  0</td>
<td>0  0</td>
</tr>
<tr>
<td>Control ------</td>
<td>34</td>
<td>0</td>
<td>22  0</td>
<td>0  0</td>
</tr>
</tbody>
</table>

A = alive; D = dead
Isolan and Thimet were the most effective and all concentrations gave 100 per cent kill of the birch leaf miner larvae. American Cyanamid Compound 12006 was not quite as effective, requiring at least 0.14 per cent actual toxicant to cause 100 per cent mortality. Dimefox was only partially effective and schradan had no apparent effect.

The treatments of the second band experiment were applied July 8 at Waltham to 16 grey birch saplings, 8 to 10 feet high. On the area of the trunk over which the bands were to be applied, three perpendicular cuts two inches long were made. Treatments of 0.2 per cent and 0.4 per cent Systox and 0.1 per cent and 0.2 per cent Isolan were made and are summarized in table 9.

Table 9. Band Treatments on Birch Saplings to Control Birch Leaf Miner (June 30).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent Tox.</th>
<th>Miners (Ave. of 3 replicates) Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Systox</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Systox</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>Isolan</td>
<td>0.1</td>
<td>27</td>
</tr>
<tr>
<td>Isolan</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>----</td>
<td>104</td>
</tr>
</tbody>
</table>

A=alive; D=dead
Of the four treatments, the 0.4 per cent Systox was the most effective. It prevented miner development within four days and did not begin to lose its effect until after 30 days. The 0.2 per cent Systox and Isolan treatments also prevented miner development within four days but had apparently begun to wane at 30 days, allowing partial miner development. The 0.1 per cent Isolan was the least effective, producing only 74 per cent mortality at four days and producing no apparent protection at 30 days.

In 1956, testing was limited to Thimet and Systox as the 1955 tests indicated them to be the more effective materials. On June 1, before the hatching of any larvae, but when a few adult flies were found hovering over the newly developed leaves, the first of a series of soil drench experiments were made. Two gallons of 0.4 and 0.8 per cent Thimet were applied to ten birch saplings, 12 feet high. The results are summarized in table 10.

Both treatments prevented the development of the larvae throughout the summer. However, the occurrence of slight phytotoxicity minimizes their practical effectiveness. Possibly, lower concentration might control the miner and not produce phytotoxicity.
Table 10. Thimet Soil Drench Treatments to Control Birch Leaf Miner (June 1).

<table>
<thead>
<tr>
<th>Per Cent Tox.</th>
<th>Gal. Tree</th>
<th>5</th>
<th>13</th>
<th>20</th>
<th>27</th>
<th>34</th>
<th>48</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>2</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>0.8</td>
<td>2</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>23</td>
<td>35</td>
<td>28</td>
<td>31</td>
<td>28</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>

*Phytotoxicity consisting of a general yellowing of leaves and hardening around egg punctures and edge of leaves occurred at this time.

A=alive; D=dead

On July 18, to test the effectiveness of lower concentrations and diluent-toxicant ratios, Systox and Thimet soil drenches were applied to seedlings three to four feet high. A series of treatments containing 0.38 ml. of actual toxicant were applied in dilutions of one-half, one, and two gallons of water. Another series of treatments containing ten times the amount of actual toxicant, 3.8 ml., were also applied in dilutions of one-half, one and two gallons of water. The results are given in table 11.
Table 11. Soil Drench Treatments on Birch Seedlings to Control Second Generation Birch Leaf Miner (July 18).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent Tox.</th>
<th>ml. Tox.</th>
<th>Gals.</th>
<th>Per Tree</th>
<th>Days after treatment</th>
<th>Miners (Ave. of 3 replicates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systox</td>
<td>0.02</td>
<td>0.38</td>
<td>1/2</td>
<td>35</td>
<td>0</td>
<td>38 0 30 1 23 0</td>
</tr>
<tr>
<td>Systox</td>
<td>0.01</td>
<td>0.38</td>
<td>1</td>
<td>29</td>
<td>0</td>
<td>28 0 16 0 27 0</td>
</tr>
<tr>
<td>Systox</td>
<td>0.005</td>
<td>0.38</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>21 1 12 0 30 0</td>
</tr>
<tr>
<td>Systox</td>
<td>0.2</td>
<td>3.8</td>
<td>1/2</td>
<td>33</td>
<td>0</td>
<td>35 0 20 0 0 22</td>
</tr>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>3.8</td>
<td>1</td>
<td>31</td>
<td>0</td>
<td>25 1 21 0 3 17</td>
</tr>
<tr>
<td>Systox</td>
<td>0.05</td>
<td>3.8</td>
<td>2</td>
<td>35</td>
<td>0</td>
<td>32 0 15 0 17 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.02</td>
<td>0.38</td>
<td>1/2</td>
<td>41</td>
<td>0</td>
<td>0 43 0 0 0 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.01</td>
<td>0.38</td>
<td>1</td>
<td>62</td>
<td>0</td>
<td>0 69 0 0 0 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.005</td>
<td>0.38</td>
<td>2</td>
<td>33</td>
<td>0</td>
<td>0 28 0 0 0 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.2</td>
<td>3.8</td>
<td>1/2</td>
<td>41</td>
<td>0</td>
<td>0 39 0 0 0 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>3.8</td>
<td>1</td>
<td>61</td>
<td>0</td>
<td>0 43 0 0 0 0</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.05</td>
<td>3.8</td>
<td>2</td>
<td>37</td>
<td>1</td>
<td>0 27 0 0 0 0</td>
</tr>
<tr>
<td>Control</td>
<td>--------------</td>
<td>----------</td>
<td>-------</td>
<td>----------</td>
<td>----------------------</td>
<td>-------------------------------</td>
</tr>
</tbody>
</table>

A=alive; D=dead

The 0.38 ml. and 3.8 ml. Thimet dilutions produced 100 per cent miner kill 7 days after treatment and remained effective the remainder of the summer. The 0.38 ml. Systox treatments were ineffective. Of the 3.8 ml. Systox treatments, the one-half gallon dilution was the most effective, producing 100 per cent miner mortality 30 days after treatment, whereas the one gallon dilution produced 85 per cent mortality and two gallon dilutions produced no mortality. This indicates that a concentrated application applied
closely to the trunk is more effective than a diluted application applied over a larger area.

On July 18, a series of treatments containing 1.5 ml. of actual toxicant of Systox was applied in dilutions of two, four and eight gallons of water to saplings 8 to 10 feet high. Another series of treatments containing 10 times the amount of actual toxicant, 15 ml. was also applied in dilutions of two, four and eight gallons of water to saplings 8 to 10 feet high. The results are given in table 12.

Table 12. Systox Soil Drench Treatments on Birch Seedlings to Control Birch Leaf Miner (July 1).

<table>
<thead>
<tr>
<th>Per Cent Tox.</th>
<th>ml. Per Tox.</th>
<th>Gals.</th>
<th>Miners (Ave. of 3 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>1.5</td>
<td>8</td>
<td>15</td>
<td>0 10 1 1 0 0 0</td>
</tr>
<tr>
<td>0.01</td>
<td>1.5</td>
<td>4</td>
<td>10</td>
<td>0 9 1 3 0 0 0</td>
</tr>
<tr>
<td>0.02</td>
<td>1.5</td>
<td>2</td>
<td>17</td>
<td>0 12 0 4 0 0 0</td>
</tr>
<tr>
<td>0.05</td>
<td>15</td>
<td>8</td>
<td>16</td>
<td>0 17 0 4 0 0 0</td>
</tr>
<tr>
<td>0.1</td>
<td>15</td>
<td>4</td>
<td>12</td>
<td>0 4 0 2 1 0 0</td>
</tr>
<tr>
<td>0.2</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>0 27 0 4 1 0 0</td>
</tr>
</tbody>
</table>

A=alive; D=dead
Systox solutions containing 1.5 ml. and 15 ml. of actual toxicant when applied at two, four and eight gallons were not effective.

On July 27, soil drench treatments of 1.5 and 15 ml. of actual toxicant of Thimet in four gallons of water, were applied to saplings 8 to 10 feet high. The results are given in Table 13.

Table 13. Thimet Soil Drench Treatments on Birch Saplings to Control Birch Leaf Miner (July 18).

<table>
<thead>
<tr>
<th>Per Cent</th>
<th>ml.</th>
<th>Gal. Per</th>
<th>(Ave. of 3 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tox.</td>
<td>Tox.</td>
<td>Tree</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0.01</td>
<td>1.5</td>
<td>4</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>15</td>
<td>4</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>-----</td>
<td>----------</td>
<td>34</td>
<td>0</td>
</tr>
</tbody>
</table>

Miners had been dead for many days
A=alive; D=dead

Four gallons of Thimet solution, containing 1.5 ml. actual toxicant produced partial miner kill six days after treatment and complete kill 27 days after treatment. When 15 ml. of Thimet was applied in four gallons of water there was complete miner kill and the treatment remained effective the remainder of the summer.

On July 30, a 32 gallons, 0.1 per cent Thimet soil
drench was applied to large birch trees. Because of a very low second generation miner infestation in the area, the results of the treatment were inconclusive.

On June 1, before the hatching of any larvae, four per cent Thimet granules were applied at the rate of 1000 and 2000 ml. to saplings 8 to 10 feet high. The results are presented in table 14.

Table 14. Thimet Granular Treatments on Birch Saplings to Control Birch Leaf Miner (June 11).

<table>
<thead>
<tr>
<th>Miners (Ave. of 3 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Tox. Tree</td>
<td>A</td>
</tr>
<tr>
<td>4.0 1000</td>
<td>18</td>
</tr>
<tr>
<td>4.0 2000</td>
<td>24</td>
</tr>
<tr>
<td>Control</td>
<td>23</td>
</tr>
</tbody>
</table>

♦ Dead miners were all very small

A= alive; D= dead

The 1000 ml. treatment produced complete kill between 5 and 15 days after treatment. Later, between the 20 and 41 days counts, a few miners hatched and completed their development. The 2000 ml. treatment produced complete kill between 5 and 13 days after treatment and remained effective throughout the summer.

On July 24, 295 ml. of 4 per cent Thimet granules were
applied to saplings 8 to 10 feet high. The results are
given in table 15. The precipitation data for the area
are given in table 16.

Table 15. Thimet Granular Treatments on Birch Saplings
to Control Birch Leaf Miner (July 24).

<table>
<thead>
<tr>
<th>Per ml.</th>
<th>Cent Tox.</th>
<th>Days after treatment (Ave. of 3 replicates)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 7 12 31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A D A D A D</td>
</tr>
<tr>
<td>4.0</td>
<td>295</td>
<td>37 0 36 0 27 0 0 0 34</td>
</tr>
<tr>
<td>Control</td>
<td>---</td>
<td>44 0 41 0 27 0 26 0</td>
</tr>
</tbody>
</table>

A=alive; D=dead

Table 16. Precipitation Data - Waltham Field Station*

<table>
<thead>
<tr>
<th>Aug. 1956</th>
<th>Days after Treatment</th>
<th>Inches of Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>14</td>
<td>0.14</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>Trace</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>0.53</td>
</tr>
<tr>
<td>13</td>
<td>20</td>
<td>0.30</td>
</tr>
<tr>
<td>18</td>
<td>25</td>
<td>0.05</td>
</tr>
<tr>
<td>20</td>
<td>27</td>
<td>0.23</td>
</tr>
<tr>
<td>21</td>
<td>28</td>
<td>0.23</td>
</tr>
<tr>
<td>22</td>
<td>29</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*There was no rain from the beginning of treatment July 24 to August 7.

Between the first count, 12 days after treatment and
the third count, 31 days after treatment, there was com-
plete kill of miners. Apparently the rains (total of 1.59
inches) during this period, were sufficient to transport an effective amount of Thimet to the roots.

On June 22, 1000 ml. of 0.4 per cent and 0.8 per cent Thimet and 0.4 per cent Systox were injected into trees 15 to 20 inches in diameter. The results are given in table 17.

<table>
<thead>
<tr>
<th>Material</th>
<th>Per ml.</th>
<th>Cent</th>
<th>Per</th>
<th>Miners (Ave. of 3 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0*</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.4</td>
<td>1000</td>
<td></td>
<td>0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Thimet</td>
<td>0.8</td>
<td>1000</td>
<td></td>
<td>0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Systox</td>
<td>0.4</td>
<td>1000</td>
<td></td>
<td>1 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>--------</td>
<td></td>
<td></td>
<td>1 0 36 0 26</td>
<td></td>
</tr>
</tbody>
</table>

♦ First generation miners recently emerged.
♦♦ Many undeveloped egg punctures present on leaves of treated trees.

A=alive; D=dead

All of the treatments prevented second generation miner development and remained effective the remainder of the summer.

On June 1, before the hatching of any larvae, bark paint treatments of 100 ml. of 5, 20 and 40 per cent Thimet were applied to saplings 10 to 12 feet high. The
results are given in table 18.

Table 18. Thimet Bark Paint Treatments on Birch Seedlings to Control Birch Leaf Miner (July 22).

<table>
<thead>
<tr>
<th>Per ml. Cent Per</th>
<th>5 A</th>
<th>13 A</th>
<th>27 A</th>
<th>41** A</th>
<th>43 A</th>
<th>62 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 100</td>
<td>17  D</td>
<td>0  D</td>
<td>0  D</td>
<td>20  D</td>
<td>0  D</td>
<td>0  D</td>
</tr>
<tr>
<td>20 100</td>
<td>20  D</td>
<td>0  D</td>
<td>0  D</td>
<td>39  D</td>
<td>0  D</td>
<td>0  D</td>
</tr>
<tr>
<td>40 100</td>
<td>18  D</td>
<td>0  D</td>
<td>0  D</td>
<td>21  D</td>
<td>0  D</td>
<td>0  D</td>
</tr>
<tr>
<td>Control</td>
<td>23  D</td>
<td>39  D</td>
<td>28  D</td>
<td>23  D</td>
<td>2  D</td>
<td>40  D</td>
</tr>
</tbody>
</table>

*Phytotoxicity consisting of slight yellowing of leaves visible on all treatments.
**All miners very small.
A=alive; D=dead

All treatments produced 100 per cent kill, 13 days after treatment but there was partial miner development between 30 to 46 days after treatment. Phytotoxicity, consisting of slight yellowing of leaves, was visible at 41 days on all treatments.

On July 3, bark paint treatments of 100 ml. of 5, 10 and 20 per cent Systox and 5 and 10 per cent Thimet were applied to seedlings 10 to 12 feet high. The results are given in table 19.
Table 19. Bark Paint Treatments on Birch Saplings to Control Birch Leaf Miner (July 3).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent</th>
<th>Miners (Ave. of 3 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tox.</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Systox</td>
<td>5.0</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Systox</td>
<td>10.0</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Systox</td>
<td>20.0</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Thimet</td>
<td>5.0</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Thimet</td>
<td>10.0</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Control</td>
<td>----</td>
<td>A</td>
<td>D</td>
</tr>
</tbody>
</table>

*Slight phytotoxicity consisting of general yellowing of the leaves, occurred on one of the three replicates of this concentration at this time. A=alive; D=dead.

All treatments prevented development of new miners 7 days after treatment.

Because of the excellent results from the preliminary band applications in 1955 (charts 8 and 9) further tests were performed in 1956.

On June 1, 80 ml. of 0.1 per cent and 0.2 per cent Thimet were applied in bands to saplings 10 to 12 feet high. There was no visible effect on the miners or on the tree.

On June 12, 80 ml. of 0.2 and 0.4 per cent Thimet
and Systox were applied in bands to saplings 10 to 12 feet high. The results are given in table 20.

Table 20. Band Treatments on Birch Saplings to Control Birch Leaf Miner (June 13).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent Tox.</th>
<th>ml. Per Tree</th>
<th>7 AD</th>
<th>14 AD</th>
<th>21 AD</th>
<th>28 AD</th>
<th>35 AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thimet</td>
<td>0.2</td>
<td>80</td>
<td>22</td>
<td>1</td>
<td>15</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.4</td>
<td>80</td>
<td>15</td>
<td>6</td>
<td>13</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Systox</td>
<td>0.2</td>
<td>80</td>
<td>11</td>
<td>0</td>
<td>14</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Systox</td>
<td>0.4</td>
<td>80</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>----</td>
<td></td>
<td>28</td>
<td>0</td>
<td>31</td>
<td>0</td>
<td>26</td>
</tr>
</tbody>
</table>

A=alive; D=dead

There was no control of miners with either 0.2 per cent Thimet or 0.2 per cent Systox and only slight kill with 0.4 per cent Thimet. In the 0.4 per cent Systox treatment, there was partial kill at 7 and 14 days with complete kill not being obtained until 21 and 28 days.

On June 20, 80 ml. of 1.6 per cent Systox and of Thimet were applied in bands to saplings 10 to 12 feet high. The results are given in table 21.
Table 21. Band Treatments on Birch Saplings to Control Birch Leaf Miner (June 20).

<table>
<thead>
<tr>
<th>Mat.</th>
<th>Tox.</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28*</th>
<th>35</th>
<th>42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thim.</td>
<td>1.6</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Syst.</td>
<td>1.6</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Cont.</td>
<td>---</td>
<td>31</td>
<td>0</td>
<td>28</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Slight phytotoxicity visible on all treatments.
*A=alive; D=dead

The 1.6 per cent Systox gave 100 per cent kill by 7 days after treatment and remained effective the remainder of the summer. The 1.6 per cent Thimet produced partial kill in 14 days and there was no indication of reinfection of miners until 35 days after treatment. Slight phytotoxicity consisting of leaf yellowing was visible on all treatments at 28 days.

On June 1, spray treatments of 0.1 per cent and 0.2 per cent Thimet were applied to saplings 6 to 8 feet high. There was no visible effect on the miners or the trees.

Saplings 10 feet high were divided into two groups. In one group, the entire tree was sprayed with emulsions of 0.2 per cent and 0.4 per cent Systox and of Thimet, whereas of the other group, only the bottom half was sprayed with emulsions of 0.4 per cent Systox or Thimet.
The results are given in table 22.

<table>
<thead>
<tr>
<th>Mat.</th>
<th>Per Cent Tox.</th>
<th>Coverage</th>
<th>Miners (Ave. of 3 replicates)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Days after treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Syst. 0.2</td>
<td>Complete</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Syst. 0.4</td>
<td>Complete</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Thim. 0.2</td>
<td>Complete</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Thim. 0.4</td>
<td>Complete</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Syst. 0.4</td>
<td>Upper half untreated</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Lower half treated</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Thim. 0.4</td>
<td>Upper half untreated</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Lower half treated</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>---------------</td>
<td>28</td>
<td>0</td>
</tr>
</tbody>
</table>

A=alive; D=dead

The 0.2 per cent sprays of Systox and Thimet were ineffective. The 0.4 per cent sprays produced complete kill in 7 days but reinfestation had taken place in 14 days. In trees which received partial coverage, the treated foliage was protected against miners for 7 days and there were no effects on miners in the untreated foliage. This indicates that little absorption and/or translocation occurred from the treated to untreated leaves.
The 0.4 per cent Thimet and the Systox soil drenches controlled the birch leaf miner on saplings throughout the summer but there was also phytotoxicity. The 0.005 per cent Thimet soil drench controlled second generation miner on saplings the entire season, whereas 0.005 per cent Systox did not. Of the two materials, Thimet appeared to be the more effective soil drench material. 4 per cent Thimet granules were as effective as soil drenches but are dependent upon rainfall or irrigation. 5 per cent Thimet and Systox bark paint treatments controlled miners on small saplings as did 0.4 per cent Thimet injected into large trees. Systox and Thimet applied by means of bands or sprays were of little value.
Oystershell Scale

The oystershell scale *Lepidosaphes ulmi* (L.) attacks many forest, shade and fruit trees and ornamental shrubs. Of the many species of shrubs infested, lilac is probably most often seriously damaged.

The insect overwinters as eggs underneath the old scale. Upon hatching in early June, the young nymphs usually crawl about for a few days before they settle down to feed. They molt twice during the summer, before they become adults, and in late August the mature female lays her eggs.

As a control for the pest, Becker (1950) recommends a spring dormant spray of 2 gallons of superior type oil or 2 quarts of a dinitro material per 100 gallons of water. Also suggested is an early summer treatment, applied when the crawlers appear, of 2 pounds of 50 per cent DDT wettable powder per 100 gallons of water.

On August 24, soil drenches of Thimet and Systox were applied on lilac seedlings 2 to 3 feet high. They consisted of 2 gallons of 0.5 per cent and 1 and 2 gallons of 0.1 per cent solutions. Also Parazoxon 0.1 per cent, was applied at 2 gallons. The results are given in table 23.
Table 23. Soil Drench Treatments on Lilac Seedlings to Control Oystershell Scale (August 24).

<table>
<thead>
<tr>
<th>Material</th>
<th>Per Cent Tox.</th>
<th>Gal.</th>
<th>Per Tree</th>
<th>Scales - Per Cent Kill* (Ave. of 2 replicates)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Days after treatment</td>
</tr>
<tr>
<td>Systox</td>
<td>0.05</td>
<td>2</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>1</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>2</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.05</td>
<td>2</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>1</td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>2</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Parazoxon</td>
<td>0.1</td>
<td>2</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Control</td>
<td>----</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

*20 nymphs under scales examined per replicate.

The Systox treatments produced only 5 to 15 per cent mortality within 35 days and therefore were ineffective. The 0.1 per cent Thimet applied at 2 gallons gave 85 per cent insect kill within 20 days; the 0.1 per cent Thimet at 1 gallon gave 85 per cent kill; and the 0.05 per cent Thimet at 2 gallons gave 50 per cent kill within 35 days.

On August 1, soil drenches of 18 gallons, of 0.1 per cent Thimet and of Systox were made to lilac shrubs 12 to 15 feet high. The results are given in table 24.
**Table 2a. Soil Drench Treatments on Lilac Shrubs to Control Oystershell Scale (August 1).**

<table>
<thead>
<tr>
<th>Material</th>
<th>Tox.</th>
<th>Per Cent</th>
<th>Per Gal.</th>
<th>Scales - Per Cent Kill* (Ave. of 2 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Thimet</td>
<td>0.1</td>
<td>18</td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Control</td>
<td>-----</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Systox</td>
<td>0.1</td>
<td>18</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Control</td>
<td>-----</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

*100 Nymphs under scales examined per replicate.

The 0.1 per cent Thimet gave 40 per cent kill within 34 days while the 0.1 per cent Systox produced no definite kill.
Oak Mite

The oak mite, *Oligonychus bicolor* (Banks) feeds mainly on the upper leaf surface of oaks and is responsible for the brown condition of the leaves in July and August. The mite overwinter as eggs on the bark of the larger branches or twigs. The eggs hatch about the time the leaves begin to unfold in the spring. Following generations occur in rapid succession with maximum development during midsummer.

As a control for the pest, Becker (1950) recommends a spring dormant spray of 2 gallons superior type oil or 2 quarts of a dinitro material per 100 gallons of water. For summer treatment, to be applied as needed, he recommends a spray of 2 pounds of 15 per cent Aramite wettable powder per 100 gallons of water.

On August 27, 1000 ml. of 2.85 per cent Systox were injected into large red oak trees, *Quercus borealis*, 8 to 10 inches in diameter. The results are given in table 25.

Table 25. Systox Injection Treatments on Oak Trees to Control Mite (August 27)

<table>
<thead>
<tr>
<th>Per Cent Tox.</th>
<th>ml. Per Tree</th>
<th>Mites* (Ave. of 2 replicates)</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.85</td>
<td>1000</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Control</td>
<td>--</td>
<td>17</td>
<td>30</td>
</tr>
</tbody>
</table>

*10 leaf sections, 1 inch square, examined for mites per replicate.

**Eggs

***Mites very small, apparently newly hatched.
Systox injection treatment reduced mites within 6 days after treatment and gave complete kill within 14 days.
Summary

The systemic materials Thimet, Systox, Schradan, Isolan, dinexox and parazoxon were tested in a series of 32 experiments conducted during 1955 and 1956 at Waltham, Amherst, and Woronoco, Massachusetts for controls of spruce gall aphid on Norway spruce, arborvitae soft scale on arborvitae, birch leaf miner on grey birch, oystershell scale on lilac and oak mite on oak.

Systox, Thimet and Isolan applied as soil drenches, granules, trunk injections and band treatments, did not prevent gall formation by the spruce gall aphid on Norway spruce. Systox and Isolan soil drench and granular treatments did, however, kill aphid nymphs within the galls, sometime between 53 and 89 days after treatment, but the treatments caused mild phytotoxicity.

Systox and Thimet soil drench treatments on arborvitae seedlings and shrubs did not control arborvitae soft scale.

Failure to obtain control of spruce gall aphid on spruce and soft scale on arborvitae was probably due to poor absorption, or translocation or both.

Systemic insecticides were applied as soil drenches, granules, trunk injections, bark paints, band treatments, and foliar sprays on 220 grey birch, including seedlings,
saplings and trees.

Soil drench treatments with 0.4 per cent Thimet prevented the development of larvae of birch leaf miner throughout the summer, but they were also phytotoxic to the trees. There was an indication that Thimet concentrations as low as 0.005 per cent were effective against second generation infestations. The indication is that smaller amounts of high concentration soil drench were more effective than large amounts of low concentration.

Granule applications of four per cent Thimet prevented miner development throughout the summer. The treatment is easier to apply and is apparently as effective as soil drench, if water, either irrigation or rainfall, is present to dissolve the granules and carry the chemical to the roots.

An injection of 0.4 per cent Thimet into large birch trees prevented second generation birch leaf miner larvae development.

Thimet and Systox applied as a five per cent bark paint effectively prevented miner development for many days.

Band applications of Thimet and Systox were ineffective.

Foliar sprays of Thimet and Systox killed the miners present at the time of treatment but did not protect new growth. There was very little translocation of toxic materials from sprayed leaves on lower parts of the trees.
to unsprayed leaves on the upper parts of the tree.
The 0.1 per cent Thimet and 0.1 per cent parazoxon
soil drenches produced 85 per cent mortality of oyster-
shell scale on lilac seedlings, whereas the 0.1 per cent
Systox gave no kill. On large lilacs shrubs, 0.4 per cent
Thimet produced 40 per cent mortality but there was no
kill with 0.4 per cent Systox.

Systox injections into large red oak trees caused
a complete oak mite kill within eight days.
Conclusions

Spring and summer applications of Systox and Thimet did not prevent spruce gall aphid development. Gall development was not prevented, probably due to poor absorption and/or translocation of the systemic by the tree.

Further testing of Thimet and Systox soil drenches, granules, and trunk injections for the control of sucking and leaf mining pests on deciduous trees and ornamentals is warranted.
Technical Data

**Systox**

**Alternative Names:**
- 0,0-diethyl 0-2-ethylmercapto-ethyl phosphonothioate.
- Ethyl mercaptoethyl diethyl thiophosphate.
- Diethoxythiophosphoric acid ester of 2-ethylmercapto ethanol.
- E-1059.
- Demeton.

**Empirical Formula:** C_{8}H_{19}O_{3}PS_{2}

**Structural Formula:**

\[ \text{CH}_3\text{--CH}_2\text{--O} \quad \text{S} \quad \text{O} \quad \text{CH}_2\text{--S} \quad \text{CH}_3 \]

**Composition of the Systox used for tests:**

- **Active ingredients:**
  - 0,0-diethyl 0-2-ethylmercapto ethyl phosphonothioate...21.2%
  - related organic phosphates........................................1.8%
  - inert ingredients..................................................77%

**Physical Properties:**

- **Appearance:** clear yellow to light brown liquid.
- **Odor:** skunk-like odor.
- **Boiling point:** 134°C/2 mm.
- **Volatility:** 3.5 mg/m^3 at 20°C.
Chemical Properties:

Solubility: slightly soluble in water, soluble in most organic solvents. Insoluble in petroleum derivatives.

Hydrolysed: by strong alkali.

Compatibility: compatible with most non-alkaline spray materials except water-soluble mercury compounds.

Biological Properties:

Toxicity: acute oral LD60 to female rats 9.4 mg/Kg; LD50 to rabbits by skin application 24 mg./Kg.

Method of Manufacture: by reaction of 2-hydroxyethyl ethyl sulphide with diethyl phosphoro-chloridothionate in presence of anhydrous sodium carbonate and metallic copper. (Taken from Martin, 1953: Chemagro Corp. Systox label.)
**Thimet**

**Alternative Names:**
0,0-diethyl S-(ethylthiomethyl) phosphorodithioate.

**Empirical Formula:** C$_7$H$_{17}$O$_2$PS$_3$

**Structural Formula:** \((C_2H_5O)_2S \rightarrow S\rightarrow \text{CH}_2S\rightarrow \text{C}_2\text{H}_5\)

**Composition of Thimet used in tests**

- **Emulsifiable liquid:**
  - 0,0-diethyl S-(ethylthiomethyl) phosphorodithioate: 47.5%
  - Xylene: ........................................... 37 %
  - Inert ingredients: .................................. 15.5%

- **Granular:**
  - 0,0-diethyl S-(ethylthiomethyl) phosphorodithioate: 2%
  - Inert ingredients: .................................. 98%

**Physical Properties:**

- **Appearance:** yellow to brownish liquid.
- **Odor:** characteristic, repulsive odor.
- **Boiling Point:** 118-120° at 0.8 mm. Hg.
  - 40-43° at 10 micron. Hg.
- **Vapor Density:** 0.0106 g./l at 120°C and 1 mm. pressure.
- **Specific Gravity:** (technical) 1.167 at 25°C.
- **pH:** 3.3.

**Chemical Properties:**

- **Solubility:** 50 ppm in water.
  - Miscible with xylene, dioxane, carbon tetrachloride, methylecellosolve, dibutyl phthalate and vegetable oils.
Stability: subject to hydrolysis under alkaline conditions.

Compatibility: compatible with most insecticides and fungicides.

Toxicity: oral administration of 1.75 mg/kg produce LD50 in rats. Dermal toxicity for guinea pigs is about 300 mg/kg.

(Taken from American Cyanamid Company Technical Data on Thimet.)
Isolan

Alternative Names:
Isopropylmethylpyrazolyl dimethyl carbamate.
1-isopropyl-3-methyl-pyrazolyl-(5)-dimethyl carbamate.

G-23611

Empirical Formula: C_{10}H_{17}N_{3}O_{2}

Structural Formula:

Composition of the Isolan used for tests, Geigy Company Isolan.

Active Ingredients: Isopropylmethylpyrazolyl......25%
Inert Ingredients: ........................................75%

Physical Properties:

Appearance: a reddish-brown liquid.
Odor: spicy odor.
Boiling Point: 105-110 at .3 mm. Hg

Chemical Properties:

Solubility: miscible with water, alcohol, acetone and xylene.
Biological Properties:

Toxicity: The LD50 by oral administration to white rats and mice was 14.0 and 11.5 mg/kg respectively.

(Taken from Martin, 1953; and Geigy Company, Technical Data Sheet.)
Schradan

Alternative Names:

- Bis(dimethylamino)phosphorus anhydride.
- Octamethylpyrophosphoramide.
- OMPA.
- Octamethylpyrophosphoramide.
- Pyrophosphoryltetrakis(dimethylamid.
- Tetrakis(dimethylaminophosphorus anhydride.
- Pestox III.
- Pestox 3.
- Bis(bis(dimethylamine)phosphorus anhydride.
- Bis(bis(dimethylamine)pyrophosphate.

Empirical Formula: $C_8H_{24}N_4O_3P_2$

Structural Formula:

![Structural Formula Image]

Composition of the Schradan used for tests:

Monsanto OMPA

Active ingredients: Octamethylpyrophosphoramide.......70%
Related organic phosphates..............................20%
Inert ingredients.........................................10%
Physical Properties:

Appearance: clear yellow to brown colored liquid.
Odor: spicy odor.
Boiling point: 135° at 1 mm. Hg
Specific Gravity: 1.109 at 25°C.

Chemical Properties:

Solubility: soluble in water, ethanol, acetone, ethyl ether, ethyl acetate, methyl chloride and xylene. Insoluble in 30-60 C. petroleum, ether, heptane.

Stability: hydrolyzed under acid conditions to orthophosphoric acid and dimethylamine.

Biological Properties:

Toxicity: The LD₅₀ for most laboratory animals after oral administration is in the range of 25 to 35 mg/kg. For rats the lethal oral or subcutaneous dose is 18 mg/kg. The lethal dosage for white mice is 1.5 to 7 mg/kg.

(Taken from Martin 1953: Monsanto Technical Bulletin 1953).
Dimefox

Alternative Names:
- Bis dimethylaminofluorophosphine oxide.
- Bis (dimethylamido) fluorophosphate.
- Hanane,
- Pestox 14,
- Schrader's #13/28.

Empirical Formula: \( \text{C}_4\text{H}_8\text{F}_2\text{N}_2\text{O}_4 \)

Structural Formula:

\[
\begin{align*}
\text{(CH}_3\text{)}_2\text{N} & \quad \text{O} \\
\text{P} & \quad \text{F} \\
\text{(CH}_3\text{)}_2\text{N} & 
\end{align*}
\]

Composition of the Dimefox used for tests, Pest Control Ltd.
- Active Ingredient: Bis dimethylaminofluorophosphine oxide...50%
- Inert Ingredients: Hexamethyl orthophosphoramide............15%
  - Schradan........................................5%
  - Chloroform......................................30%

Physical Properties:
- Appearance: colorless, however a purple dye is added.
- Odor: faint characteristic odor.
- Boiling point: 67°C at 4 mm. Hg.

Chemical Properties:
- Solubility: soluble in water.

Biological Properties:
- Toxicity: the LD\text{50} range for most mammals is between 2 and 3 mg/kg.

(Taken from Patterson, 1955, and Edwards, 1951.)
Parazoxon

Alternative Names:
Diethyl-p-nitrophenyl phosphate.
E600.
Mintacol.

Empirical Formula: $C_{11}H_4NO_6P$.

Structural Formula:

\[
\begin{align*}
\text{C}_2\text{H}_5\text{O} & \quad \text{POC} \quad \text{NO}_2 \\
\text{C}_2\text{H}_5\text{O} & \quad
\end{align*}
\]

Composition of Parazoxon used for test:

Active Ingredients: Diethyl-p-nitrophenyl phosphate...50%
Inert Ingredients:.................................50%

Physical Properties:

Color: Reddish yellow oil.
Boiling Point: 148-151°C/mm Hg.
Vapor Pressure: $9 \times 10^5$ mm Hg at 27.4°C.

Chemical Properties:

Solubility: Slightly soluble in water.
Moderately soluble in petroleum oils.
Readily soluble in most organic solvents.

Stability: Hydrolyzes rapidly in alkaline solutions.
Darkens on prolonged exposure to sunlight.
Biological Properties:

Toxicity: LD$_{50}$ oral to rats 3.5 mg/kg, subcutaneous to white mice 0.6-0.8 mg/kg fatal.

Method of Manufacture:

Schradan:

\[
\text{alcohol} \quad \xrightarrow{\text{POCl}} (C_2H_5O)_2 \quad \xrightarrow{\text{POCl}} \quad \text{parazoxon} \\
\text{N} \\
\text{itrophenate}
\]

Atherton, Openshaw & Todd:

\[
(C_2H_5O)_2 \quad \text{POH} + NaOC_6H_4NO_2 \quad \xrightarrow{\text{parazoxon}+CHCl_3+NaCl}
\]

(Taken from Martin 1953.)
Literature Cited

American Cyanamid Co.


Ames, F. O.


Anthon, Edward W.

1951. New insecticides, including systemic insecticides for control of black cherry aphids. Jour. Econ. Ent. 44: 1012.

Ashdown, P. & H. B. Cordner

1952. Some effects on insect control and plant response of a systemic insecticide applied as a spray, as a seed treatment, as a soil treatment. Jour. Econ. Ent. 45: 302-7.

Batt, R. R., L. H. Bennett & W. D. E. Thomas


Becker, W. B.


Becker, W. B.


Bedard, W. D.

Bennett, S. H.


Bennett, S. H. & W. D. E. Thomas

1952. Experiments on the absorption and fate of a systemic insecticide bis(bis dimethylamino) phosphorous anhydride \([\text{CH}_3]_2\text{PO-0-P0 }[\text{CH}_3]_2\text{N}\] in plants. Internat'l Cong. Ent. Trans. 9(1): 951-56.

Bennett, S. H. & W. D. E. Thomas


Bond, J. A. B.


Bronson, I. E. & Dudley, J. E.


Boucherie, A. "Memoire sur la conservation des bois."

1840. Annales de Chemise et de Physique. 74: 113-57


Carter, R. H.

Casida, J. E., R. K. Chapman & T. C. Allen

1952. Relation of absorption and metabolism of octa-methyl pyrophosphosamide by pea plants to available phosphorus. Jour. Econ. Ent. 45: 568-78

Casida, J. E. & H. A. Stohmann


Casida, J. E., P. E. Gatterdam, L. W. Getzin, Jr. & R. K. Chapman


Chao Seng Tsi


1953. Translocation studies with two new phosphate insecticides. Science 118: 26

Craighead, F.C. & R. A. St. George


Craighead, F. L. & R.A. St. George

1938. Experimental work with the introduction of chemicals into the sap stream of trees for the control of insects. Jour. Forestry 36: 26-34

Cutright, L. R.

David, W. A. L.


David, W. A. L., & B. O. C. Gardiner


David, W. A. L., & B. A. Kilby


David, W. A. L., & B. O. C. Gardiner


Diamond, A. E.

1956. Personal communication

Flint, W. P.


Fukuto, T. R., R. L. Metcalf, R. R. March, & Marion G. Maxon


Gaines, J. C., E. E. Ivy, H. A. Dean, & A. L. Scales

1950. Toxicity of various sulfur and phosphorus compounds applied as sprays on spider mites and aphids. Jour. Econ. Ent. 43: 614-19

Garman, P.

Giang, P. A.


Haller, H. L.


Hanna, A. D., E. Judenko & W. Heatherington


Hofmaster, R. N., & D. E. Greenwood


Howe, W. L. & L. I. Miller


Hurd-Karrer, A. M. & F. W. Poos

1936. Toxicity of selenium-containing plants to aphids. Science 84: 252

Ivy, E. E., W. Iglinsky, Jr., & C. F. Rainwater

1950. Translocation of octamethyl pyrophosphoramide by the cotton plant and toxicity of treated plants to cotton insects and a spider mite. Jour. Econ. Ent. 43: 620-26

Jacobs, H. L.

Jeppson, L. R., M. J. Jesser & J. W. Complin

Knight, H., & C. R. Cleveland
1934. Recent development in oil sprays. Jour. Econ. Ent. 27: 269-89


Martin, H. & J. R. W. Miles

Matthysse, J. G. & J. A. Naegele
1952. Spruce mite and southern red mite control experiments. Jour. Econ. Ent. 45: 383-387

McLeod, W. S.

Metcalf, M. M.

Metcalf, R. L.

Metcalf, R. L. & R. B. March
Metcalf, R. L., R. B. March, T. R. Fukuto & Marion Maxon


Michelbacher, A. E., & O. G. Bacon


Monsanto Chemical Co.


Muller, A.


Neiswander, C. R. & V. H. Morris

1940. Introduction of selenium into plant tissues as a toxicant for insects and mites. Jour. Econ. Ent. 33: 513-525

Ortega, J. C.


Patterson, R. S.


Pierson, H. B.

1927. Control of the bronze birch borer by forest management. Jour. Forestry 25: 68-72

Plumb, G. H.

Reynolds, A. T., S. L. Anderson, & J. E. Swift

1953. Tests with two systemic insecticides on vegetable and field crops in southern Calif. Jour. Econ. Ent. 46: 555-60

Ripper, W. E., R. M. Greenslade & G. S. Hartley


Roth, A. R. & J. B. Johnson

1955. Tests with Dieldrin as a systemic against cattle grubs. Jour. Econ. Ent. 48: 761

Rumbold, C. T.


Sanford, F.

1914. An experiment on killing tree scales by poisoning the sap of the trees. Science 40: 519-20

Scherer, C. M.

1927. Tree injections for the control of fungus diseases and insect pests. Phytopathology 17: 51

Schread, J. C.


Schread, J. C.

Scott, R.
1956. Personal communication

Shattuck, G. H.
1915. Effect of potassium cyanide in trees.
Science 41: 324

Shell Development Co.
1954. OS2046-An experimental insecticide.
Shell Tech. Data, 1-4

Shepard, H. H.
1951. The chemistry and action of insecticides.

Sherrer, J. D., & F. S. Arant
1954. Effect of certain systemic compounds on a southern red mite infesting camellia.
Jour. Econ. Ent. 46: 1116-17

Surface, H. A.
1914. Cyanide of potassium in trees. Sci. 40: 852-54

Tietz, H.
1952. The 32P marked diethyl thionophosphoric ester of E-oxyethyl thioethylether (active ingredient of the systemic insecticide Systox), its absorption and translocation in plants.
Hofchen-Briefe 1: 1-55

Trelease, S. F. & Helen M. Trelease
1937. Toxicity to insects and mammals of foods containing selenium.
Am. Jour. Bot. 44:8-51

Von Runker, R.
Agr. Chem. 10(1): 42-8, 122-123
Wedding, R. T.


Wedding, R. T. & R. L. Metcalf


Wollerman, E. H., C. R. Pease & A. S. Kiefer


Zatter, F.

Acknowledgments

I should like to acknowledge with sincere appreciation, all those who assisted me in this work.

The Bartlett Tree Expert Company for its financial assistance and technical advice.

The members of my thesis committee, Drs. Frank R. Shaw, Constantine J. Gilgut, and Malcolm A. McKenzie for their guidance in the planning and writing of this thesis.

All others at the University of Massachusetts and the Waltham Field Station who assisted directly or indirectly to the completion of this work.

Professor Warren D. Whitcomb, to whom I owe the greatest debt, for without his guidance, help, and encouragement, this work would not have been possible.