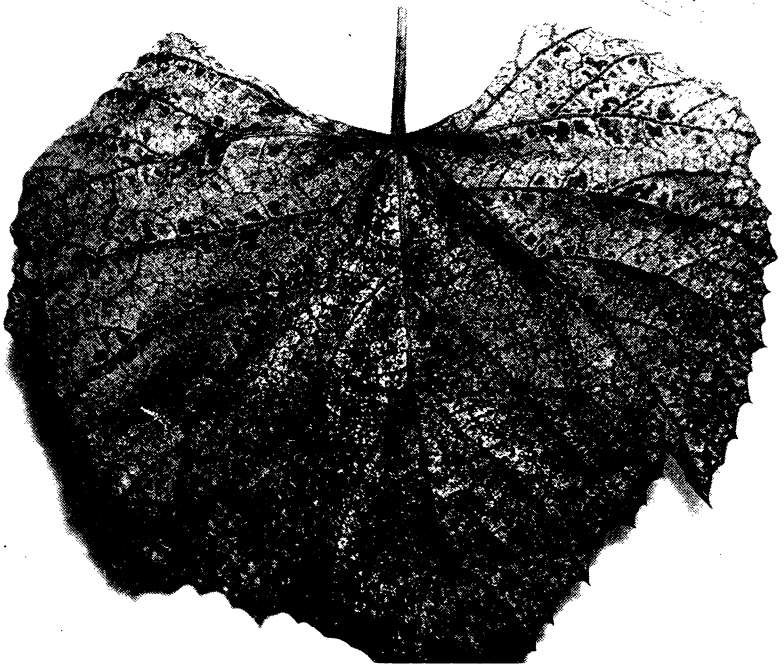
Grape Leafhopper Control

—1944 to 1947

By E. F. Taschenberg
F. Z. Hartzell



Concord grape leaf injured by grape leafhoppers. Three-fourths natural size.

New York State Agricultural Experiment Station
Cornell University, Geneva, N. Y.

BULLETIN NO. 738 ● DECEMBER, 1949

CONTENTS

BULLETIN NO. 738

GRAPE LEAFHOPPER CONTROL, 1944 TO 1947

E. F. TASCHENBERG AND F. Z. HARTZELL[1]

ABSTRACT

SPRAYING experiments for the control of the grape leafhopper, *Erythroneura comes* Say, were conducted on Concord grapes between 1944 and 1947. Most of the tests were made in the Chautauqua-Erie grape belt and the remainder in Monroe County. This bulletin, for the most part, describes the details of the investigation. A resume of the life history and habits of these insects, a brief history of the years when they were most abundant in the Chautauqua region from 1900 to 1947, and a short description of the economic importance of severe foliage injury have been included.

The insecticides tested include nicotine, a thiocyanate, rotenone, DDT, DDD, and parathion. Various brands and formulations of nicotine, thiocyanate, and DDT were used. In general, the effectiveness of each formulation for a given compound was closely related to the amount of toxicant, so all quantities are given in ounces of toxicant in 100 gallons of spray mixture.

When counts were made from 2 to 6 days after treatment with minimum practical concentrations, the following control of leafhopper nymphs was secured: nicotine, 6.4 ounces, fair to excellent; rotenone, 1.9 ounces, excellent; a thiocyanate, Lethane A70, 7.2 ounces, good; Lethane B72, 4.3 ounces, poor to good; DDT, 4 ounces, excellent; DDD, 4 ounces, excellent; parathion, 2.4 ounces, excellent.

Of these insecticides, the only compounds which kept the foliage practically free from leafhoppers from mid-July until grape harvest (early October) were DDT, 4.8 ounces, and DDD, 4 ounces. Evidently DDD kills the adults, but no pre-bloom treatments of this material were tested. DDT, 8 ounces, applied about mid-June as a pre-blossom treatment killed the overwintered adults and usually gave excellent control to the end of the season. Thus the grape grower can avoid injury from these overwintered adults and need not be particular about the timing of the applications.

The residue from a spray containing 12 ounces of DDT with 2-4-100 bordeaux mixture was toxic to the nymphs 57 days after the spraying was done. Unfortunately, no legal tolerances for the various new insecticides have been declared so it is important to use them before or shortly after bloom to avoid a residue problem on the harvested fruit.

[1] The writers are indebted to the growers whose names appear in this bulletin for permission to use portions of their vineyards for making the field tests. They wish to express their thanks for these favors.

INTRODUCTION

THE grape leafhopper, *Erythroneura comes* Say, including several subspecies, is one of the important groups of insects infesting grapes in New York and in a number of the northern states. This bulletin is a report of spraying experiments with various insecticides, aimed at the control of these insects, conducted in the Lake Erie Valley and in Monroe County.

There were four important reasons for making these field tests, *viz.*, (a) grape leafhoppers were abundant in the Chautauqua-Erie grape belt from 1938 to 1947; (b) the standard insecticide, nicotine sulfate, is rather ineffective on the adults so very precise timing is necessary to make the applications when the greatest proportion of nymphs is present; (c) the number of new insecticides which has appeared since about 1944 made field tests advisable to evaluate their effectiveness on leafhoppers; and (d) hooded booms, which have been developed during the past decade, offer advantages over the earlier methods for applying insecticides for certain insects and field tests were needed to determine their value in leafhopper control. In addition to searching for more effective materials, efforts were made to investigate the value of pre-blossom treatments and the length of time the various insecticides are toxic to this group of insects.

FLUCTUATION IN ABUNDANCE

Leafhoppers vary in numbers from year to year in all parts of the State. The most complete series of records have been accumulated for the Chautauqua-Erie belt, because, with the exception of 1905, entomologists from various institutions[2] have been investigating insects in this area from 1900 to the present time. Although other grape pests were studied, workers made observations on the leafhoppers during periods when these insects were abundant.

From 1900 to 1948 there were three distinct peaks of abundance occurring in 1902, 1911, and 1922 (18, 14, 10, 11, 20, 4, 5)[3]. In addition there was an extended period of severe infestation from 1938 to 1947 with a possible peak in 1944. Each of the earlier peaks was pre-

[2]The workers have represented the following institutions in chronological order: Cornell University Agricultural Experiment Station; United States Bureau of Entomology, working in Erie County, Pa.; New York State Agricultural Experiment Station; Pennsylvania Bureau of Plant Industry; and Pennsylvania State College.

[3]Numbers in parenthesis refer to Literature Cited, page 39.

ceded by a year or two of high population and was followed by a similar year. Thus a peak may be considered as usually consisting of three years when these insects caused serious foliage injury. During the intervening years the leafhopper population was sufficiently low to be of little or no economic importance except locally.

INJURY

The two effects that are usually the result of serious foliage injury (frontispiece and Fig. 1) are lowering of the quality of the fruit and possibly a decrease in yield.

As shown by Kertesz (16) and by Robinson, Avens, and Kertesz (17), there is no exact chemical method for determining quality and maturity of grapes. For many years, however, the sugar content of the freshly cold-pressed juice has been considered an important index of quality. In this bulletin, the "soluble solids content" is taken as the index because all reported analyses give these values, but some do not state the amount of sugar. Robinson, Avens, and Kertesz (17) claim that this is the most constant of the constituents of grape juice determined in their studies. Kertesz (16) has shown that a fair esti-

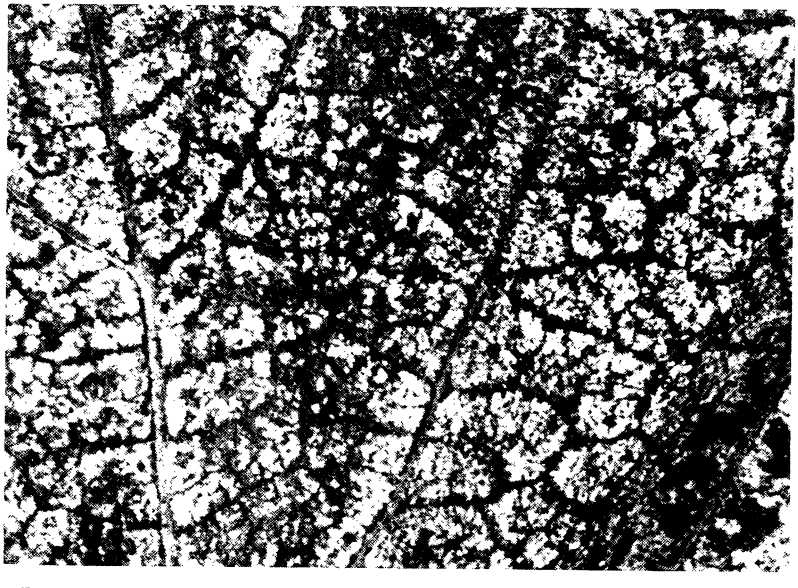


FIG. 1.—*Portion of Concord grape leaf injured by grape leafhoppers. Enlarged three times linear. Light areas are injured tissue.*

mate of the amount of reducing sugar present can be secured by subtracting 2.0 from the percentage of soluble solids. The soluble solids content previous to 1940 was secured by means of a Brix hydrometer, but in studies made by the writers since 1940 a hand refractometer has been used.

The only analyses of Concord grapes in relation to foliage injury by the grape leafhopper in the Chautauqua-Erie grape belt known to the writers are those made by Johnson (14) for 1911, by Hartzell (11) for 1912, by VanDine (20) for 1922, and by the writers for 1944, 1946, and 1948. All these workers furnished the data on soluble solids given in Table 1. The most uncertain data are in relation to foliage

TABLE 1.—EFFECT OF FOLIAGE INJURY BY GRAPE LEAFHOPPERS ON THE SOLUBLE SOLIDS CONTENT OF CONCORD GRAPES.

YEAR	INVESTIGATOR	FOLIAGE INJURY, PER CENT OF MAXIMUM OBSERVED 1909–48 (ESTIMATED)	SUNSHINE, PER CENT OF POSSIBLE *		SOLUBLE SOLIDS, GRAMS IN 100 CC OF JUICE		LOSS, PER CENT
			May 1 to Sept. 30	Aug. and Sept.	Sprayed	Not sprayed	
1911	Johnson (14)	100	49	44	19.7	13.4	32.0
1912	Hartzell (11)	70	42	36	17.3	14.6	15.6
1922	VanDine (21)	80	57	62	17.8	14.0	21.3
1944	Hartzell	40	43	45	17.5	17.3	1.1
1946	Hartzell	30	45	48	17.2	17.3	+0.6
1948	Taschenberg	25	44	47	17.9	18.1	+1.1

*Sunshine records from Monthly Weather Review, United States Weather Bureau. Those for 1911 and 1922 are for Erie, Pa. All others are averages for Erie, Pa., and Buffalo, N. Y., because the experiments were located about mid-way between these two stations.

injury for the years 1911, 1912, and 1922. These have been estimated by the junior author who was investigating grape insects in Chautauqua County from 1909 to 1925, inclusive. The difficulty lies in the fact that no fairly exact method for estimating such injury was developed previous to 1943. Efforts were made to correlate such weather and crop data as temperature, rainfall, percentage of sunshine, relative yield, and foliage injury with the soluble solids content. All the weather data were taken from the *Monthly Weather Review*.[4]

The closest relationship found was between foliage injury and percentage loss of soluble solids (Table 1 and Fig. 2). None of the weather data, except possibly percentage of sunshine, showed a reasonably close correlation with the soluble solids. It will be noted that in Table 1 the amounts of soluble solids for sprayed grapes, except for 1911, cluster rather closely around 17.5 grams per 100 cc of juice.

[4] United States Weather Bureau, Washington, D. C.

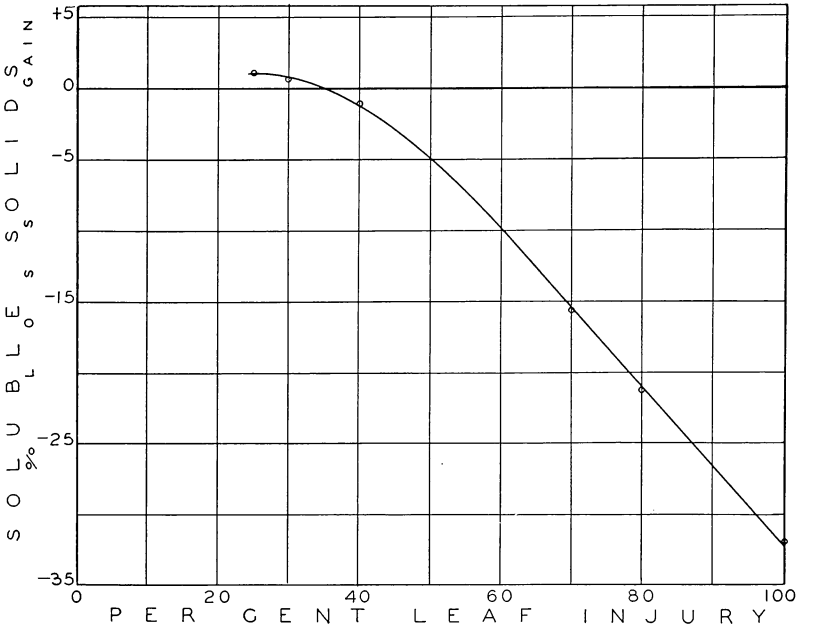


FIG. 2.—*Relation of leaf injury to percentage loss of total solids. Greatest injury observed since 1909 taken as 100 per cent. Data from Table 1.*

Disregarding the 1911 data, the percentages of sunshine and soluble solids seem to be fairly closely related, either when the average sunshine is taken for the entire growing season or only for August and September (Fig. 3). This is in accordance with the findings of Caldwell (1) who, working at Vineland, N. J., and reporting for the years 1919 to 1923, inclusive, claims that, with vines having a normal yield, variation in the amount of sunshine from March 15 to September 15 of each year was the most important factor affecting the soluble solids content of the fruit. The growing and ripening season for Concords in western New York extends from early May to the end of September of a normal year, being shorter than in southern New Jersey. For this reason the period has been taken from May 1 to September 30. The weather during August and September is considered by most grape growers as playing a prominent part in ripening for western New York, so the percentages of possible sunshine for these two months are also given. It will be noted in Fig. 3 that the latter data fit the regression line about as close as do those for the entire growing season.

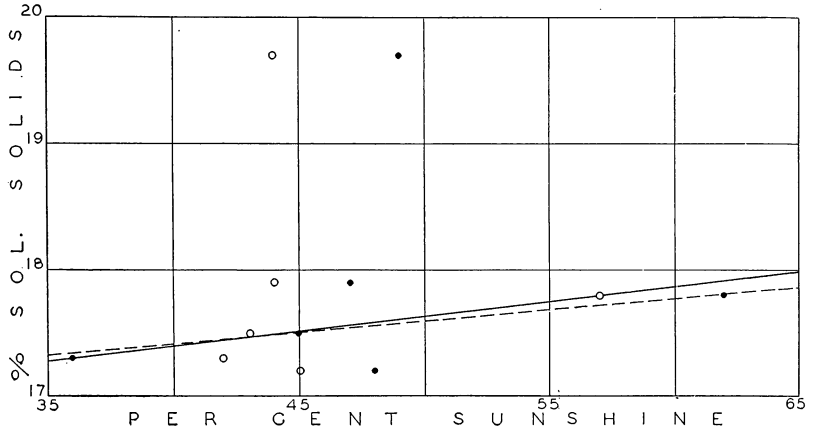


FIG. 3.—*Relation of sunshine to soluble solids of fruit on sprayed vines. Circles and solid line, May to September data; dots and dash line, August and September data. 1911 values disregarded in determining regressions. Data from Table 1.*

The most surprising result shown by the data on percentage loss in soluble solids and degree of leaf injury is that Concord seems to ripen its fruit even when about one-third of the foliage surface has been injured by leafhoppers.

A number of earlier writers, including Slingerland (18), stress the dwarfing of the vine growth by leafhoppers. Unfortunately, there are no reliable field data where such effects have been definitely proved.

SEASONAL HISTORY AND HABITS

A brief discussion of those biological factors which relate to control only is briefly presented here. A generation (also called a brood) consists of the following forms or stages: egg, nymphs, and adults. The eggs are inserted underneath the lower epidermis of the green grape leaves so are protected from most sprays. There are five nymphal stages or instars (Fig. 4) and the insects, being without wings at these stages, are easily wet by spray applied to the undersides of the leaves where the nymphs feed. It is for this reason that, with materials like nicotine or rotenone, efforts are made to apply the sprays at a time when most of the eggs have hatched but before many nymphs have changed to adults. The bodies of the adults (Fig. 5) are fairly well shielded by the wings so for this reason apparently are difficult to kill with nicotine or rotenone.

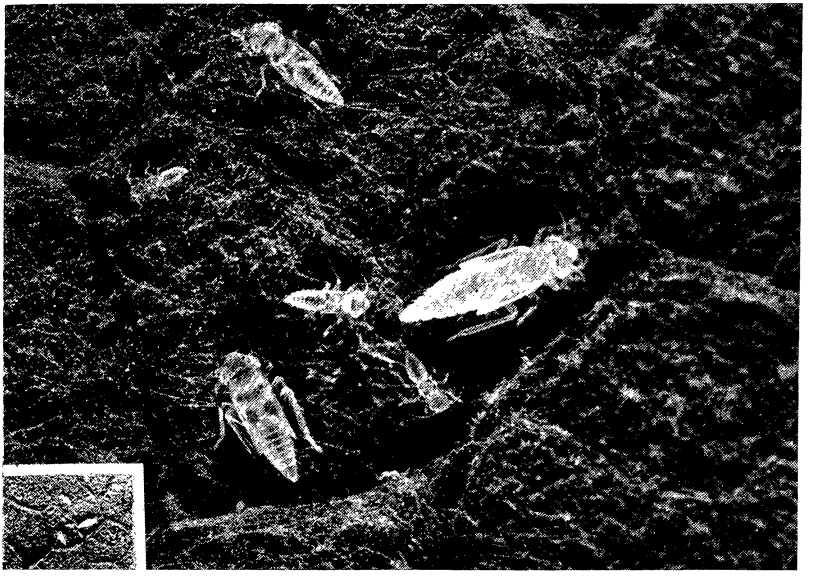


FIG. 4.—*The five nymphal stages (instars) of the grape leafhopper. Enlarged 9 times linear. Two usual first instar nymphal forms present. Insects shown natural size at lower left. Photo by Miss Gertrude A. Catlin.*

HIBERNATION AND SPRING FOOD PLANTS

Winter is passed in the adult stage usually in suitable shelter outside the vineyard. Grape leafhoppers either instinctively seek shelter favorable for hibernation or scatter at random, and only those survive which happen to locate in material that prevents snow or ice from crushing them. Such advantageous material is (a) dead, stiff grass which has lodged; (b) accumulations of tree leaves which are more or less curled and thus do not pack tightly or become sodden; and (c) various kinds of debris. With the first warm days of spring, even in early March, these adults fly about. Somewhat later in March and during April when the weather is fairly warm, they feed on any available green plant tissue. Preference during late April and early May is shown for the leaves of currants and such brambles as dewberries, raspberries, and blackberries.

This preference for brambles and currants has an important bearing on the degree of infestation in vineyards. Vines adjoining either cultivated or wild patches of such plants are, almost invariably, more seriously infested than portions of the same vineyard more removed

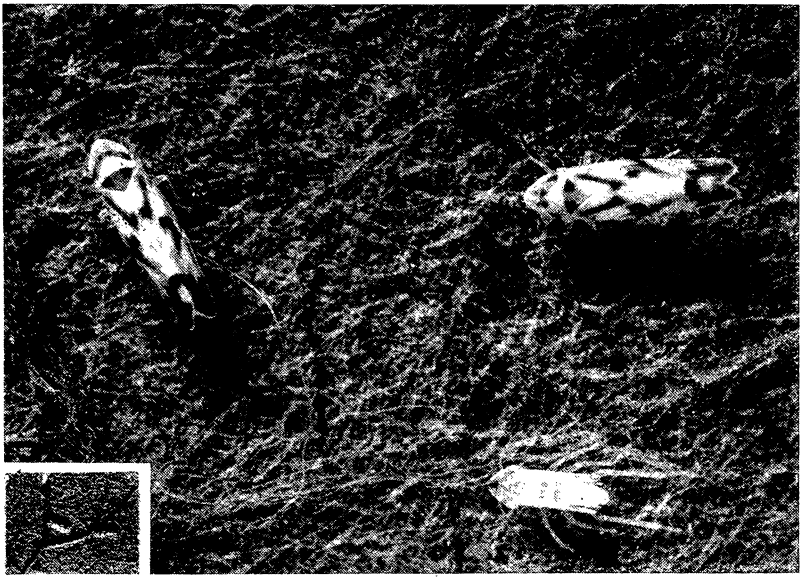


FIG. 5.—*Adults of grape leafhopper and molted skin. Enlarged 9 times linear. Insects shown natural size at lower left. Photo by Miss Gertrude A. Catlin.*

from such feeding areas. The practice of interplanting grapes and small fruits is conducive to leafhopper injury on grapes.

Fence rows and ditch banks overgrown with brush, weeds, or strawy grass, as well as open fields in which the stiffer types of dead grass tops have lodged, afford excellent hibernating quarters for leafhoppers. Vineyards having such surroundings also are more seriously infested than those surrounded by clover or alfalfa fields or where the edges are kept closely mowed in the fall.

SEASONAL HISTORY ON GRAPES

Migration of the hibernated adults to grapes usually begins about the time the third leaf has expanded on the more advanced shoots, usually between May 15 and 20. The peak of this movement occurs about one week later and, normally, by June 1 most of the adults are on the grape foliage. Eggs are laid by the hibernated females from early June until near the end of July, but the greatest number is deposited from about June 15 to about July 10. The eggs are placed underneath the epidermis of the lower sides of grape leaves.

Hatching of first brood nymphs occurs from about June 20 until

early August, the bulk appearing between July 1 and 20. Although some first brood adults may emerge by July 10, the majority emerge the last half of the month and the first week of August.

Second brood eggs may be deposited by mid-July, but the greatest number is laid during the first two weeks of August. Second brood nymphs begin to appear the last week of July, but the peak of hatching occurs during the first to third week of August. The bulk of the second brood adults appears the last week of August and the first week of September, although the earliest ones may be present during the first week of August and the last adults may not emerge until about October 1.

These second brood adults remain on the foliage until after the grape harvest, or at least until many of the leaves have fallen, after which there is a gradual movement to places for passing the winter. In these latter situations, the adults fly about on warm days of October or even November.

It should be noted that the dates given throughout this bulletin apply to western New York and the Lake Erie Valley in both New York and Pennsylvania for a season with normal temperatures. The dates usually might be from ten days to two weeks earlier in the Hudson Valley and on Long Island.

RESUME OF CONTROL MEASURES

A history of practices for the control of the grape leafhopper prior to 1904 is presented by Slingerland (18) to which publication the reader is referred for details and references. Slingerland found that any one of the following materials was effective against the nymphs: kerosene emulsion, tobacco decoction, or whale-oil soap at the rate of 1 pound in 10 gallons of water. He also devised the method of using one or more nozzles on an extension rod to direct the spray to the undersides of the leaves.

According to Hartzell (9, 10, 11) and Johnson (13, 14), experimenting between 1910 and 1912, sprays containing either Black Leaf Extract, a concentrated extract of nicotine, at the rate of 1 gallon per 100 or 150 gallons of water, or nicotine sulfate, Black Leaf 40, at the rate of ½ to ¾ pint per 100 gallons of water, gave efficient control of the nymphs but not of the adults. Trailing hose and the Slingerland nozzle arrangement were used by Johnson in all his experiments and by Hartzell in 1910 and in a portion of his 1911 tests. The latter worker (10), with F. A. Morehouse of Ripley, developed an

automatic leafhopper spraying attachment which was used in experiments of 1911 and 1912. This automatic arrangement was used by a number of grape growers during 1912.

Gleissner (8) reported in 1943 that one treatment with nicotine sulfate at a dilution of 1 to 800 (1 pint per 100 gallons) or two applications at the dilution of 1 to 1,600 were more effective than a treatment of either 10 ounces of pyrethrum extract or 1 pint of a combined extract of pyrethrum and rotenone in 2–2–100 bordeaux mixture. He also recorded a 50 to 70 per cent reduction of an overwintered population by using a quick-breaking 3 per cent emulsion of kerosene containing pyrethrum extract, 8 to 10 ounces per 100 gallons of mixture. He used hooded booms for the application of the various sprays.

Much interest in DDT for the control of the grape leafhopper has been shown by a number of workers since 1944, the year this material was first made available as an agricultural insecticide. Cox (2, 3) reported that one spray of DDT in a 4–4–100 bordeaux mixture gave satisfactory control of both adults and immature leafhoppers; also that one pre-blossom application, using 4 ounces or more of actual DDT and 3 quarts of Sunoco oil per 100 gallons, controlled the leafhoppers for the entire season. He also reported that Rhothane (DDD) at the rate of 0.5 pound actual DDD per 100 gallons as a post-blossom spray gave practically the same results as did DDT at the same rate and applied at the same time. He found that while nicotine sulfate, ¾ pint, and also Lethane B–72, 2 pounds per 100 gallons, gave good initial control, neither material prevented a serious reinfestation during the latter part of the summer. All the applications were made with hooded booms on Concord grapes and the grape leafhoppers were identified as *E. comes*.

FIELD INVESTIGATIONS FROM 1944 to 1947

MATERIALS

The insecticides, and accessories used in the experiments were as follows.

ACX70.—An emulsifiable solution containing 0.2 pound of DDT per gallon. Shell Oil Company, New York, N. Y.

Black Leaf Dry Concentrate.—A commercial nicotine product containing 14 per cent nicotine.

Black Leaf 40.—Nicotine sulfate containing 40 per cent nicotine.

Black Leaf 10.—A nicotine product containing 10 per cent nicotine.

Black Leaf 155.—A fixed nicotine product containing 14 per cent nicotine. This and the three preceding Black Leaf preparations were made by Tobacco By-Products and Chemical Corporation, Louisville, Ky.

Copper sulfate.—A snow form of crystals.

Cube powder.—Ground cube root contining 4 per cent rotenone.

DDT.—2,2–bis–(p–chlorophenyl)–1,1,1–trichloroethane. Usually sold in a miscible solvent or mixed with an inert material and a wetting agent.

DDT in benzene.—One gallon of benzene contained 48 ounces of technical grade DDT. Prepared at Experiment Station, Geneva, N. Y.

Deenate 25W and 50W.—Two wettable powders containing 25 and 50 per cent DDT, respectively. E. I. duPont de Nemours and Company, Inc., Wilmington, Del.

Dethyl.—A miscible solvent containing 25 per cent DDT. Liberty Chemical Laboratories, Maywood, Ill.

Gesarol AK 20, 40, and *50.*—A series of wettable powders containing, respectively, 20, 40, and 50 per cent DDT. Geigy Company, Inc., New York, N. Y.

Lime.—A high grade calcium hydrate.

Liquid 30 DDT.—A miscible solvent containing 30 per cent DDT. Miller Chemical and Fertilizer Corporation, Baltimore, Md.

Lethane A70.—A liquid, 90 per cent of which consisted of beta beta dithiocyano diethyl ether. Rohm and Haas, Philadelphia, Pa.

Lethane B72.—A wettable powder, 13.5 per cent of which consisted of beta beta dithiocyano diethyl ether. Rohm and Haas, Philadelphia, Pa.

Parathion.—0,0 diethyl, 0–p–nitrophenyl thiophosphate. At present available in powdered preparations containing 15 and 25 per cent of this toxicant.

Rosin fish oil soap.—No. 9 potash rosin fish oil soap. James Good Company, Philadelphia, Pa.

Rhothane.—A wettable powder containing 50 per cent DDD, 2,2–bis–(p–chlorophenyl)–1,1–dichloroethane. Rohm and Haas, Philadelphia, Pa.

Sovaspray oil No. 1.—A highly paraffinic type of summer spray oil. Socony Vacuum Oil Company, Inc., New York, N. Y.

Sovaspray oil No. 3.—A summer oil containing an anti-oxidant. Socony Vacuum Oil Company, Inc., New York, N. Y.

Spreader-sticker.—As used in this bulletin it refers to a homemade preparation of 9 parts of Sovaspray oil No. 3 and 1 part of Triton B1956.

Thiophos 3422.—A wettable powder containing 15 per cent parathion. American Cyanamid Company, New York, N. Y.

Triton B1956.—Technically known as phthalic anhydride of glycerol alkyl resin, used as an emulsifying agent in the field tests described later. Rohm and Haas, Philadelphia, Pa.

25R.—A miscible solvent containing 25 per cent DDT. E. I. duPont de Nemours and Company, Inc., Wilmington, Del.

To avoid confusion in dosages, the following system is used in this bulletin:

When the commercial name of a product is used, the amount following refers to the weight or measure of that product as prepared; and when the toxicant is stated, the amount following refers to the dosage in terms of the actual toxicant. For example, Gerasol AK 20, 2.5 pounds, means that 2.5 pounds of the mixture were used. If it is desired to state the dosage of DDT which this amount of Gesarol AK 20 contained, it would be written DDT, 0.5 pound or 8 ounces. An exception is found in Figs. 7 and 8 with Lethane, Black Leaf 40, and Black Leaf Concentrate. Although the brand names are used, the numbers refer to the ounces of toxicant in 100 gallons of water.

METHODS

APPLICATION OF MATERIALS

The treatments were applied with a 15-gallon-per-minute pump operating at a pressure of 425 pounds. A hooded boom (Fig. 6) carrying a total of 14 nozzles was employed which treated both sides of the row at one time (19). Sprays were applied at the rate of 175 gallons per acre on plots treated before the grapes blossomed, whereas in the

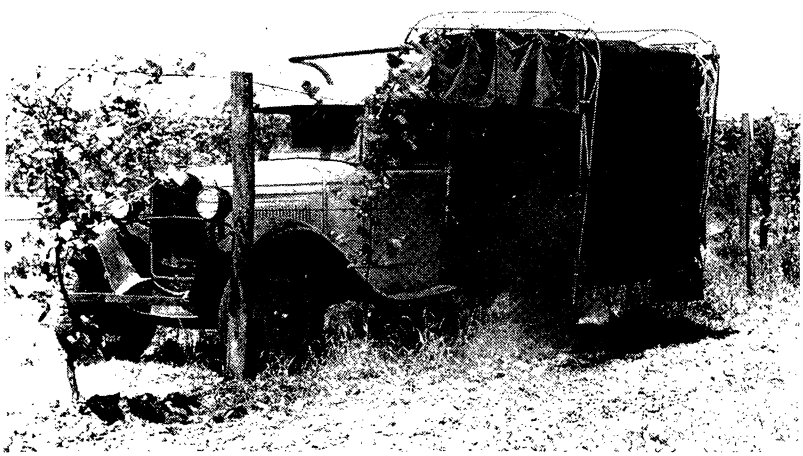


FIG. 6.—*Adjustable hooded boom operating in vineyard. Photo by C. V. Flagg.*

post-blossom period 225 gallons were used per acre. The variety Concord was used in all tests.

SPRAY MIXTURES

Bordeaux mixture was used in all sprays with the exception of those containing fixed nicotine or parathion. The spray mixture contained a spreader-sticker unless the insecticide was dissolved in a solvent. Where both grape berry moth and leafhopper were present, lead arsenate, 3 pounds per 100 gallons, was included in spray mixtures containing Lethane B70, Lethane B72, Black Leaf 40, Black Leaf 10, or Black Leaf Dry Concentrate.

RECORDING DATA

An estimation of the leafhopper population was made according to the method developed by Hartzell and Horsfall (12). Counts were taken usually before and after the treatments were applied. All samples included at least 10 leaves. These were taken from vines in the center two rows of each plot. Leaves representative of the infestation were selected at random.

The use of "pre-treatment" and "post-treatment" counts on all treated and check plots has two important advantages over the use of "post-treatment" counts only, *viz.*, (a) the two sets of counts on the check plots give information regarding the amount of increase or decrease in the leafhopper population for the interval between counts from which a correction can be made for all post-treatment counts on the treated plots; and (b) the corrected post-treatment value for each treated plot was used for computing the percentage control, thus giving more accurate values than by using only post-treatment counts in which treated plots are compared with check plots.

It will probably be easier for the reader to grasp the importance of each test if a simple scale of control values is established. The one used in this bulletin is as follows:

	Interval under 28 days, per cent	Interval more than 28 days, per cent
Excellent (E)	93–100	90–100
Good (G)	86– 92	80– 89
Fair (F)	80– 85	70– 79
Poor (P)	Below 80	Below 70

Degrees of control based on this scale are given in Tables 2, 3, and 5 to 9, inclusive.

CALCULATION

In view of the fact that usually the population increased or decreased on untreated plots between the time pre-treatment and post-treatment counts were made, the following formula was used to calculate the percentage of control:

$$100\frac{\left(\frac{A}{B}C\right)-D}{\frac{A}{B}C} = \text{Percentage of control}$$

where A represents the post-treatment count on the check plot, B the pre-treatment count on the same check plots, C the pre-treatment count on the treated plot, and D the post-treatment count on the same $\frac{A}{B}$ is the correction factor for the pre-treatment counts on each treated plot. In other words, it shows in each instance the natural change in population between the two counts.

FIELD TESTS DURING 1944

Tests were conducted in two blocks of the Carl Titus vineyard at West Portland. The objects of the experiments were (a) to compare sprays of three nicotine materials, a thiocyanate both in the form of a wettable powder and as a liquid, and a wettable powder containing 20 per cent DDT, and (b) to determine whether the efficiency of nicotine sulfate is increased by the addition of a small amount of sticker-spreader. All plots were six rows wide and 48 vines long, thus containing about 0.4 acre.

Two series of treatments were made, the first on block A and the second on block B, each plot receiving a single application. Block A was treated when the maximum number of first brood nymphs was present, July 15. Block B was sprayed when the population consisted of 95.8 per cent second brood nymphs, August 17. It will be noted in Table 2 that the nymph population decreased on the untreated plots of both series between the pre-treatment and post-treatment counts.

The foliage was very dense at the time the sprays were applied; furthermore, the low trellis limited the thoroughness of the applications. Counts were made less than one week after treatment.

TABLE 2.—CONTROL OF GRAPE LEAFHOPPERS IN TITUS VINEYARD, 1944.

MATERIALS PER 100 GALLONS	TOXICANT AND AMOUNT, OUNCES	LEAFHOPPERS PER LEAF*		PER CENT CONTROL	DEGREE OF CONTROL†
		Pre-treatment	Post-treatment		
Block A‡					
Black Leaf 40, ½ pint	Nic., 3.2	120.0	32.8	63	P
Black Leaf 40, 1 pint	Nic., 6.4	122.8	12.0	87	G
Black Leaf 10, 2½ lbs.	Nic., 5.6	144.8	8.0	93	E
Lethane B72, 2 lbs.	B§, 4.3	117.5	17.0	81	F
Lethane A70, ½ pint	B§, 7.2	121.2	7.0	92	G
Gesarol AK20, 4 lbs.	DDT, 12.8	120.8	5.1	94	E
Untreated (check)	——	101.8	75.6	—	—
Block B¶					
Gesarol AK20, 2 lbs.; soap, 2 lbs.	DDT, 6.4	61.6	2.0	96	E
Black Leaf 155, 3 lbs.; soap, 10 ozs.	Nic., 5.9	48.8	6.5	85	F
Black Leaf 40, ½ pt.; soap, 2 lbs.	Nic., 3.2	51.0	7.6	83	F
Black Leaf 40, 1 pt.; soap, 2 lbs.	Nic., 6.4	34.6	6.1	80	F
Black Leaf 40, ½ pt.; oil, 1 qt.	Nic., 3.2	57.4	5.3	90	G
Black Leaf 40, 1 pt.; oil, 1 qt.	Nic. 6.4	36.1	1.4	96	E
Lethane B72, 2 lbs.; soap, 2 lbs.	B§ 4.3	47.6	6.0	86	G
Untreated (check)	——	49.2	43.7	—	—

*All counts made on samples of 20 leaves per plot.
†E = Excellent; G = Good; F = Fair; P = Poor.
‡Each material, except Black Leaf 10, was used in 100 gals. bordeaux mixture 2–4–100 plus soap, 2 lbs. All sprays except those of Black Leaf 10 and Gesarol AK20 contained lead arsenate, 3 lbs. Pre-treatment count, July 15; treated, July 15; and post-treatment count, July 19. Interval between treatment and counting, 4 days.
§B = Beta beta dithiocyano diethyl ether.
¶Each material, except Black Leaf 155, was used in 100 gals. bordeaux mixture 2–2–100. All sprays except those of Black Leaf 155 and Gesarol AK20 contained lead arsenate, 3 lbs. Pre-treatment count, Aug. 16; treated, Aug. 17; and post-treatment count, Aug. 22. Interval between treatment and counting, 6 days.

Materials used, dates of treatments, and results secured are given in Table 2.

FIELD TESTS DURING 1945

The vineyards of Gerald Dorman, Fredonia; Carl Titus, West Portland; and Walter Piehl, Westfield, were used for the experiments in Chautauqua County and the vineyard of Joseph M. Kujawa, West Webster, in Monroe County. In the Dorman vineyard a pre-blossom spray of DDT was applied to determine its value for the control of overwintering adults. The treated plot consisted of nine rows, each 60 vines long, and the untreated plot was four rows wide. On three sides there were vineyards which received no spray for the control of leafhoppers. The mixture used and the results are shown in Table 9 with pre-blossom treatments of following years.

The test in the Piehl vineyard consisted of 20 treated and 2 untreated plots. Each plot was 15 vines long and six rows wide. This spraying experiment was planned to test the efficiency of six concen-

trations of DDT, two nicotine materials, a wettable thiocyanate powder, and DDD (Rhothane), an analog of DDT. One half of the plots received only one application of each of the ten mixtures on July 30. The other ten plots were given two applications each which were made July 30 and August 14. On July 30, 85 per cent of the leaf hoppers present were in the nymphal stage. It is recognized that the applications were a few days late for nicotine and Lethane B72. The mixtures used, dates of counts, and control are given in detail in Table 3. The changes in leafhopper population at intervals of 14 and 57 days are shown in Fig. 7.

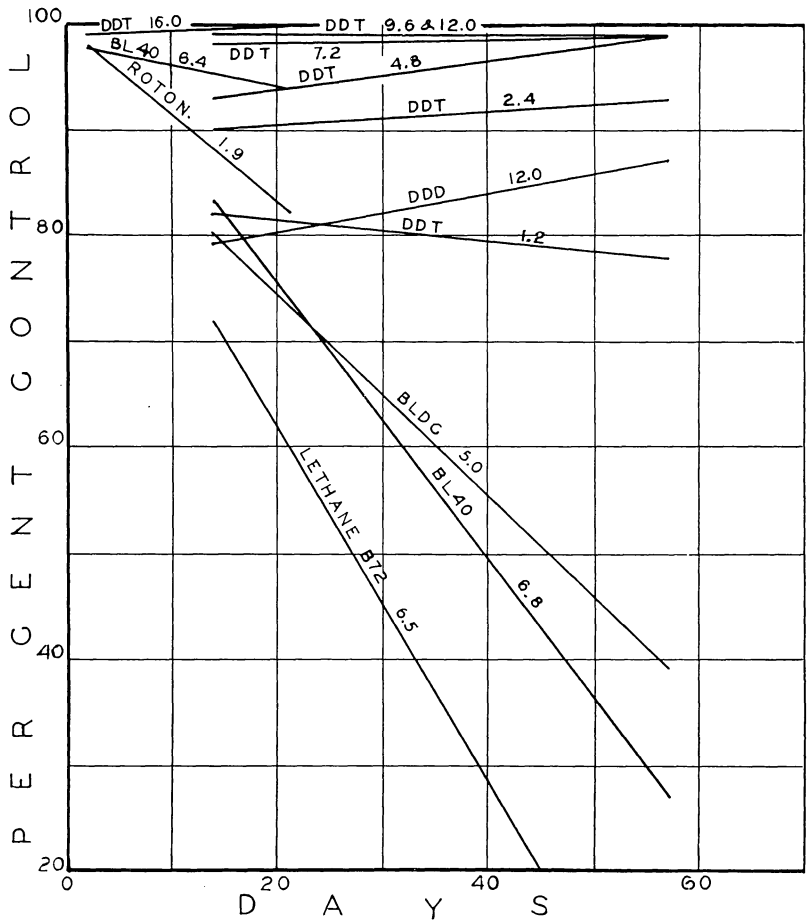


FIG. 7.—*Control of grape leafhoppers by various materials at intervals of 2 and 21 days, also 14 and 57 days after treatment. Numbers represent ounces of toxicant per 100 gallons spray mixture. Data from Tables 3 and 6.*

TABLE 3.—CONTROL OF GRAPE LEAFHOPPER IN PIEHL VINEYARD, 1945.

MATERIALS PER 100 GALLONS*	TOXICANT AND AMOUNT, OUNCES	PRE-TREATMENT, NUMBER LEAFHOPPERS PER LEAF†	POST-TREATMENT‡			END OF SEASON§					
			One application¶			One application¶			Two applications‖		
			No. leafhoppers per leaf	Per cent control	Degree of control**	No. leafhoppers per leaf	Per cent control	Degree of control**	No. leafhoppers per leaf	Per cent control	Degree of control**
Black Leaf Dry Concentrate, 2¼ lbs.	Nic., 5.0	31.7	4.0	80	F	8.3	39	P	5.0	76	F
Black Leaf 40, ¾ pt.	Nic., 4.8	36.2	3.3	83	F	9.8	27	P	4.5	78	F
Gesarol AK40, 3 ozs.	DDT, 1.2	32.1	3.8	82	F	3.0	78	F	0.7	97	E
Gesarol AL40, 6 ozs.	DDT, 2.4	2.4	2.0	90	G	0.9	93	E	0.1	99	E
Gesarol AK40, 12 ozs.	DDT, 4.8	38.7	1.6	93	E	0.2	99	E	0.0	100	E
Gesarol AK40, 18 ozs.	DDT, 7.2	39.6	0.4	98	E	0.2	99	E	0.1	99	E
Gesarol AK40, 24 ozs.	DDT, 9.6	49.0	0.2	99	E	0.1	99	E	0.0	100	E
Gesarol AK40, 30 ozs.	DDT, 12.0	57.1	0.2	99	E	0.1	99	E	0.0	100	E
Rhothane 50W, 1½ lbs.	DDD, 12.0	46.3	6.0	79	P	1.7	87	G	0.5	98	E
Lethane B72, 3 lbs.	B††, 6.5	48.2	8.4	72	P	22.6	—	P	18.0	13	P
Untreated (check)	—	44.4	28.0	—	—	13.5	—	—	20.8	—	—

*Each material was used in 100 gals. of 2–4–100 bordeaux mixture plus soap, 2 lbs.; lead arsenate, 3 lbs. added to nicotine and Lethane sprays.
†Pre-treatment counts made July 28 on samples of 25 leaves from each plot.
‡Post-treatment counts made August 13 on samples of 25 leaves from each plot, the interval being 14 days.
§Counts made September 25 on samples of 20 leaves from each plot, there being an interval of 57 days for plots receiving a single application and 42 days for those having two applications.
¶Sprayed July 30.
‖Sprayed July 30 and August 14.
**E = Excellent; G = Good; F = Fair; P = Poor.
††B = Beta beta dithiocyano diethyl ether.

In the Titus vineyard the plots received a progressive series of treatments, using DDT, 8 ounces per 100 gallons, in each application. The arrangement was similar to the one devised by Glasgow (7), the object being to determine the correct time of treatment and the least number of applications necessary for control. A diagram showing sequence of treatments on each plot and the results are given in Table 4.

TABLE 4.—RESULTS OF TIMING TESTS FOR LEAFHOPPERS IN TITUS VINEYARD, 1945.

	SEQUENCE OF APPLICATION (10-DAY INTERVALS)										
BLOCK NO.	A				B			D		E	C
PLOT NO.	1	2	3	4	5	6	7	8	9	10	Check
Applications*											
1. July 10....	X	X	X	X							
2. July 20....		X	X	X	X	X	X				
3. July 30....			X	X		X	X	X	X		
4. Aug. 9.....				X			X		X	X	
Counts Made September 13 on 20 Leaves Per Plot											
Leafhoppers:											
Total.....	2	1	1	0	4	0	3	1	0	0	488
Per leaf.....	0.1	0.05	0.05	0	0.2	0	0.15	0.05	0	0	24.4
Reduction:											
Per cent.....	99.6	99.8	99.8	100	99.2	100	99.4	99.8	100	100	—
Intervals (days)	65	55	45	35	55	45	35	45	35	35	—

*Spray mixture: Deenate 25W, 2 lbs. (DDT, 8 ozs.); soap, 1½ lbs., in 100 gallons bordeaux 2–4–100.

The leafhopper control studies made in the vineyard of Joseph M. Kujawa, West Webster, Monroe County, fall into two series. Series I was a rose chafer experiment in which the effects of DDT on leafhoppers were so striking that data were taken. There were two blocks in this series, one at the north end of the vineyard and the other at the south end. Each plot was four rows wide and 12 vines (about 84 feet) in length, thus containing nearly 0.08 acre. No pre-treatment counts were made. The treated plots were sprayed on June 22 and 28 and no effort was made to cover the undersides of the foliage. Most of the leafhoppers present on June 22 were overwintered adults. The mixtures used, dates of counts, and control are given in Table 5.

The east side of the same vineyard adjoined a planting of black raspberries several acres in extent. The grape vines near the berries were heavily infested with leafhoppers, the overwintering adults having migrated from the raspberries. The grape rows paralleled the

TABLE 5.—CONTROL OF GRAPE LEAFHOPPERS, SERIES I, KUJAWA VINEYARD, SPRAYED JUNE 22 AND 28, 1945.

MATERIALS PER 100 GALLONS*	JULY 28 COUNTS†			AUG. 16 COUNTS‡		
	Number of leafhoppers per leaf	Per cent control	Degree of control§	Number of leafhoppers per leaf	Per cent control	Degree of control§
	North Block					
Gesarol AK40 (DDT), 2½ lbs.	0.1	99	E	0	100	E
Cube root, 3 lbs. (1.9 oz. rotenone)	—	—	—	9.0	49	P
Check	4.5	—	—	17.2	—	—
	South Block					
Gesarol AK40 (DDT), 2½ lbs.	0.2	98	E	0.1	98	E
Cube root, 3 lbs. (2.4 oz. rotenone)	—	—	—	10.9	0	P
Check	12.3	—	—	5.1	—	—

*Bordeaux 4–4–100, plus B1956, 2 ounces, used with all materials.
†Interval of 30 days.
‡Interval of 49 days.
§E = Excellent; P = Poor.

raspberry rows, the distance between the west row of the berries and the first row of grapes being about 14 feet. There was a decided decrease in leafhopper population on the grape foliage as the distance from the berries increased. For this reason pre-treatment and post-treatment counts made were on leaves from rows 2, 6, 10, and 14, using 20 leaves in each sample. This area, designated as series II, had no previous spray treatments in 1945. The treated plots were four rows wide, each having an area of about 0.12 acre, and the sprays were applied July 26, using trailing hose fitted with short extension rods each having two cyclone nozzles set at an angle of 90°. The spray was directed to the undersides of the leaves. Most of the leafhoppers were in the nymphal stages. The mixtures used, dates of counts, and the data secured are given in Table 6. The changes in leafhopper population between intervals of 2 and 21 days are shown in Fig. 7. In series II the rate of increase of leafhopper population from July 26 to August 16 on the untreated vines (row 14) was used to compute the probable check values of rows 2, 6, and 10 for the latter date.

FIELD TESTS DURING 1946

Two series of field tests were made in 1946, *viz.*, (a) pre-blossom treatments and (b) sprays applied in July when the great majority of the grape leafhoppers were in the nymphal stages.

TABLE 6.—CONTROL OF GRAPE LEAFHOPPERS, SERIES II, KUJAWA VINEYARD, SPRAYED JULY 26, 1945.

MATERIALS PER 100 GALLONS*	TOXICANT AND CONCENTRATION, OUNCES	DISTANCE FROM EAST SIDE VINEYARD, ROW NUMBER	NUMBER OF LEAFHOPPERS PER LEAF		PER CENT CONTROL	DEGREE OF CONTROL§	NUMBER OF LEAFHOPPERS PER LEAF, AUG. 16‡		PER CENT CONTROL	DEGREE OF CONTROL§
			Pretreatment, July 26	Post-treatment, July 28†			Probable check value	Counts		
Gesarol AK40, 2½ lbs.	DDT 16.0	2	106.4	1.0	99	E	208	0	100	E
Cube root, 3 lbs.	Rot. 1.9	6	27.0	0.7	98	E	53	9.3	82	F
Nicotine sulfate, 1 pint	Nic. 6.4	10	24.3	0.5	98	E	47	2.6	94	E
Untreated.....	—	14	12.8	14.3	—	—	—	25.0	—	—

*Bordeaux mixture, 4–4–100, and Triton B1956, 2 ounces, were used with all materials.
†Interval from treatment to count 2 days.
‡Interval from treatment to count 21 days.
§E = Excellent; F = Fair.

Tests for control by pre-blossom treatments made in 1945 strongly indicated but did not prove that one application of DDT would control these insects for the remainder of the growing season. To secure more data on this problem, applications of bordeaux mixture with a spreader and 8 ounces of actual DDT per 100 gallons of mixture were made in a single plot in each of three vineyards at Fredonia, owned respectively by Gerald Dorman, Marion Dorman, and Harry Joy. (A wettable powder containing 50 per cent of DDT was used.) In the Joy vineyard an additional plot was sprayed with practically the same mixture except that a miscible solvent containing 30 per cent DDT was used at a rate of 7.8 ounces actual toxicant per 100 gallons. All the plots in the three vineyards were about ¾ acre in extent, each was in contact with untreated vines, and the spraying was done June 15. On this date most of the insects were overwintered adults but, of course, some eggs had been deposited. The data from these tests are given in Table 9.

The second series of tests was made in the vineyards of Walter Piehl and Harry Taylor at Westfield. In the former vineyard, the tests were practically a repetition of those of 1945 except that there were no plots which received two applications and Lethane B72 was omitted. In the Taylor vineyard four plots were sprayed, using DDT in a miscible solvent at two concentrations and DDT dissolved in benzene also at two concentrations. The applications in both vineyards were made July 19, counts being taken a day previous to applying treatment and on July 25 and on September 26, 6 and 65 days after spraying, respectively. On July 19 the population consisted of 8 per cent adults and 92 per cent nymphs. In both vineyards the sprayed plots were six rows wide, while the check plots were three rows wide. The data from the counts and the materials used are given in Table 7. Effects of the materials 6 and 65 days after treatment are shown in Fig. 8.

FIELD TESTS DURING 1947

Tests of sprays for controlling the leafhopper were conducted in the vineyards of William Bell, Westfield, and G. W. Skinner, Portland. In the latter vineyard the pre-blossom treatment of DDT was made in two blocks, each approximately ¾ of an acre. This test was a repetition of those made during the previous two seasons in other vineyards, using a single application containing 8 ounces of actual DDT with bordeaux 2–4–100 made June 25. The materials used and the date of counts are given in Table 9.

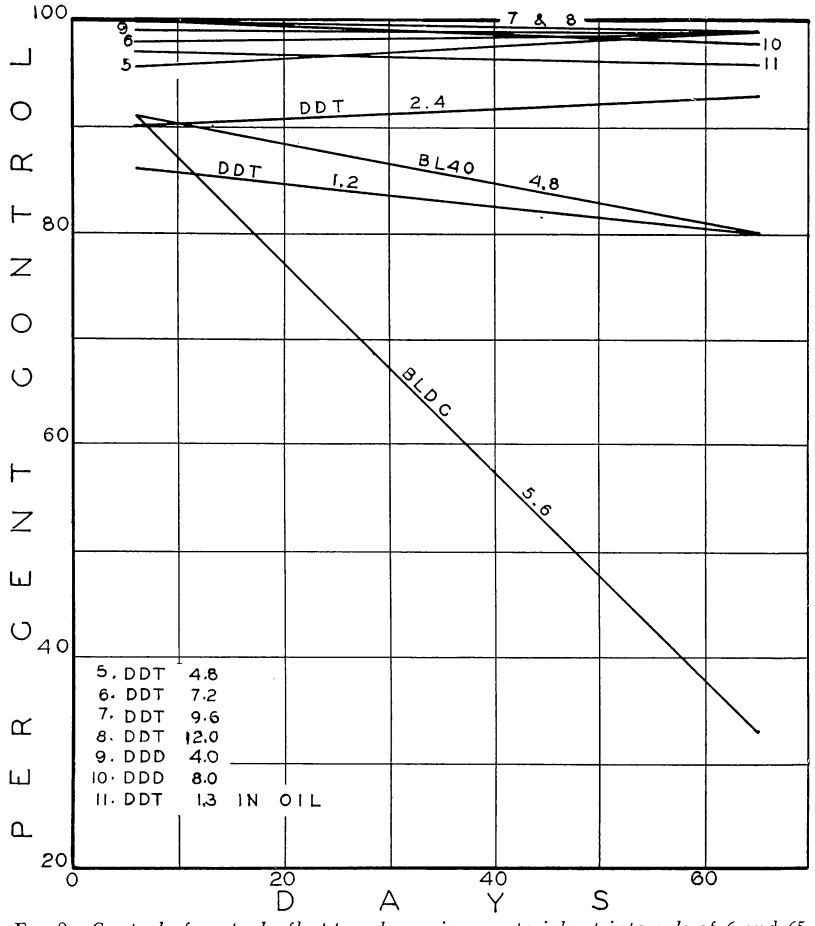


FIG. 8.—*Control of grape leafhoppers by various materials at intervals of 6 and 65 days after treatment. Numbers following materials represent ounces of toxicant per 100 gallons of spray mixture. Materials and dosages of lines Nos. 5–11 given in the lower left portion of graph. Data from Table 7.*

In the Bell vineyard the experiments on second brood nymphs included single treatments with three concentrations each of DDT and DDD, two commercially prepared emulsible solvents containing 25 per cent DDT, and two concentrations each of nicotine sulfate and parathion (Thiophos 3422). An oil spreader sticker was used in all spray mixtures except those of the miscible solvents with 25 per cent DDT and with parathion. Parathion sprays contained soap at the rate of ¾ pound per 100 gallons. All plots were 60 vines long.

TABLE 7.—CONTROL OF GRAPE LEAFHOPPERS IN PIEHL AND TAYLOR VINEYARDS, 1946.

MATERIALS PER 100 GALLONS*	TOXICANT AND AMOUNT, OUNCES	NUMBER OF LEAFHOPPERS PER LEAF		PER CENT CONTROL	DEGREE OF CONTROL§	NUMBER OF LEAFHOPPERS PER LEAF END OF SEASON¶	PER CENT CONTROL	DEGREE OF CONTROL§
		Pretreatment†	Post-treatment‡					
Piehl Vineyard								
Black Leaf Dry Concentrate, 2½ lbs.	Nic., 5.6	30.7	8.2	91	G	19.4	33	P
Black Leaf 40, ¾ pt.	Nic., 4.8	31.2	8.5	91	G	5.8	80	G
Gesarol AK50, 2.4 oz.	DDT, 1.2	29.4	12.4	86	G	5.9	80	G
Gesarol AK50, 4.8 oz.	DDT, 2.4	34.8	9.9	90	G	1.9	93	E
Gesarol AK50, 9.6 oz.	DDT, 4.8	36.6	4.5	96	E	0.2	99	E
Gesarol AK50, 14.4 oz.	DDT, 7.2	35.3	2.3	98	E	0.2	99	E
Gesarol AK50, 19.2 oz.	DDT, 9.6	33.3	0.1	99.9	E	0.3	99	E
Gesarol AK50, 24.0 oz.	DDT, 12.0	34.3	0.1	99.9	E	0.1	99	E
Rhothane 50W, 8 oz.	DDD, 4.0	36.1	1.4	99	E	0.4	99	E
Rhothane 50W, 16 oz.	DDD, 8.0	33.1	0.1	99.9	E	0.6	98	E
DDT in oil, 2 qts.	DDT, 1.3	33.4	2.8	97	E	1.2	96	E
Untreated (check)	———	29.5	85.5	—	—	28.9	—	—
Taylor Vineyard								
Liquid 30, 13.5 oz.	DDT, 4.1	19	0.13	99.6	E	0	100	E
Liquid 30, 27.0 oz.	DDT, 8.1	14.2	0.07	99.5	E	0.2	99	E
DDT in benzene, 12 oz.	DDT, 4.5	30.5	2.0	96	E	0.3	99	E
DDT in benzene, 24 oz.	DDT, 9.0	13.9	0.0	100	E	0.1	99.6	E
Untreated (check)	———	17.7	26.2	—	—	22.5	—	—

*Each material was used in 100 gallons of 2–4–100 bordeaux mixture. Soap, 2 lbs., was added except where DDT was used in a solvent. Applied on both vineyards July 19.
†Counts were made on 15 leaves per plot on July 18.
‡Counts were made July 25 on 15 leaves per plot, the interval being 6 days.
§E = Excellent; G = Good; P = Poor.
¶Counts were made Sept. 22 on 20 leaves per plot, the interval being 65 days.

TABLE 8.—CONTROL OF GRAPE LEAFHOPPERS IN BELL VINEYARD, 1947.

MATERIALS PER 100 GALLONS*	TOXICANT AND AMOUNT, OUNCES	PRETREATMENT, NUMBER OF LEAFHOPPERS PER LEAF†	POST-TREATMENT‡		
			Number of leafhoppers per leaf	Per cent control	Degree of control§
Black Leaf 40, ¾ pt	Nic., 4.8		1.9	92	G
Black Leaf 40, 1 pt	Nic., 6.4		1.3	94	E
Thiophos 3422, 1 lb.¶	P.‖, 2.4		1.3	94	E
Thiophos 3422, 2 lbs.¶	P.‖, 4.8		0.3	99	E
Untreated	—	34.8	25.1	—	
Dethyl, 1 qt.	DDT, 8		0.2	99	E
25R, 1 qt.	DDT, 8		0.1	99.6	E
Untreated	—	29.6	23.2	—	
Rhothane, ½ lb	DDD, 4		0.6	98	E
Rhothane, 1 lb	DDD, 8		0.7	98	E
Rhothane, 1½ lbs.	DDD, 12		0.1	99.9	E
Untreated	—	37.8	34.3	—	
Deenate 50W, ½ lb	DDT, 4		0.4	99	E
Deenate 50W, 1 lb	DDT, 8		0.5	99	E
Deenate 50W, 1½ lbs.	DDT, 12		0.1	99.8	E
Untreated	—	46.0	49.1	—	

*Each material except Thiophos was used in 2–4–100 bordeaux mixture to which was added an oil spreader-sticker, 3 pints, except for Dethyl and 25R. Applied July 31.

†Counts were made July 30 on samples of 10 leaves from each of the four check plots only.

‡Counts were made Aug. 7 on samples of 30 leaves from each plot, the interval being 7 days.

§E = Excellent; G = Good.

¶Tennessee Tribasic Copper Sulfate, ¾ lb. and soap 10 ounces used with Thiophos 3422 in 100 gallons of water.

‖P = parathion.

The width were six and three rows, respectively, for the treated and untreated plots, equivalent to about 0.73 and 0.36 acre each. "Pretreatment" counts were made in the four untreated check plots. At this time the population was made up of 6.5 per cent adults and 93.5 per cent nymphs. The date of application was July 31. Mixtures used and data secured are shown in Table 8.

EFFECTS OF DDT SPRAY RESIDUE ON NYMPHS

The residue from a DDT-bordeaux spray was reported by Cox (2) as being toxic for several months, during 1944, to the nymphs and adults of *E. comes* at North East, Pa. During 1945 and 1946 insectary tests were conducted at Fredonia to determine whether the residue from one mid-season application of DDT in bordeaux mixture would be toxic to leafhopper nymphs near harvest time. The procedure was to take samples of leaves from field plots about the middle of September. The leaves selected usually were those that developed at either the fourth or fifth node of each shoot and showed a covering of spray residue on the undersides. Replicate samples of

TABLE 9.—CONTROL OF GRAPE LEAFHOPPERS WITH A PRE-BLOSSOM TREATMENT OF DDT, 1945–47.

MATERIALS PER 100 GALLONS*	DDT, OUNCES	POST-TREATMENT, NUMBER OF LEAFHOPPERS PER LEAF	CONTROL		VINEYARD OWNER	ADDITIONAL INFORMATION
			Per cent	Degree†		
			1945			
Deenate 25W, 2 lbs....	8	3.3	72	F	G. Dorman	Treated June 10; counts on 20 leaves per plot Sept. 12; interval 94 days
Untreated.....	–	11.9				
			1946			
Deenate 50W, 1 lb.....	8	0.7	98	E	G. Dorman	Treated June 15; counts on 15 leaves per plot Sept. 23; interval 100 days
Untreated.....	–	23.4				
Deenate 50W, 1 lb.....	8	1.2	88	G	M. Dorman	
Untreated.....	–	10.2				
Deenate 50W, 1 lb	8	0.4	97	E	H. Joy	
Untreated.....	–	13.7				
Liquid 30 DDT, 26 oz.	7.8	1.9	89	G	H. Joy	
Untreated.....	–	18.0				
			1947			
Deenate 50W, ½ lb....	4	0.8	98	E	W. G. Skinner	Treated June 23; counts on 16 leaves per plot Aug. 29; interval 67 days
Untreated.....	–	38.5				
Deenate 50W, ½ lb.....	4	0.1	99.7	E	W. G. Skinner	
Untreated.....	–	33.5				

*Each material was used in 100 gallons of 2–4–100 bordeaux mixture. Soap, 1½ lbs. per 100 gallons in 1945 and 1946; in 1947 1 qt. oil spreader-sticker. Soap or spreader-sticker omitted when using a miscible solvent containing DDT.

†E = Excellent; G = Good; F = Fair.

three leaves each were taken from treated and untreated plots. The leaf stalk or petiole was cut near the shoot. Immediately after the sample was taken, the petiole of each leaf was placed in a 250-cc Erlenmeyer flask filled with water. A wad of cotton was used to stopper the mouth of the flask and to hold the leaves firmly in place.

Immature leafhoppers, second, third, and fourth instar nymphs, were transferred to the upper surface of the leaves by a camel's hair brush but the brush was not allowed to contact the leaf surface. The nymphs moved to the undersides of the leaves. At least 65 leafhoppers were used in each of the replicated samples. After the transferring was completed each flask with the leaves was placed on a sheet of white paper and enclosed by a large lantern globe which was covered with a piece of unbleached muslin, held in place by a rubber band. These experiments were conducted in an open-air insectary.

During 1945 tests were made on samples of leaves taken from two experimental vineyards. In one vineyard there were five treated plots. Each plot received only one application of a spray mixture containing 1 pound of actual DDT and 1 quart of spreader-sticker. The first plot was treated on July 19 and the last one on August 29. The interval between treating and date when nymphs were added varied from 11 to 52 days. The data regarding kill of the nymphs are shown in Table 10 and Fig. 9.

In the other vineyard the samples were taken from six plots. These were treated on July 30 with various concentrations of DDT in a 2–4–100 bordeaux mixture containing soap. The tests were made 41 days after the sprays were applied (Table 11).

Tests comparing the toxicity of residues from treatments with various concentrations of DDT were repeated in 1946. There was an interval of 57 days between the time of treating and the time leaf samples were collected. The results with leaves from this vineyard during 1945 and 1946 are given in Table 11 and the toxicity to the nymphs in all tests is shown in Fig. 10.

The residue from a spray containing 1 pound of DDT per 100 gallons was toxic to the grape leafhopper nymphs 52 days after the treatment was made (Table 10). All nymphs were dead in the five tests within 48 hours after being placed on the treated foliage. The results of tests made on foliage treated with various concentrations of DDT are presented in Table 11. In 1945 the tests were started 41 days after the spray was applied. The deposit from a treatment with

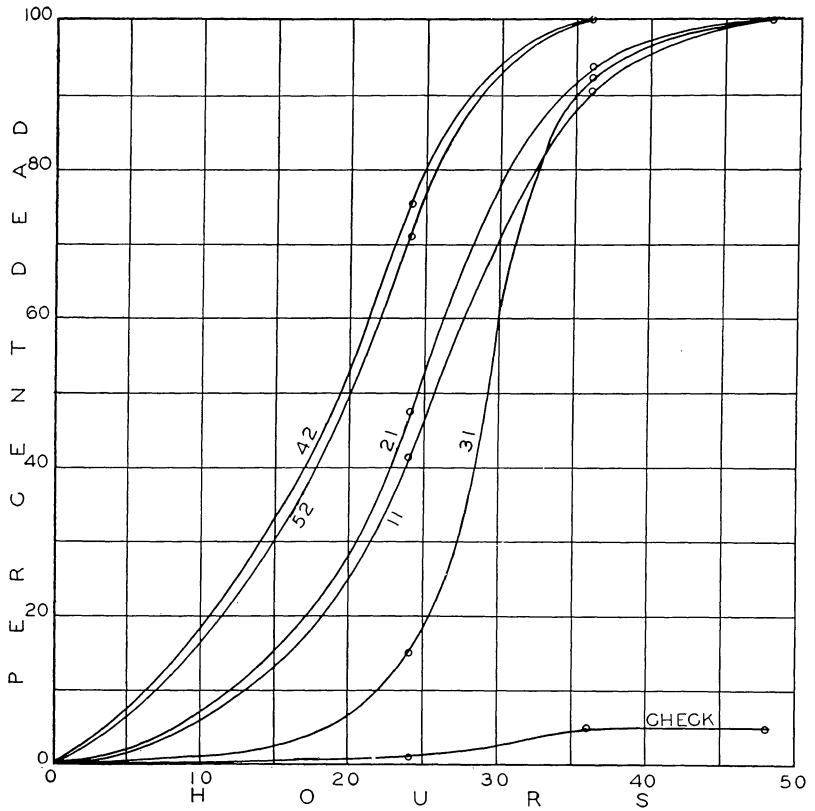


FIG. 9.—*Rate of kill of grape leafhopper nymphs by DDT residue at intervals of 11 to 52 days after treatment. Numbers on curves represent intervals (days) after treatment that nymphs were placed on leaves. See page 28 and Table 10 for details.*

TABLE 10.—EFFECTS OF DDT RESIDUES ON GRAPE LEAFHOPPER NYMPHS, 1945.

DATE OF TREATMENT*	DAYS AFTER APPLYING TREATMENT†	NUMBER OF NYMPHS TRANSFERRED	NUMBER OF DEAD NYMPHS PER			NUMBER OF LIVE NYMPHS REMAINING AFTER 48 HOURS
			24 hours	36 hours	48 hours	
Aug. 29	11	74	31	67	74	0
Aug. 19	21	65	31	61	65	0
Aug. 9	31	66	10	61	66	0
July 29	42	69	52	69	—	0
July 19	52	76	54	76	—	0
Check	—	101	1	5	5	96

*A single application was made on unsprayed leaves at each date. Spray mixture contained Gesarol A40, 2½ lbs. (DDT, 1 lb.) and oil spreader-sticker, 1 qt.

†Nymphs transferred to treated and untreated leaves Sept. 9.

4.8 ounces or more of DDT killed all nymphs within 72 hours. It should be noted that in 1946 the interval between time of treating and the time of taking samples was 57 days. The only treatment giving a complete kill in 96 hours was one containing 12 ounces of DDT per 100 gallons.

RESULTS OF SPRAYING TESTS

The six insecticides used for the control of the grape leafhopper from 1944 to 1947, inclusive, were nicotine, rotenone, thiocyanate, DDT, DDD, and parathion. In the discussion which follows, to avoid repetition, all quantities given refer to the amount in 100 gallons of spray mixture.

NICOTINE

Various nicotine products were used during one or more of the four years. They consisted of Black Leaf 40, Black Leaf 10, Black Leaf 155, and Black Leaf Dry Concentrate. Of these preparations, Black Leaf 40 has long been the standard insecticide for grape leafhopper control and was used in these field trials to serve as a comparison with other materials. It was applied at the rate of 1 pint in bordeaux mixture 2–4–100, using either soap, 2 pounds, B1946, 2 ounces, or a miscible oil, 1 quart, as the spreader in 1944, 1945, and 1947. With soap the results were fair to good at intervals of 4 to 6 days (Table 2), excellent with B1956 at intervals of 2 and 21 days (Table 6), and with oil excellent at intervals of 6 and 7 days (Tables 2 and 8). (See page 15 for the range in percentage used for excellent, good, fair, and poor.)

At the rate of ¾ pint in bordeaux mixture 2–4–100, Black Leaf 40 was used from 1945 to 1947, inclusive. With the addition of soap a single treatment at a 6-day interval gave good results (Table 7) but only fair at a 14-day interval and also fair control after an interval of 57 days (Table 3) and good results after 65 days (Table 7). Two applications of the same mixture gave fair control at an interval of 42 days (Table 3).

Black Leaf 40, ½ pint, in bordeaux mixture with soap, in 1944, gave poor to fair control at 4- and 6-day intervals, but with oil instead of soap the control was good at an interval of 6 days (Table 2).

These results show that the control with Black Leaf 40, 1 pint, shortly after treatment may be excellent and may continue excellent for 21 days and that with ¾ pint the control may be fair to excellent at intervals of 14, 6, and 7 days, respectively. Two applications of the same mixture after 57 days was fair. The control may

TABLE 11.—EFFECT OF THE RESIDUE FROM VARIOUS CONCENTRATIONS ON GRAPE LEAFHOPPER NYMPHS, 1945 AND 1946.

MATERIALS PER 100 GALLONS*	AMOUNT OF ACTUAL TOXICANT, OUNCES	NUMBER OF NYMPHS TRANSFERRED	NUMBER OF NYMPHS DEAD AFTER				NUMBER OF NYMPHS ALIVE AFTER		PER CENT CONTROL
			24 hours	48 hours	72 hours	96 hours	72 hours	96 hours	
				1945†					
40% DDT, 3 oz.....	1.2	73	7	11	33	—	40	—	35
40% DDT, 6 oz.....	2.4	77	19	47	71	—	6	—	91
40% DDT, 12 oz.....	4.8	67	42	62	67	—	0	—	100
40% DDT, 18 oz.....	7.2	80	75	80	80	—	0	—	100
40% DDT, 24 oz.....	9.6	81	58	72	81	—	0	—	100
40% DDT, 30 oz.....	12.0	86	69	79	86	—	0	—	100
Check	—	112	11	13	17	—	95	—	—
				1946‡					
50% DDT, 2.4 oz....	1.2	75	—	2	—	2	—	73	3
50% DDT, 4.8 oz....	2.4	93	—	9	—	37	—	56	40
50% DDT, 9.6 oz....	4.8	82	—	27	—	58	—	24	71
50% DDT, 14.4 oz...	7.2	71	—	33	—	67	—	4	94
50% DDT, 19.2 oz...	9.6	66	—	36	—	60	—	6	91
50% DDT, 24 oz.....	12.0	87	—	66	—	87	—	0	100
Check.....	—	84	—	0	—	1	—	83	—

*Soap, 2 lbs., added to all sprays.
†Materials applied July 30. Nymphs transferred to treated and untreated leaves Sept. 9, 41 days after spraying.
‡Materials applied July 19. Nymphs transferred to treated and untreated leaves Sept. 14, 57 days after spraying.

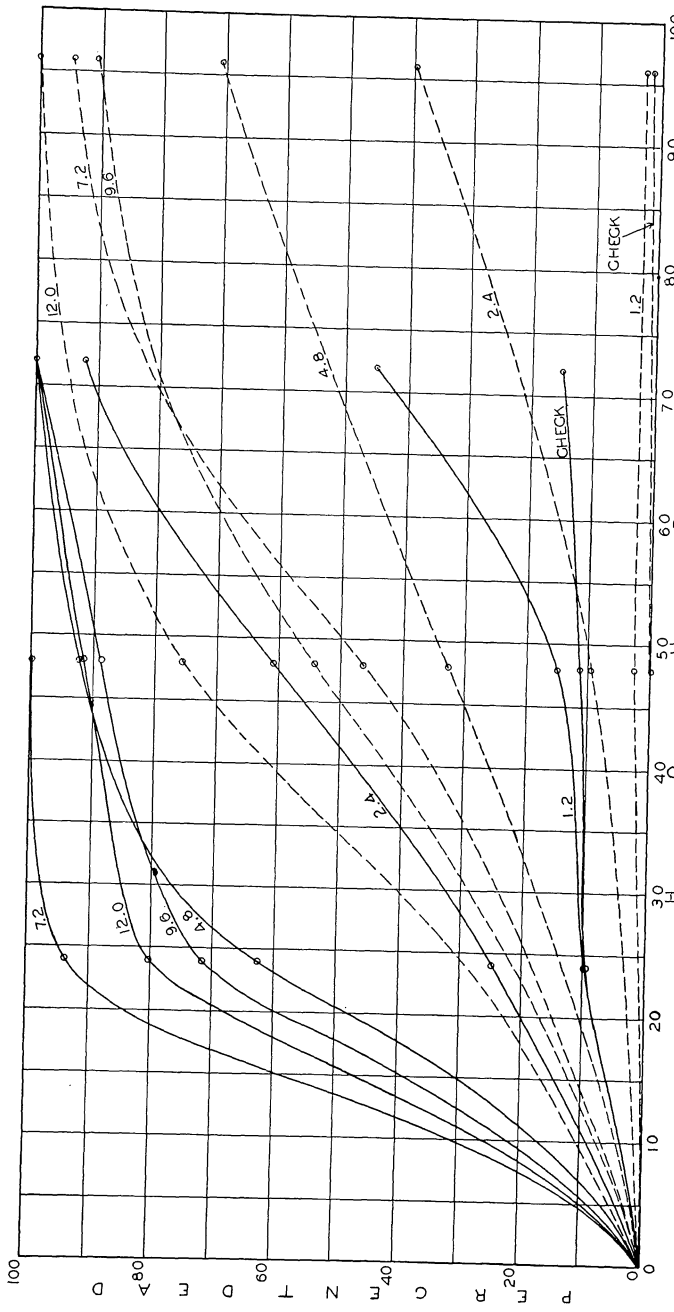


FIG. 10.—*Toxicity of DDT residues to grape leafhopper nymphs. Numbers on curves represent ounces of actual DDT per 100 gallons of water. Solid lines are for 1945 tests started after an interval of 41 days. Broken lines are for 1946 tests started after an interval of 57 days. See pages 28 to 30 and Table 11 for details.*

be poor to good after 1½ to 2 months. Other preparations used at the same nicotine content gave control comparable to that of Black Leaf 40 (Tables 3 and 7).

One important feature should be emphasized, *viz.*, grapes properly sprayed with nicotine, one application at the correct time, usually are not seriously injured by the reinfestation that occurs, since this usually comes late in the season. While it is true that nicotine is not effective against the adults, it does not introduce a residue problem even if applied shortly before the fruit is to be harvested.

ROTENONE

In the form of pulverized cube root, 3 pounds, rotenone was used only in 1945. It gave poor results against the adults (Table 5), but against nymphs it gave excellent control at an interval of 2 days. By 21 days after treatment, however, the results were fair (Table 6). Thus this material, like nicotine, does not remain effective as long as DDT.

THIOCYANATE

The active ingredient of Lethane A70 and Lethane B72 is beta beta dithiocyanodiethyl ether. The former preparation, ½ pint (7.2 ounces of the toxicant), with soap in bordeaux mixture gave good control at an interval of 4 days (Table 3). Lethane B72, 2 pounds (4.3 ounces of the toxicant), in bordeaux mixture gave fair to good control in two blocks at intervals of 4 and 6 days in 1944 (Table 2) but resulted in poor control at an interval of 14 days in 1945 even when used at the rate of 3 pounds which contained 6.5 ounces of the toxicant (Table 3).

DDT

This new insecticide, which was first released for experimental agricultural use about 1944, appeared in a number of forms by 1946. Thus there were wettable powders and DDT dissolved in various solvents, usually miscible in water, several of which were tested against grape leafhoppers as discussed previously under descriptions of experiments.

Due to the number of formulations and to the fact that some treatments were made before bloom and some after blossoming, the reader will doubtless get a clearer idea of the tests if the standard experiment is regarded as consisting of DDT in the form of a wettable powder applied after bloom when most of the leafhoppers were

in nymphal stages. Having first discussed the variations in the standard test, attention can then be directed to comparisons of formulations and to pre-bloom tests on adults with discussion of other important results.

One of the main problems was to determine the minimum concentration necessary for practical control of the nymphs. Owing to the small amount of material available in 1944, only two concentrations were tested, 6.4 and 12.8 ounces of DDT (all amounts are given as actual DDT), both producing excellent results at 6- and 4-day intervals, respectively (Table 2). Counts at longer intervals were not made, but it was noted that the sprayed vines remained practically free from leafhoppers for the remainder of the season in both tests.

With more material available, an extensive series of concentrations was tested in 1945 (Table 3) and was repeated in 1946 (Table 7). Neglecting for the present the two-application blocks of 1945, the series consisted of one application each with the following concentrations of DDT: 1.2, 2.4, 4.8, 7.2, 9.6, and 12.0 ounces during both years when most of the leafhoppers were first brood nymphs. In 1945 the counts were made at intervals of 14 and 57 days, while for 1946 the intervals were 6 and 65 days. It will be noted that 2.4 ounces of DDT was the lowest concentration which gave a reduction of 90 per cent or better in counts at all the intervals; while to secure excellent control at all intervals, a minimum of 4.8 ounces of DDT was necessary. In the block where two treatments per plot were given the count was made at an interval of 42 days and here 1.2 ounces per application, or a total of 2.4 ounces, were needed to give excellent control (Table 3). During 1946, 4.1 ounces of DDT in oil, benzene, or other solvent gave excellent control at both 6 and 65 day intervals (Table 7).

Pre-blossom sprays of DDT were applied from 1945 and 1947, inclusive, for the control of the overwintered adults, using 8 ounces of DDT in all except the Kujawa and Skinner vineyards (Tables 5 and 9). In the Dorman vineyard at Fredonia, in 1945, the treatment was made June 10, but the application was not made until June 22 in the Kujawa vineyard at West Webster. The latter grapes were near the shore of Lake Ontario and did not bloom before June 28. Here, also, 16 ounces of DDT per treatment and a second application were given since this was a rose chafer experiment and heavy, driving rains washed off most of the first treatments. The end-of-season counts indicated fair control in the Dorman vineyard at an interval of 94

days. The treatment, however, kept the population low until late in the summer, so the economic loss from the leafhoppers was very small. The plot was bordered on two sides by unsprayed grapes which were heavily infested (Table 9). In the Kujawa vineyard the control was excellent at intervals of 30 and 49 days (Table 5). Observations at harvest time showed the vines practically free from leafhoppers. The entire vineyard, however, except the experimental blocks, was sprayed by the owner for rose chafer; furthermore, the original leafhopper infestation was very light.

The pre-bloom treatments for overwintered leafhoppers, one application each, in the four Fredonia vineyards during 1946 were all made on June 15 and counts were made at an interval of 100 days. The control was good in two and excellent in two vineyards, but the infestation was light (Table 9). In 1947, two plots in the Skinner vineyard at Portland were given the pre-blossom spray June 23, using 1.6 and 4 ounces of DDT. At an interval of 67 days, the control was excellent in both blocks, but here again the infestation was light (Table 9).

The results secured with DDT corroborate those of Cox (2, 3) in Erie County, Pennsylvania, with *E. comes*. Also, during the same period these tests were being made, Jones, Glover, and Hansberry (15) and Frazier and Stafford (6) secured similar results in California in the control of *E. elegantula,* so there is considerable confirming evidence that the results secured on *E. comes* in the East are valid.

The reader should remember that when the pre-blossom treatments were given, most of the leafhoppers were overwintered adults. Thus DDT was the first insecticide found that controlled both adults and nymphs. This fact should be of great importance to the grape grower. First, it enables him to control the adults during June. Some years the injury by these adults is very severe, causing stunting of the vines. The buds for the following year's grape crop are formed in July, so healthy vines are needed to insure strong buds. Second, by being able to control these insects by means of pre-bloom sprays, the DDT residue problem is avoided, at least so far as leafhoppers are concerned. Third, no attention need be paid to the timing of the application as proved by the results of the pre-blossom treatments and the timing test (Tables 4 and 9).

It was found in cage experiments that sufficient DDT remains on the foliage to kill the nymphs at least 52 and 57 days after treatment (Tables 10 and 11). No visible foliage injury to grapes was caused by any of the mixtures used.

DDD

A new insecticide popularly known as DDD, having the brand name Rhothane, was used on grapes from 1945 to 1947, inclusive. One application, using 12 ounces of DDD in 2–4–100 bordeaux with soap gave poor control in 1945 at an interval of 14 days and progressed to good results at an interval of 57 days. Two applications of the same mixture in the same vineyard showed excellent control at an interval of 42 days (Table 3). In 1946, DDD at 4 and 8 ounces in bordeaux mixture with soap gave excellent control at intervals of 6 and 65 days (Table 7). Then, in 1947, at 4, 8, and 12 ounces, DDD in bordeaux mixture with an oil spreader gave excellent control in each treatment at an interval of 7 days (Table 8).

Thus, apparently another excellent insecticide for grape leafhopper is available. Unfortunately, no pre-blossom tests of this material were made. Visible injury to grape foliage was lacking in all the tests.

PARATHION

Another new insecticide, parathion, was made available for experimental purposes several years ago and was tested against the grape leafhopper in 1947. The brand used was Thiophos 3422 which contained 15 per cent parathion. It was applied with tribasic copper sulfate, ¾ pound, and soap, 10 ounces, the parathion content being 2.4 and 4.8 ounces. Excellent control of the nymphs was secured with both dilutions at an interval of 7 days, the respective control being 94 and 99 per cent (Table 8). Unfortunately for the tests, the leafhopper infestation was rather light during 1947 and the population was so low in 1948 that no further tests were made. Considerable testing needs to be done to determine the following information regarding parathion: effects on adults, permanency of control, residue on harvested fruit, and effects on foliage under various weather conditions. The sprays used in 1947 caused no visible foliage injury.

SUGGESTIONS FOR CONTROL

The choice of insecticide for controlling grape leafhoppers will depend upon the time of application. If the spraying can be done with DDT before the grapes bloom, most of the early leaf injury by the hibernated adults will be prevented and the residue problem will be avoided. The experiments have proved that a single application, using 8 ounces of actual DDT in 100 gallons of 2–4–100 bor-

deaux mixture and a spreader, will give adequate control for the remainder of the season. The spreader may be either potash rosin fish-oil soap, 2 pounds, or 3 pints of an oil spreader (Sovaspray Oil No. 3, 9 parts, with B1956, 1 part). The question of the amount of DDT residue that will be legal has not been decided, so late July applications of DDT cannot be advised. Vines sprayed shortly after the fruit has set probably would not have sufficient residue on the fruit at harvest to be objectionable. The field tests indicate that DDD is about equal to DDT in effectiveness on leafhoppers.

If it is desired to control leafhoppers after early July, nicotine sulfate, 1 pint, in 100 gallons of bordeaux mixture containing a spreader should be used, since this insecticide does not introduce a residue problem.

In spite of the fact that DDT, DDD, and nicotine sulfate are very toxic to the leafhoppers, success in control depends on the thoroughness with which the spray is applied. The undersides of the foliage must be covered. This is accomplished by setting the nozzles at proper angles to direct the spray to the undersides of the leaves. A hooded spray boom, by reducing the effect of the wind, makes the application more thorough. A pressure of about 400 pounds at the pressure chamber is satisfactory. From 175 to 225 gallons per acre are needed, depending on the amount of vine growth.

SUMMARY

Grape leafhoppers belonging to the species *Erythroneura comes* Say, including subspecies, are important pests of grapes in New York during periods of abundance. The relative abundance has been known for the Chautauqua-Erie grape belt since 1900. Peaks of greatest populations occurred in 1902, 1911, and 1922, with a possible peak in 1945. The outbreak occurring from 1938 to 1947 was the longest on record for this area, but the population during any year did not equal that of the peak years 1911 and 1922.

Concord seems to be able to tolerate a rather heavy infestation without the quality of the fruit being affected; but when foliage injury is very severe, as occurs during peak periods, the soluble solids content of the freshly pressed juice is reduced considerably. This soluble solids content is the most common index of sugar and flavor used for evaluating ripeness of grapes.

The seasonal history of the species is reviewed and the relation of

surroundings to vineyard infestation is stressed. The various insecticides used before 1944 are reviewed. The main part of the bulletin consists of discussions of field experiments, from 1944 to 1947, inclusive, aimed at the control of grape leafhoppers. Most of the tests were made in Chautauqua County, but during 1945 a few plots were located in Monroe County.

The following insecticides were compared: nicotine, rotenone, thiocyanate, DDT, DDD, and parathion, all but the latter being used in 2–4–100 bordeaux mixture with a spreader. Parathion was used with tri-basic copper and soap, 10 ounces. All amounts given are for 100 gallons of liquid.

One application of nicotine sulfate, 1 pint, gave excellent control of nymphs for a period of 21 days and at ¾ pint kept the population low for 14 days. The other nicotine materials, Black Leaf Dry Concentrate, Black Leaf 10, and Black Leaf 155, when used at comparable nicotine concentrations, gave control similar to nicotine sulfate. One disadvantage which nicotine suffers in comparison with DDT is its ineffectiveness on the adults, so it is not practical for controlling the overwintered adults in June. Nicotine has one advantage over all the well-known contact insecticides and most of the newer compounds in that it does not leave an objectionable residue even when applied late in August, so it is the only insecticide that is at present suggested for leafhopper control after early July. One application for the first brood nymphs, if properly timed and correctly applied, usually gives adequate control for the remainder of the summer.

Rotenone did not control adults but on the nymphs gave results similar to nicotine. It should not be applied late in the season because it may leave an objectionable residue at harvest.

A thiocyanate, Lethane A70, gave good control of nymphs when used at the rate of 7.2 ounces of toxicant. Lethane B72, at rates of 4.3 and 6.5 ounces of toxicant, gave variable results on the nymphs.

DDT was found to be very effective against the nymphs and the adults at concentrations as low as 4.8 ounces when applied in July when the majority of the insects were nymphs. One application kept the vines free from the leafhoppers for the remainder of the season. Concentrations as low as 2.4 ounces killed the nymphs but did not have quite the lasting effects as did 4.8 ounces. The use of 8 ounces as a pre-bloom spray in June killed the hibernated adults and protected the vines throughout the summer. Counts made as long as 100 days after treatment showed good to excellent results in most in-

stances. With a light infestation in 1947, single applications of pre-blossom sprays at the rate of 4 ounces per 100 gallons, gave excellent control at an interval of 67 days. In other tests it was found that the residue from sprays containing as low as 4.8 ounces of DDT killed all the nymphs transferred to the leaves 41 days after treatment. In 1946 a similar set of tests revealed that 12 ounces of DDT killed all the nymphs transferred to the leaves 57 days after treatments.

One of the chief advantages of DDT is its effectiveness against overwintered adults in June, thus preventing early foliage injury and avoiding a residue problem for the harvested fruit. Another advantage of this material is that no attention need be paid to timing the applications as regards the stages of the leafhoppers.

The tests with DDD indicate that this insecticide at the same concentrations acts practically like DDT on nymphs and adults. Unfortunately, no pre-blossom tests were made.

Parathion showed great promise during the short time it was tested. Applied at the rate of 2.4 and 4.8 ounces with tri-basic copper and soap, it gave excellent control of nymphs. More experiments are needed to prove its value thoroughly. The light infestation during 1948 prevented thorough testing of this material.

It should be noted that none of the materials caused foliage injury and that all were used with fungicides.

LITERATURE CITED

1 Caldwell, J. S. Some effects of seasonal conditions upon the chemical composition of American grape juices. *Jour. Agr. Res.*, **30:** *1133–1176. 1925.*

2 Cox, J. A. DDT for the control of grape leafhoppers. *Jour. Econ. Ent.*, **38:** *278–279. 1945.*

3 ————————. Control of the grape leafhopper. *Jour. Econ. Ent.*, **40:** *195–198. 1947.*

4 DeLong, D. M. The boom nozzle system and the traction duster as factors in grape leafhopper control. *Jour. Econ. Ent.*, **15:** *87–90. 1922.*

5 Eyer, J. R. The relation of temperature and rainfall to outbreaks of the grape leafhopper, *Erythroneura comes* Say. *Ann. Ent. Soc. Amer.*, **24:** *238–259. 1931.*

6 Frazier, N. W., and Stafford, E. M. Control of the leafhopper, *Erythroneura elegantula,* on grape with DDT and other insecticides. *Jour. Econ. Ent.*, **40:** *487–495. 1947.*

7 Glasgow, Hugh. A plot arrangement for timing the applications in a control program. *Jour. Econ. Ent.*, **33,** *357–361. 1940.*

8 Gleissner, B. D. Biology and control of berry moth in the Erie grape belt with notes on other grape insects. *Pennsylvania Agr. Exp. Sta. Bul. No. 451. 1943.*

9 Hartzell, F. Z. A preliminary report on grape insects. *New York Agr. Exp. Sta. Bul. No. 331. 1910.*

10 ————————. The grape leafhopper and its control. *New York Agr. Exp. Sta. Bul. No. 344. 1912.*

11 ————————. The grape leafhopper. *New York Agr. Exp. Sta. Bul. No. 359. 1913.*

12. ———————— and Horsfall, J. L. A method for evaluating treatments for grape leafhopper and for analysing the heterogeneity of the infestation. *Jour. Econ. Ent.,* **37:** *219–224. 1944.*

13. Johnson, Fred. Spraying experiments against the grape leafhopper in Lake Erie Valley. *United States Dept. Agr. Bur. Ent. Bul. No. 97, Pt. 1. 1911.*

14 ————————. Spraying experiments against the grape leafhopper in the Lake Erie Valley in 1911. *United States Dept. Agr. Bur. Ent. Bul. No. 116, Pt. 1. 1912.*

15 Jones, P. R., Glover, L. C., and Hansberry, Roy. An oil-DDT vapor spray to control grape leafhopper. *Jour. Econ. Ent.,* **39:** *770–774. 1946.*

16 Kertesz, Z. I. The chemical composition of maturing New York State grapes. *New York State Agr. Exp. Sta. Tech. Bul. No. 274. 1944.*

17 Robinson, W. B., Avens, A. W., and Kertesz, Z. I. The chemical composition of ripe Concord-type grapes grown in New York in 1947. *New York State Agr. Exp. Sta. Tech. Bul. No. 285. 1949.*

18 Slingerland, M. V. The grape leafhopper. *Cornell University Agr. Exp. Sta. Bul. No. 215. 1904.*

19 Taschenberg, E. F. Hooded booms for grape spraying. *New York State Agr. Exp. Sta. Bul. No. 732. 1948.*

20 VanDine, D. L. The effect of leafhopper injury on the sugar content of grapes. *Jour. Econ. Ent.,* ***16:*** *353–357. 1923.*