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THE GRAPE LEAF-HOPPER

F. Z. HARTZELL.

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THE GRAPE LEAF-HOPPER.

F. Z. HARTZELL.

SUMMARY.

This bulletin deals with studies on the hibernating habits and spring food-plants of the grape leaf-hopper and with experiments to establish efficient spraying practices.

Large numbers of adults survived the winter of 1911–12 and threatened many vineyards, but weather conditions during the summer were unfavorable for the nymphs, causing a decrease of the insects during the late summer and autumn of 1912.

The most favorable hibernating places for the leaf-hopper are fence rows, woods, brush and waste land, weeds or situations where leaves accumulate by the wind. Grass which has lodged also affords winter shelter to the insects. The drier, well-drained soils are more conducive to the safe wintering of the adults than the heavier soils.

Green cover crops do not afford suitable hibernating places for the grape leaf-hopper during severe winters.

The foliage of raspberry, strawberry, blackberry, currant, gooseberry, catnip, Virginia creeper, burdock, beech and sugar maple is eaten by the grape leaf-hopper before it migrates to the foliage of the grape. Strawberry and raspberry are the preferred spring food plants. The insects migrate from the strawberry to the raspberry during early May and from the raspberry to the grape during the latter part of May.

Mating of the hibernated adults takes place on the spring food plants.

The foliage of the grape is injured by the overwintering adults, but most of the feeding is restricted to the lower leaves, especially those on the young shoots or suckers at the base of
the vine. The amount of injury to vineyards varies directly with
their proximity to favorable hibernating places and spring food
plants.

Spraying experiments during 1912 showed, (1) that Black
Leaf 40, one part to 1600 parts of water or bordeaux mixture, is
an efficient spray for the leaf-hopper. (2) The automatic attach-
ment is a practical machine in the hands of careful sprayers.
(3) The fruit from vines protected from the leaf-hopper is
superior to fruit from vines subjected to the attacks of this pest.
Chemical analyses of grapes from sprayed vines gave a gain of
from 8 to 68 per ct. in sugar over those from untreated vines,
while the unsprayed grapes had from 0 to 20.6 per ct. more
acid than sprayed grapes.

The destruction of hibernating places of the grape leaf-hopper
is recommended as a method of control, especially to save the
young foliage of the grape in the spring.

When hibernating adults are on the young foliage, delaying
the removal of the young shoots at the base of the vine will
tend to keep the insects on the lower leaves and thus afford some
protection to the more permanent foliage. The lower shoots
should be removed just previous to spraying.

INTRODUCTION.

Experiments to develop efficient spraying practices to control
the grape leaf-hopper have been conducted for three seasons and a
part of the results of this work have been published.* During
the past year additional facts have been gathered which have to do
largely with the hibernating and early spring habits of this insect.
These studies have emphasized the importance of certain control
measures which are designed principally to protect the young
foliage of the grape during the latter part of May and June when
it is impracticable to attempt to combat the pest by spraying.
Moreover the increasing use of cover crops, due to the recommend-
dations of the Horticultural Department, has prompted some

studies to ascertain if the plants are attractive to the insects for purposes of hibernation and the effects, if any, of cover crops in promoting attacks on the vines early in the spring. Chemical analyses of grapes have shown the effects of injured foliage, due to the work of this pest, on the quality of the fruit. These phases of the problem are of much importance at this time owing to the abundance of the leaf-hoppers for the past two years and the danger that exists of these insects appearing in destructive numbers in certain of the grape-growing sections. This bulletin is designed to place before the grape-growers of the State the facts recently acquired and recommendations based on them.

CONDITIONS WITH RESPECT TO LEAF-HOPPER DURING 1912.

This insect was very abundant during the latter part of the summer of 1911 and it is estimated that in Chautauqua county alone at least one-fourth of the vineyards, representing approximately ten thousand acres, showed extensive feeding on the foliage by this species. The conditions with respect to this pest in other grape regions of the State were similar. The winter of 1911–12 proved to be severe and hopes were entertained that this would cause a high mortality among the hibernating adults. However, with the arrival of spring the leaf-hoppers emerged from their winter quarters in great numbers and seriously injured the young foliage in many vineyards. This invasion of the vines caused considerable apprehension among growers and led to more extensive spraying to combat the insect than has heretofore been practised in this region.

Considering the summer as a whole considerable injury was done to vineyards; yet the damage was less than was expected because of the cool weather during June, July, August and September. The weather conditions during this period were unusual as will be noted from the accompanying record.* The temperature for June was 106 degrees below normal — a daily deficiency of 3.5 degrees; July was slightly below normal; August gave a deficiency

*From the Monthly Meteorological Summary for 1912 of the U. S. Weather Bureau, for Buffalo, N. Y., which is forty-five miles distant from Fredonia.
of 125 degrees — a daily average of 4 degrees; September temperatures were 59 degrees above normal — a daily excess of 1.7 degrees. In the months when growth is most active — May to September — there was a deficiency of 148 degrees — 1 degree daily.

The amount of precipitation for May, August and September was above the normal while June and July were deficient in rainfall. From the middle of July until the end of September there was an excess of rainfall and cloudy weather combined with the low temperatures. There were only four clear days between July 15th and 31st and August had only one clear day, the others being cloudy or partly cloudy. The percentage of sunshine during August was 42 — 23 per ct. below normal — while the rainfall was 4 inches or 1.01 inches above normal, 40 per ct. more than in a normal year. September had 11 clear days, 53 per ct. of sunshine, 8 per ct. departure from normal, and an excess rainfall of 0.13 inch or 4 per ct. above the average. These abnormal weather conditions were unfavorable to plant growth, and appeared to be especially detrimental to the grape leaf-hopper since it prevented a second summer brood and apparently interfered with the health of the nymphs as well as the adults. This has resulted in a greatly decreased number of hoppers going into winter quarters during the fall of 1912 compared with the number in the preceding autumn. Judging from the conditions prevailing during the autumn many acres of vineyards are in danger of severe infestation in the spring, although not as many as in 1912. The unfavorable weather conditions interfered with the proper ripening of the fruit in many vineyards, irrespective of their conditions with regard to the insect, but the interference with the ripening and quality was most marked when the leaf-hopper injury was severe.

BIOLOGICAL STUDIES.

HIBERNATION HABITS.

The adult leaf-hoppers remain on the vines until most of the foliage drops to the ground. During autumn they may be observed among fallen leaves, cover crops, weeds and grass that may
be present in the vineyards. The normal time of entrance into permanent hibernation quarters is from the latter part of October until the early portion of December, depending on weather conditions. Warm, sunny days during this time, or even during the winter, cause the hoppers to fly about more or less. Since the various hibernating places have a direct bearing on the infestation of vineyards, considerable study was given to the habits of the insect during this season.

Green weeds or green grasses, except where the upper portions are dead and lodged, do not usually afford favorable places for the wintering of the leaf-hoppers. However the grasses, such as the fox-tail grass (*Setaria glauca*), that grow in abundance during late summer on cultivated land and which die and lodge either about large weeds and corn stubble or about their own roots, offer excellent shelters to the insects, and large numbers of them exist in such situations. Plate I, fig. 3, shows clumps of grass which were sheltering many leaf-hoppers in April after the very severe winter of 1911–12. Grassy headlands (Plate II, figs. 1–2), grass and rubbish along ditches or fence rows (Plate I, figs. 1–2, and Plate V, figs. 2–3) are capital places for the insects during the winter. Burdock has large flat leaves which remain green during the winter and these shelter the pests. Raspberry and blackberry patches (Plate III) as well as woodland or waste land which retain many leaves are favorite places for hibernating hoppers. Old stumps which have had many holes eaten into them by borers were found to shelter hundreds of leaf-hoppers. The firmer leaves of trees when carried by the wind and caught in the locations mentioned above are perhaps the most powerful single influence in making these places favorable shelters as they do not pack together tightly, but offer the insects many safe hiding places. While the adults may be observed during the months of November and December among various plants growing in the vineyards, careful search during the spring has so far failed
to reveal any of the insects in green cover crops or among fallen grape leaves as these appear to be pressed too tightly by the snow for the hoppers to survive. Usually such green cover crops are not high enough to catch many leaves and so are not conducive to sheltering the leaf-hoppers. Cover crops examined were cow-horn turnips, wheat, clover, rye and vetch. Chickweed (*Stellaria media*) in vineyards has also not been found to shelter the insects.

**EFFECTS OF MOISTURE AND COLD ON INSECTS.**

The leaf-hopper survives the winter in greatest numbers in dry locations and is absent from low-lying land, such as the clay and some of the loam soils. On the higher soils — the gravel and large areas of the loam soils — there is no winter flooding and the rains soon drain away, thus offering the driest winter quarters to be found in the grape belt. Here the leaf-hopper abounds. Although wet situations are not favorable to them, the insects are not easily drowned. They are able to walk on water for a considerable time without drowning. They are even able to rise on wing from the surface of water, at least in the summer when the temperature is higher, and no doubt are able to withstand considerable water during the winter. Notwithstanding all these protective adaptations they instinctively seek dry winter quarters. This species is also able to withstand considerable cold, and it does not seem as though our normal winters influence appreciably the numbers of the leaf-hoppers. The winter of 1911–12 was extremely severe. Low temperatures prevailed, as well as other unfavorable factors such as winter rains followed by snow, which soaked and packed down leaves and froze them together, while the temperature at one time dropped to 18° below zero and later to 14° below. Yet with all these apparently unfavorable conditions the numbers of adults appearing in the spring did not indicate a high mortality.

**SPRING FOOD PLANTS.**

From the first warm days in the spring until the grape foliage appears, the leaf-hoppers feed, especially during the warmer days,
on a number of species of plants. The most important are raspberry, blackberry, strawberry, burdock (*Arctium* sp.), catnip (*Nepeta cataria*), Virginia creeper (*Pseuderu quinquefolia*), currant and gooseberry. Their preferences are in the order given, raspberries always being favored when in foliage while strawberries are sought if the raspberries are not in leaf. The observations made during 1912 in a locality where the chosen plants existed showed that from the time of the first warm weather, about April 15 to May 6, the principal feeding was on the leaves of the wild strawberry (*Fragaria* sp.) (Plate IV, fig. 2), and that on May 6 they began to feed on the lower leaves of the black raspberry, which were at this time about one and a half inches long. At this latter date the Burbank plum and sweet cherry were coming into bloom, while the buds of the Concord grapes were just bursting. By May 10 most of the hoppers were found feeding on the foliage of raspberries, principally on the lower leaves, very few being found more than half way to the top of the bushes. By May 15 all portions of the foliage were attacked (Plate IV, fig. 1). Migration of the insects from raspberries to grapes began May 20, at which time grape foliage appeared as in Plate V, fig. 1. This movement of the insects was at its height about May 24, when grapes were at the stage of growth shown in Plate VI. By June 1, practically all of the leaf-hoppers had made their way to the grape vines.

An interesting observation was taken May 24 in a small area of woodland which sheltered many leaf-hoppers during the winter. There were no raspberries, blackberries nor strawberries present in the vicinity so that the hoppers were compelled to feed on other plants. A few vines of the Virginia creeper served as food for a number of the insects, but most of them had been feeding on the leaves of the beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*). Both species of trees appeared to be badly infested on the lower branches, but, however, beech and maple usually escape attacks from this insect when the favorite food-plants as listed above are present.
MATING HABITS.

Accounts of the copulatory habits of this species are meagre, but our studies show that the hibernating insects mate while feeding on the raspberry and various plants other than the grape. The first pair in copulation was observed on burdock about ten o'clock on May 20. The weather was fair with a maximum temperature for the day of 63° F., and the sun was shining. This appeared to be the beginning of the mating season as the weather previous to this time had been cold and wet, during which time the insects were sluggish. The next day a copulating pair was observed on a raspberry leaf for about one hour, at about noon. The maximum temperature for the day was 68° F. Mating is accomplished by the male and female bringing the ends of their abdomens together. They remain very quiet except that the claspers of the male are almost continuously active. A slight disturbance will cause them to separate. No mating by the overwintering adults was observed on grape foliage. Many of the males die shortly after copulation as the following facts show: May 20, 225 leaf-hoppers were captured on the raspberry bushes of which 112 were males and 113 females, but during the latter part of May when the migration to the grape was nearly completed the females predominated, there being about one-fourth as many males as females. During the early part of June it was difficult to find males, while the females were numerous. A pair of the summer brood was observed mating on July 23. Unlike the habit of the hibernating forms the act takes place on the grape. The mating season for this brood extended into August. Since this was an unusually cool summer all the dates upon the activities of this insect after July 1 are from one to two weeks later than normal.

RELATION OF HIBERNATING PLACES TO LEAF-HOPPER INJURY.

That certain vineyards are more susceptible to attacks by the leaf-hopper is a common observation. The degree of infestation of vineyards is, however, not a matter of chance. Our studies
on the hibernating habits of the insect as previously noted showed
plainly that situations in which dead weeds or grasses abound
or where leaves from trees collect provided the best conditions
for the wintering of the leaf-hoppers. Observations on the
eyear movements of the insects in the spring also demonstrated
that vineyards badly infested with this species were always
adjacent to locations attractive for purposes of hibernation or
where spring food-plants existed. The infestation of the grapes
extended from such places outward across the vineyard. Fig. 2
is a sketch of a vineyard that presented a very unfavorable condi-
tion during the spring and early summer. It will be noted that
the proximity of portions of the vineyard to grass fields, grassy
headlands, wooded banks of a stream, blackberries, and rasp-
berries determined the relative amount of leaf-hopper injury to
the vines, as is indicated by the shading. This vineyard had been
allowed to produce considerable weeds and summer grasses dur-
ing the previous season and for that reason the insects were found
throughout the area, but the portions having the greatest infesta-
tion were always adjoining situations that provided favorable
winter quarters and spring food plants. In fact most vineyards
whose owners have systematically "cleaned up" adjacent weedy
and neglected land were free from excessive injury at least until
August and usually the entire summer. While it is true that
the nymphs and adults of the summer brood inflict much injury,
owing to numbers, considerable damage is done by the hibernat-
ing adults in the spring since they attack young foliage, causing
yellowing of the leaves, which is very noticeable in some years.
This injury takes place at a time when it is impossible to con-
trol the insects with sprays. This phase of the habits of the
hibernating adults has not been emphasized sufficiently hereto-
fore owing perhaps to the fact that spraying for the summer
brood of the nymphs has been depended on to protect the vine-
yard. This damage to the young grape foliage by the adults is
needless, however, and can largely be prevented by burning over
the winter quarters of the insects, which will destroy the greater
portion of them.
Fig. 2 — Map of Vineyard and Surroundings Showing the Relation of Favorable Hibernating Places and Spring Food Plants to Grape Leaf-Hopper Injury.

(Amount of feeding in the vineyard indicated by depth of shading.)
EARLY HABITS ON GRAPE VINES.

On migrating to the grape vines, the leaf-hoppers feed first on the lower leaves and shoots. This they may continue to do until the middle of July, although there is a general movement of the insects to the upper portions of the vines as the summer advances and the injured foliage below begins to die. Many eggs are deposited in the lower leaves, but as they become soiled and pitted with many dead areas they cease to be attractive to the insects, either for oviposition or for subsistence. The grape normally produces a quantity of shoots and foliage about its base. As it is considered good practice to remove these during the summer, the injury to such suckers is obviously less important than that to the leaves on canes that are allowed to remain and perform their normal functions for the entire summer.

The habit of this species to select first the lower portions of the grape vines may perhaps be accounted for by the fact that the under leaves are less subject to disturbance by the wind. During a storm the majority of the adults flit to grass or weeds or to dry lumps of earth but when the wind abates they return to their former haunts. A small percentage of the leaf-hoppers nevertheless remain on the vines, and they seem to be able to cling to the leaves even during storms when the wind velocity is high.

EXPERIMENTS FOR THE CONTROL OF GRAPE LEAF-HOPPER.

Experiments for the control of the grape leaf-hopper were made in a number of vineyards in various portions of the Grape Belt in Chautauqua county during 1912. These were co-operative experiments in which the growers furnished their own material but applied it under the author's direction. All applications were made by means of automatic grape leaf-hopper sprayers.*

* The automatic grape leaf-hopper sprayer mentioned is described in Geneva Bulletin No. 344, Feb., 1912. No spraying was done by means of trailing hose described in Geneva Bulletin No. 331 because of the successful working of the new attachment. In vineyards located on very steep hillsides, when the rows run across instead of up and down, it will be found difficult to use such an attachment and the trailing hose had better be substituted.
Experiments were made in the Experimental Vineyard at Fredonia and in the vineyards of the following men: Nicholas Feinen, George O'Brian, Fredonia; J. Dunham, Brocton; M. B. Jillson and A. Freeling, Westfield; and W. M. Kingsley, Ripley. The conditions of the different tests will be discussed separately.

M. B. JILLSON VINEYARD.

This vineyard, near Westfield, was the most severely infested of any in which experiments were conducted. This was due to the location of favorable hibernating places in and about the vineyard and the proximity of spring food plants. (Fig. 2.) The hibernating quarters of the insect were found to be the wooded banks of a stream, a blackberry patch, a raspberry patch, and grassland; and many leaf-hoppers also passed the winter in the shelter of the summer grass which the former owner had allowed to grow as a natural cover crop in the vineyard the previous year. When first reported the hoppers were already on the grape foliage in great numbers, where their feeding punctures had caused large areas of the lower leaves to turn brown. Fortunately they were feeding on the lower leaves and therefore "suckering" was delayed until just before spraying. This kept the leaf-hoppers low on the vines and allowed the more permanent foliage to mature the crop. The lower shoots in this vineyard were removed during the second week of July and spraying was commenced on July 15 and continued until the 17th. Only one application was made, using "Black Leaf 40" in the proportions of one part to sixteen hundred parts of water. In certain portions where the root-worm was present in considerable numbers arsenate of lead was used with the nicotine. As a result of the spraying most of the nymphs were killed and the few that remained did not seriously affect the vines. Comparison of the foliage of this vineyard with adjoining plantings during September and October showed that these hitherto badly-infested vines which had poor prospects during the spring had more green.
foliage and better fruit than those of neighboring vineyards which had a better outlook early in the season but which were not sprayed. The chemical analyses of fruit from sprayed and unsprayed vines in the same vineyard are shown in Table I.

**J. DUNHAM VINEYARD.**

This vineyard was near Brocton. Several portions of it were more severely infested than others. Here the importance of destroying the hibernating places was shown; for the severest injury in this planting always occurred in areas adjoining situations which offered shelter to the insects during the winter. It should be said that, for the season, this was only a moderately-infested vineyard. Spraying was done on July 15 to 17 and "Black Leaf 40" was used with bordeaux mixture. The nymphs were killed and the foliage remained green. This vineyard was surrounded by others which were not sprayed, and during September it stood like an island of green in a sea of yellow. The effect of the treatment on the fruit is shown in Table I.

**A. FREELING VINEYARD.**

The effect of proximity of spring food-plants and favorable winter quarters was clearly shown in this vineyard, which was at Westfield. Cultivated raspberries were the food plants, while grassland aided in sheltering the insects. The vines were severely infested and were sprayed on July 16 and 17, and one application only of nicotine extract was made. The foliage of the sprayed vines remained green longer than that of the unsprayed ones and the difference in quality of the fruit will be noted in the analyses. Table I.

**N. FEINEN AND G. O'BRIAN VINEYARDS.**

Since these two vineyards, at Fredonia, are similarly located and were in all respects alike so far as the control of the leafhopper is concerned, the spraying operations are considered as one experiment. The sources of infestation were grassland and
EXPLANATION OF PLATES.

PLATE I.—SOME HIBERNATING PLACES OF GRAPE LEAF-HOPPERS.

Fig. 1, Fence row adjoining vineyard in which "hoppers" were very evident during the Spring of 1912.
(Photographed May 24, 1912.)

Fig. 2, Raspberry bushes and rubbish along fence. Height shown by 12-inch rule.
(Photographed April 10, 1912.)

Fig. 3, Dead grass which sheltered grape leaf-hoppers. Height shown by 12-inch rule.
(Photographed April 10, 1912.)

The last two figures illustrate the small amount of rubbish necessary to shelter these insects.

PLATE II.—VINEYARD SURROUNDINGS THAT MAKE SPRING CONTROL OF LEAF-HOPPERS DIFFICULT.

Fig. 1, View in vineyard showing grassy headlands and bushes along a dry brook.
(Photographed July 17, 1912.)

Fig. 2, Waste land at edge of vineyard—a favorite retreat for the "hoppers" during winter.
(Photographed July 15, 1912.)

PLATE III.—RASPBERRY PATCH, AND GRASS AND WEEDS IN SWALE WHICH FAVOR INCREASE OF "HOPPERS" IN ADJOINING VINEYARDS.

The insects were very abundant in a vineyard behind the camera as well as in the ones shown.
(Photographed September 17, 1912.)

PLATE IV.—RASPBERRY (1) AND STRAWBERRY (2) LEAVES INJURED BY FEEDING OF GRAPE LEAF-HOPPER.

(Fig. 1, Photographed May 24, 1912; Fig. 2, Photographed May 6, 1912.)

PLATE V.—GRAPE FOLIAGE WHEN FEEDING BY GRAPE LEAF-HOPPERS BEGINS; REFUGES OF "HOPPERS."

Fig. 1, Grape leaf-hoppers begin to migrate from other food plants to the vines when foliage is at the stage shown.
(Photographed May 24, 1912.)

Fig. 2, Grass strip at edge of vineyard.
(Photographed July 8, 1912.)

Fig. 3, Weeds adjoining vineyards.
(Photographed September 12, 1912.)

The vineyards, Figures 2 and 3, were injured along the borders by leaf-hoppers.

PLATE VI.—GRAPE FOLIAGE WHEN "HOPPER" MIGRATION TO VINES IS GREATEST.
(Photographed June 1, 1912.)
PLATE I — SOME Hibernating Places of Grape Leaf-Hoppers. (See page 44.)
PLATE II.—VINEYARD SURROUNDINGS THAT MAKE SPRING CONTROL OF LEAF-HOPPERS DIFFICULT.  
(See page 44.)
PLATE IV.—Raspberry (1) and Strawberry (2) Leaves Injured by Feeding of Grape Leaf-Hoppers
Plate V.—Grape Foliage when Feeding by Grape Leaf-Hoppers Begins; Refuges of "Hoppers" (See page 44.)
PLATE VI.—GRAPE FOLIAGE WHEN "HOPPER" MIGRATION TO VINES IS GREATEST.
fence rows. The number of insects present was considerable. Spraying with nicotine extract was done in the Feinen vineyard on July 18–19 and in the O'Brian vineyard on July 22–23. At this time many of the nymphs were in the fourth and fifth instars, but the spray material was effective against them as was shown by the difference in the conditions of the foliage and fruit in sprayed and unsprayed areas. Table I.

**M. W. KINGSLEY VINEYARD.**

The leaf-hopper and the grape berry-moth (*Polychrosis viteana*), were present in this vineyard, at Ripley, so the problem was more complicated than in the other experiments, as an effort was made to control both pests with the same spraying. The application was planned for the third week in July since the eggs of the moth were present on the grape berries at that time; but the breaking of the sprayer and unfavorable weather conditions delayed operations until July 27. The spraying was completed by the 30th. This delay in the treatment gave opportunity for a few of the hoppers to develop to adults but the majority of them consisted of nymphs of the fourth and fifth instars. The material used was arsenate of lead 6 lbs., "Black Leaf 40" ½ pint, whale-oil soap 3 lbs., water 100 gallons. The soap was used primarily as a so-called "sticker" which might more correctly be called a "spreader" for the arsenate of lead, but it is believed to have added to the efficiency of the nicotine in killing the leaf-hoppers for they were controlled very effectually notwithstanding the fact that they consisted largely of the older nymphs. The eggs of the grape berry-moth fortunately did not hatch before the spraying, owing to the cool wet weather during the latter part of July, so that the treatment proved effective also against the larvae of this pest.
EXPERIMENTAL VINEYARD.

Owing to line fences, along which were growing many bushes, besides weeds and grass (Plate I, figs. 1–3), large numbers of leaf-hoppers went into hibernation during the autumn of 1911 along the margins of the vineyard. As these vines are grown for various experimental purposes, all of them were sprayed with nicotine extract to control the insects since it was not desirable to leave checks. However, careful observations were made to note the effects of the treatment on the pest, which showed that the vines were efficiently protected by the spraying. Unfortunately there was in this planting considerable winter-injury, which caused the vines to appear as if they were damaged by the leaf-hopper, a condition quite prevalent in this region and not generally understood. Thus the vines as a whole did not present the uniform dark green appearance found in most of the other vineyards in which experiments were made.

RELATION OF LEAF-HOPPER INJURY TO QUALITY OF FRUIT.

The destruction of leaf tissue by the feeding of these insects causes a decreased wood growth which in time must affect the crop, but by far the most important loss to the grape-growers arises from a depreciation in the quality of the fruit. Concord grapes normally have a bluish-black color when ripened, but fruit from leaf-hopper-infested vines has a red appearance* and a decided

*In this connection it is important to add a word of caution. The fact that a Concord grape has a red appearance and is poor in quality is not conclusive evidence that the condition was caused by grape leaf-hopper. A peculiar vine trouble, resembling leaf-hopper injury, was of common occurrence in the vineyards of Chautauqua county. This trouble can be distinguished from insect injury in several ways: (1) It affects vines which have not been infested with grape leaf-hoppers; (2) The grape leaf-hopper punctures the epidermis or skin of the leaf and close examination will show distinct yellowish areas uniformly over the leaves caused by the feeding wounds. The ribs of the leaf have a yellow, punctuated appearance. If the leaf dies it will be found to die along the veins as quickly as on the margins. On the other hand vines having “leaf blight” (?) show leaves having darkened areas along the veins and the margins yellow and die first. It is important that every vineyardist distinguish between the injuries, for failure to do so has caused the waste of spray materials.
lack of flavor. Grapes affected by this insect show a decrease in sugar and an increase in acid — two important factors in determining the quality of the product. In order to have exact data showing the effects of injuries to the vines by this pest upon the quality of the fruit, chemical analyses* were made of grapes taken from sprayed and unsprayed vines, which are given in Table I. For the reasons given below, comparisons of the analyses can only be made as indicated — sample 3 with sample 5, 4 with 6, etc.

It should be noted in these analyses: (1) That every sample of Concord from a sprayed section gave a gain in sugar over its mate from the adjoining unsprayed section. These increases varied from 8.4 per ct. to 68.1 per ct., an average of 27.0 per ct. The two samples of Clinton grapes varied only 2.8 per ct.

(2) That in every sample of unsprayed grapes except one (Samples 7 and 8 which gave the same amount), the amount of acid was greater than in the corresponding sample from a sprayed vine. The excess of acid in the unsprayed grapes as compared with those sprayed varied from 0 per ct. to 20.6 per ct., an average of 11.2 per ct.

(3) Grapes from the upper portion of a vine gave a higher percentage of sugar than grapes from the lower portion of the same vine; on one vine the upper clusters showed 16.3 per ct. more

* These analyses were made by Mr. O. B. Winter, through the courtesy of Dr. L. L. Van Slyke of the Department of Chemistry of this Station. The taking of the samples received most careful attention, for unless care is exercised in the selection of the fruit the data secured are worthless. For example, analyses of two samples, one from upper portion and the other from the lower portion of the same vine (Samples Nos. 20 and 21) show a difference of sugar content, the grapes from the upper portion having 16.3 per ct. more sugar than the grapes from the lower portion. Samples Nos. 22 and 23 from another vine on clay soil but poorly ripened show a difference of 9.7 per ct. in sugar. In taking samples, two vines were selected that represented the average of the plat at that place, from the same soil, of the same age and variety, the one sprayed, the other unsprayed; an eight-pound basket of fruit was picked from each, care being taken to select the fruit uniformly from all portions of the vine; and duplicate samples were usually obtained from another portion of the same vineyard. With all these precautions small errors will undoubtedly occur in judging what constitute average vines, but the selection of a number of samples, all of which give similar results, should be fairly conclusive evidence that the data are reasonably accurate.
### Table I.—Chemical Analyses of Grapes: Sprayed and Unsprayed; or on Upper and Lower Portions of Vines.
(Samples 17 and 19, Clinton; others Concord.)

<table>
<thead>
<tr>
<th>No. of sample</th>
<th>Vineyard</th>
<th>Condition</th>
<th>Description of fruit</th>
<th>Amount of juice</th>
<th>Brix reading</th>
<th>Specific gravity</th>
<th>Amount in 100 c.c. of juice of —</th>
<th>Increase of sugar in sprayed grapes</th>
<th>Increase of acid in unsprayed grapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Palmer</td>
<td>S*</td>
<td>Well ripened; berries fair size; color purple.</td>
<td>1,405</td>
<td>15.4</td>
<td>1.062</td>
<td>Reducing sugar 13.19</td>
<td>Grams. 1.04</td>
<td>Per ct. 43.7</td>
</tr>
<tr>
<td>3</td>
<td>Palmer</td>
<td>N*</td>
<td>Poorly ripened; berries small; color red.</td>
<td>1,370</td>
<td>13.7</td>
<td>1.056</td>
<td>Total acid as tartaric 9.18</td>
<td>1.08</td>
<td>3.8</td>
</tr>
<tr>
<td>6</td>
<td>Palmer</td>
<td>S</td>
<td>Well ripened; color dark.</td>
<td>778</td>
<td>14.7</td>
<td>1.059</td>
<td>14.10</td>
<td>1.13</td>
<td>23.4</td>
</tr>
<tr>
<td>4</td>
<td>Palmer</td>
<td>N</td>
<td>Poorly ripened; color red.</td>
<td>1,345</td>
<td>14.1</td>
<td>1.057</td>
<td>11.41</td>
<td>1.18</td>
<td>4.4</td>
</tr>
<tr>
<td>7†</td>
<td>Jillson</td>
<td>S</td>
<td>Well ripened; cluster good; color dark.</td>
<td>755</td>
<td>17.7</td>
<td>1.072</td>
<td>13.48</td>
<td>1.23</td>
<td>8.4</td>
</tr>
<tr>
<td>8†</td>
<td>Jillson</td>
<td>N</td>
<td>Fairly ripened; cluster fair; red tinge.</td>
<td>775</td>
<td>17.6</td>
<td>1.071</td>
<td>12.43</td>
<td>1.23</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>Freeling</td>
<td>S</td>
<td>Well ripened; purple.</td>
<td>750</td>
<td>18.4</td>
<td>1.075</td>
<td>14.45</td>
<td>1.04</td>
<td>16.3</td>
</tr>
<tr>
<td>11</td>
<td>Freeling</td>
<td>N</td>
<td>Poorly ripened; red.</td>
<td>760</td>
<td>14.8</td>
<td>1.059</td>
<td>12.42</td>
<td>1.22</td>
<td>17.3</td>
</tr>
<tr>
<td>10</td>
<td>Freeling</td>
<td>S</td>
<td>Well ripened; purple.</td>
<td>800</td>
<td>18.8</td>
<td>1.078</td>
<td>13.79</td>
<td>1.03</td>
<td>16.1</td>
</tr>
<tr>
<td>12</td>
<td>Freeling</td>
<td>N</td>
<td>Poorly ripened; red.</td>
<td>770</td>
<td>16.0</td>
<td>1.065</td>
<td>11.87</td>
<td>1.21</td>
<td>17.5</td>
</tr>
<tr>
<td>15</td>
<td>Dunham</td>
<td>S</td>
<td>Well ripened; purple.</td>
<td>745</td>
<td>17.5</td>
<td>1.070</td>
<td>13.41</td>
<td>1.07</td>
<td>68.1</td>
</tr>
<tr>
<td>14</td>
<td>Dunham</td>
<td>N</td>
<td>Poorly ripened; red.</td>
<td>1,600</td>
<td>11.2</td>
<td>1.045</td>
<td>7.98</td>
<td>1.29</td>
<td>20.6</td>
</tr>
<tr>
<td>18†</td>
<td>Feinen</td>
<td>S</td>
<td>Well ripened; purple.</td>
<td>1,255</td>
<td>17.3</td>
<td>1.070</td>
<td>13.43</td>
<td>1.01</td>
<td>13.0</td>
</tr>
<tr>
<td>16†</td>
<td>Feinen</td>
<td>N</td>
<td>Fairly ripe; red tint.</td>
<td>1,270</td>
<td>17.0</td>
<td>1.066</td>
<td>11.89</td>
<td>1.16</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>Feinen</td>
<td></td>
<td>Clinton variety; well ripened</td>
<td></td>
<td>990</td>
<td>21.7</td>
<td>1.091</td>
<td>16.62</td>
<td>1.56</td>
</tr>
<tr>
<td>----</td>
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<td>------</td>
</tr>
<tr>
<td>17</td>
<td>Feinen</td>
<td>N</td>
<td>Clinton variety; fairly ripe</td>
<td></td>
<td>1,000</td>
<td>21.5</td>
<td>1.090</td>
<td>16.16</td>
<td>1.65</td>
</tr>
<tr>
<td>19</td>
<td>Experimental</td>
<td>U</td>
<td>Well ripened; purple</td>
<td></td>
<td>1,275</td>
<td>14.2</td>
<td>1.057</td>
<td>9.77</td>
<td>1.15</td>
</tr>
<tr>
<td>20</td>
<td>Experimental</td>
<td>L</td>
<td>Fairly ripened; red</td>
<td></td>
<td>1,210</td>
<td>12.8</td>
<td>1.050</td>
<td>8.42</td>
<td>1.19</td>
</tr>
<tr>
<td>21</td>
<td>Experimental</td>
<td>U</td>
<td>Well ripened; purple</td>
<td></td>
<td>1,280</td>
<td>14.0</td>
<td>1.056</td>
<td>10.38</td>
<td>1.20</td>
</tr>
<tr>
<td>22</td>
<td>Experimental</td>
<td>L</td>
<td>Poorly ripened; red</td>
<td></td>
<td>1,250</td>
<td>13.4</td>
<td>1.052</td>
<td>9.46</td>
<td>1.37</td>
</tr>
</tbody>
</table>

* S and N, in this column, indicate that the grapes came, respectively, from sprayed and unsprayed vines; and U and L that they came from the upper and lower portions, respectively, of the same vine.

† Bunches included under this sample number came from two vines rather widely separated but in the same row.

Remarks: Samples 5, 3, 6, 4, 7, 8, 15, 14, 16, 18, 17, 19, 21 and 20 came from vines on gravel soil; samples 9, 11, 10, 12, 23 and 22, from vines on clay soil. Vines on which samples 3 and 4 grew were two rows from those bearing their paired samples of sprayed grapes; samples 8, 11, 12 and 14 were from vines three rows distant from their sprayed mates; sample 16 came from a vine five rows away from that bearing sample 18; while sample 19 was taken several rows away from sample 17.
sugar than the lower one and on another vine the difference was 9.7 per ct.

(4) The amount of acid was greater in grapes from the lower portions of the vine than from the upper portion of the same vine.

CONCLUSIONS DEDUCED FROM THE EXPERIMENTS.

These experiments were designed to test out the recommendations given in previous bulletins.* The Station has now conducted experiments for three years with nicotine extract, and two years with the automatic leaf-hopper sprayer. From the work done during these years the following points should be noted:

(1) Nicotine at the rate of .02 of one per ct. either in water or bordeaux mixture is an effective insecticide against the nymphs of the grape leaf-hopper.

(2) During three seasons there has been no burning of the grape foliage by the nicotine sulphate or nicotine in other forms used in our experiments; nor has the taste of nicotine been found on ripe grapes.

(3) Although it is necessary to combat the pest during its nymphal existence there is considerable time during which effective spraying can be done. The operations during 1912 covered a period of 15 days or half a month; but during years with hot weather during July the transformations are more rapid and ten days would be a safer margin for effective work.

(4) The automatic grape leaf-hopper sprayer has given satisfaction in the hands of careful grape growers. Carelessness in driving will bend or even break the booms, but with an average amount of care no trouble has been experienced with the attachment. Several manufacturers have attached the contrivance to their spraying machines, which gave satisfactory results, when pumps worked properly.

(5) Grapes from vines protected from leaf-hoppers had a higher percentage of sugar and less acid, and were of a darker color than grapes grown under identical conditions but subjected to the attacks of the insects.

(6) The destruction of the hibernating places by removing dead grass, leaves, bushes and rubbish assists greatly in reducing injuries by the grape leaf-hoppers and during ordinary seasons this measure alone will hold the pest in check. During seasons when the insects are superabundant, the grower should supplement this practice by spraying.

(7) Delaying the removal of the shoots at the base of the vine, "suckering," until just previous to spraying has helped to protect the more permanent foliage and thus aided the maturing of the fruit.