New York Agricultural Experiment Station.

GENEVA, N. Y.

CONTROL OF GREEN APPLE APHIS IN BEARING ORCHARDS.

H. E. HODGKISS,

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CONTROL OF GREEN APPLE APHIS IN BEARING ORCHARDS.

H. E. HODGKISS.

SUMMARY.

Oviposition by *Aphis pomi* occurs in the autumn, and the eggs hatch the following spring. The maximum numbers of newly-hatched nymphs are ordinarily observed as color is showing in the leaf tips of the opening blossom buds. Development of the insects is rapid, and winged forms of the second generation appear during late May or early June, when there is a migration to other plantings. The species breeds continuously throughout the summer, producing many broods, which vary in size and number according to seasonal conditions.

The green aphid prefers succulent tissues such as exist on terminal growths, water-sprouts and suckers, and is generally present in injurious numbers for more or less extended periods during the summer months in nursery plantings and young apple orchards. In occasional years destructive outbreaks of the insect occur in bearing orchards.

Attacks by the aphid cause curling of apple leaves which may result in defoliation of affected branches. Succulent growth often exhibits a dying back of terminal areas. Invasion of fruit clusters may be attended with dwarfed, misshapen apples which display pimpling and red stippling of the surfaces. The appearance of the fruits is often marred by the sooty fungus (*Fumago vagans* Fries) which thrives upon the excretions of the lice.

Records of the green aphid show destructive outbreaks in bearing orchards during 1903, 1909 and 1912. During June and July, 1918, the species was abundant in many plantings in western New York, and was especially destructive to apple crops in Orleans County.
The principal facts and experimental results of an organized effort to control the green aphids during 1918 are as follows:

The green aphid was the dominant species at the time of breaking of the buds. Prior to attack of apple clusters there was generally severe infestation of succulent growth on trunks and large limbs, as water-sprouts, suckers, etc., interplantings of young trees and adjacent newly-planted orchards. Natural enemies of the insects were quite scarce up to the time important injuries became noticeable, and for a period of thirteen weeks there was a progressive increase in the numbers of the aphid. Orchards free from the insects at the time of breaking of the buds showed considerable infestation by midsummer as a result of invasion by winged forms from adjacent plantings.

The delayed dormant treatment protected bearing orchards until about the middle of June, when there was a reinfestation from winged migrants. While plantings that were given the delayed dormant treatment were not conspicuously injured by the aphid, the experiments so far conducted do not indicate conclusively that this treatment may safely be relied on to afford reasonable and satisfactory commercial control.

In the Station experiments a spraying during midsummer resulted in the efficient control of the green aphid. Following the treatment there was noticeable improvement in the conditions of apples in most orchards with respect to shape, size and freedom from reddish discolorations.

Of twenty-three bearing orchards sprayed in cooperation with the Orleans County Farm Bureau, successful results in treatment for the aphid were reported in nineteen plantings. Opinions as to the practicability of the treatment were withheld in three instances, while in one orchard the application was regarded as unprofitable.

Comparative tests of nicotine sulphate with soap or large amounts of lime indicated few differences in insecticidal qualities of these preparations. The advantages of the lime wash were the deterrent action on the aphids and its cleansing properties to the fruits. On account of its lack of surface tension and the difficulty and cost of application to large trees, the use of the lime mixture should properly be limited to young, non-bearing trees or those of moderate size.
The rapid killing with nicotine sulphate in combination with soap and its greater spreading properties point to its superiority for large trees. It is probable, for these considerations, that apple growers having trees of great height with widespread branches will continue to place their dependence on the nicotine sulphate-soap spray for the control of the green aphis.

The conclusions drawn from the Station experiments are that in regions where aphids are annually destructive or attacks are apprehended, reliance should be placed on the delayed dormant treatment with lime-sulphur and nicotine sulphate, and on a supplementary spraying during midsummer with nicotine sulphate and soap when the green aphis threatens to develop to destructive numbers on fruit clusters.

INTRODUCTION.

The green apple aphis (A. pomi De Geer) exacts annually a certain toll from New York orchards. It does not usually affect the fruits in old apple plantings, but is most often a dwarfing and deformative agent of the new growth of younger trees. During some seasons the insects breed rapidly and in considerable numbers in older orchards, when they may attack the fruits as well as foliage. In late June, 1918, the numbers of pomi in some orchards increased alarmingly, especially in Orleans County. Early in July fruits and foliage were sticky and blackened from the "honey dew" fungus and the growing apples were being distorted. Notwithstanding earlier warnings of danger from the lice, no definite spraying program was being adopted by fruit growers, and in mid-July it became necessary for this Station to direct steps for the protection of apple plantings. Following a survey of this county, special control measures were suggested and parallel tests of various insecticides were made under our direction.

Acknowledgments are due to Mr. L. J. Steele, Manager, for the extensive cooperation of the Orleans County Farm Bureau; to Messrs. Donahue, McCrillis and Mack, Holley; and to Mr. B. G. Wilson, Carlton, for the use of their orchards for experimental purposes and for their personal assistance, which aided greatly in the successful prosecution of the work.
HISTORY OF THE SPECIES IN BEARING ORCHARDS IN NEW YORK.

The early records of *pomi* appear to be confused to a considerable extent with those of *avenae*. Accounts of unusual outbreaks, however, have come to us with much accuracy, despite a paucity of early knowledge of the separation characters. Our more definite records coincide in point of time with the renewed interest in fruit growing and the development of more modern methods of spraying. Such reports bear evidence that in all these years the green apple aphid has been of more or less casual abundance, and only at long intervals of time has it been of importance in bearing orchards. The first severe infestation of the past twenty-five years was in 1903. Prof. M. V. Slingerland in writing of this outbreak mentioned that "one orchardist thinks his apple crop was reduced one-half by the lice, and a prominent buyer reported it was difficult to pack good stock in the infested orchards." As to the damage to nursery plantings, he stated that two leading nurserymen estimated their loss at $5000.00 each. The following year (1904) saw a return to normal conditions, which was succeeded by several seasons when the aphids were not a factor in the production of apples. The summer of 1909 experienced another onslaught which was comparable to the outbreaks in 1897 and 1903. The literature for 1909 does not state clearly the extent of injury caused by *pomi*, but from unpublished records it is evident that the species was responsible for considerable damage to young trees. The insect did not attract serious attention again until 1912, when in June of that year considerable apprehension was caused by the abundance of the aphids, especially in plantings of younger trees and on nursery stocks. In bearing orchards the inroads of the lice were accompanied by serious defoliation of the trees and extensive injuries to the apple crop. For the next two summers *pomi* existed apparently in unimportant numbers. During June, 1915, young non-bearing trees were severely injured by this species, and on June 22 at Geneva it was necessary for owners of nurseries to resort to spraying in order to prevent further injuries. Older bearing trees were not immune from attacks, but at no time were the lice a serious

menace to the young fruits. During succeeding years *pomi* was again unimportant until in 1918 there occurred a destructive outbreak which was comparable to that of 1903.

**LIFE HISTORY AND APPEARANCE OF THE INSECT.**

**Egg.—** The egg is oval in form, and is somewhat flattened on the side next to the bark. It does not differ from *Aphis avenae* in shape, but is, on the average, slightly longer. The smallest eggs of *pomi* are, however, shorter than the longest ones of *avenae*. The width in both cases is the same. Ova of *pomi*, in our studies, averaged 0.62 mm. in length and 0.26 mm. in width. The extreme measurements were 0.59 mm. to 0.66 mm. long by 0.25 mm. to 0.28 mm. wide.

When deposited, the egg is pale greenish-yellow. In a short time it becomes dull, dark green, and finally changes to a glossy black. On young apple stocks in the Station nursery during the autumn of 1914 permanent coloration of *pomi* eggs became fixed in four days. During the following season the color changes occupied five days.²

Deposition takes place in the fall. The eggs may be laid singly or in rows in the creases at the bases of the buds, or in collections in scars on the young bark. They are rarely seen on the larger limbs or on the trunks of older trees. It is common to find them scattered over the more succulent stems and young wood, and sometimes the bark is almost obscured by the minute ova, especially wherever the aphids have been abundant. The species hibernates only in the egg stage.

**Stem-mother.—** This is the name given to the nymph of the first generation, which is the only brood developing from a sexual egg. At hatching the young nymphs are not unlike first-stage individuals of *Aphis avenae* and *A. sorbi* in gross anatomy. A close examination of the initial stages discloses certain differences in color and external structures which provide easy identification characters. Newly-hatched nymphs of *pomi* are most often of a dark, dull green color, while the corresponding stages of *sorbi* and *avenae* are somewhat darker. The essential features of the first-stage nymphs are

² Baker and Turner (*Jour. Agr. Research*, 5: 960, 1916) give this period, under artificial conditions, as “one to four days, usually a little over one.”
the size of the antennæ and the button-like "honey tubes" which are intermediate between those of *avenæ* and *sorbi*.

Summer form.—As maturity approaches, the stem-mother becomes larger, and is distinctly unlike either *sorbi* or *avenæ*. Adults of *pomi* are plain green in color and, except for individuals of a dull yellowish tinge, the stem-mothers are of a uniform green with black appendages. The head and thorax usually have a whitish powdery coating. The adult is wingless, and produces both winged and wingless offspring. Several generations of similar forms occur during the summer. These are composed mostly of wingless females. Winged forms do occur in each later brood, but they are not as abundant as in the second generation.

The sexes.—In early autumn, wingless sexed individuals are produced. These are of a pale color. Within a short time after mating, the females deposit eggs which, according to Baker and Turner, must develop to a resting stage before the first heavy frosts; otherwise they may be winter-killed.

**SEASONAL ACTIVITIES OF THE APHIS.**

The eggs of *pomi* are deposited during late October or early November. The period of oviposition at Geneva during 1914 was nineteen days. That year eggs were being deposited in considerable numbers on October 23. Ordinarily the first eggs of *pomi* have been observed between November 4 and November 8. Hatching of the eggs occurs with the approach of warm weather in the spring. In western New York the first appearance of young nymphs is usually coincident with the appearance of color in the leaf tips of the blossom buds. At this Station a record of the hatching of *pomi* during a period of ten years indicates that, in the main, there is but a slight variation in the first appearance of nymphs of this species in the spring. These records are given in Table I.

Stem-mothers of *pomi* usually mature as color is showing in the blossom clusters. Seasonal conditions apparently produce some variation in the time consumed between the hatching of the eggs and the appearance of the adults, as is indicated by the records for the years 1915 to 1918. During this period adults of the earliest nymphs of the first generation at Geneva were noted on the follow-

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ing dates: 1915, May 4; 1916, May 13; 1917, May 26; 1918, May 10. During these years pink was abundant in apple clusters May 6, 1915; May 17, 1916; May 27, 1917; May 9, 1918.

**Table I.—Record of Hatching Between 1909–1918.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Date of hatching</th>
<th>Year</th>
<th>Date of hatching</th>
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<tbody>
<tr>
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<td>1914</td>
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</tr>
<tr>
<td>1910</td>
<td>April 3</td>
<td>1915</td>
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<td>1911</td>
<td>April 22</td>
<td>1916</td>
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<td>April 20</td>
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<td>1913</td>
<td>April 14</td>
<td>1918</td>
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<td>April 20</td>
</tr>
</tbody>
</table>

In 1917, nymphs of the second generation were first observed during the period of May 26–28. The following year (1918), development of the lice was much earlier, which was indicated by the finding of the second generation larvae on May 12, and reproduction thereafter was very rapid. On June 11, 1917, some individuals of the second generation were developing wings. Ten days afterwards a distinct flight of winged adults took place, which was coincident in point of time with the migration of *pomi* in 1915 and three weeks later than that of 1918 which occurred on May 31.

A few nymphs of the third generation appeared on June 9, 1917. As did the preceding broods, this one developed much earlier during 1918. In outside breeding cages, a number of newly hatched nymphs of the third generation were detected on May 19. In orchards, the progeny of winged migrants were not numerous until June 9. Subsequently the lice increased rapidly until about July 22 when, owing to the transformations of the insects and reductions in numbers by parasites and predaceous enemies, they apparently became less abundant.

In the vicinity of Geneva sexual forms develop usually in the month of October. During the period of 1912–1918 the first specimens were observed between October 13 and October 21. Two notable exceptions were the years 1912 and 1917, when no sexed forms appeared on the trees until November 8 and November 4 respectively. In some years winged fall migrants have been noticed.
quite late in the autumn. In 1912 apple foliage remained on the
trees until early in December, and on December 6 two winged forms
were found accompanied by several young sexed individuals. At
this date, however, the sexes were mostly mature; and on December
14 a note was made that all were adult, and less than one-third as
many were on the apples as observed on December 6.

ACTIVITIES OF THE INSECTS DURING 1918.

Situation in the commercial apple regions.—The area affected by
the unusual abundance of *pomi* during 1918 embraced the entire
fruit-growing section of western New York. In some districts
attacks of the lice were of local importance, while in other centers
heavy losses were averted only by timely spraying. The area most
seriously threatened by the outbreak was in the eastern portion of
Orleans County. In other counties the damage to the apple crop
was apparently not of great importance, and certainly not of such
serious extent as was feared at the beginning of the onslaught.

It is interesting to note that, on June 7, exceptional activities
of the insect were observed in the territory bordering on Lake
Ontario, especially in the counties of Niagara and Orleans. As the
season advanced, orchard conditions in Niagara County improved
somewhat. Treatments in restricted areas would undoubtedly have
effected a better size of the apples on the average, but the Farm
Bureau Spraying Service considered a general campaign against the
pests inadvisable owing to the slow rate of increase of the insects
and the comparative freedom of the fruit clusters from infestation.
Similar conditions prevailed in Monroe and Wayne counties and,
while it became necessary to combat *pomi* in some orchards, spray-
ing was in the main restricted to individual plantings.

In Ontario County the lice early sought the water-sprouts and
succulent terminals of bearing trees. Attacks upon the young
apples were not general, the most conspicuous evidences of the
work of the pest being seen in badly discolored foliage and fruits
due to the "honey dew" exuded by the insects, and its attendant
fungus.

About Oswego and other apple centers to the extreme east of the
western apple belt few instances of damages by the lice were noted;
and it appears that these were mostly in orchards where, ordinarily,
a high degree of orchard cultivation is practised, with the attendant advantage, from the insect standpoint, of the existence of considerable amounts of succulent stems common to trees in a vigorous growing condition.

The apple section of the Hudson Valley furnished fewer complaints of the green apple aphis than the Lake region. From reports of county agents, however, it appears that the orchard conditions as regards this insect were quite similar to those of western New York outside of Orleans County.

_Early spring conditions in Orleans County._—The spring migration of _pomi_, which occurred during the last week of May, 1918, preceded by a few days an inspection of experimental plats in some of the larger bearing apple orchards in the vicinity of Albion and Medina. During these explorations it was noticed that winged migrants were scattered throughout the plantings. In some instances the winged forms were so numerous that the attention of officers of the Farm Bureau was called to the situation, and a warning was given, coupled with the suggestion that a close watch be kept on the lice, as conditions might render spraying advisable. During a subsequent visit to this section on June 18, it was observed that _pomi_ nymphs had stunted the terminal growths of apple trees, and the leaves, even of fruit clusters, were being curled. In certain instances, the insects were seen on apple stems and young apples.

The most severely infested orchard at this date was the extensive Baldwin planting of Mr. Clark Allis, Medina. These trees, which are of unusual height, and have wid espread branches, were so badly overrun by the lice that terminals, fruit and leaf clusters, and watersprouts were deformed and curled. The foliage was smeared and dripping with "honey dew" and the apples were sticky. Aphids were feeding on the fruits, and many of the little apples were coated with the pests. Young apples that were attacked showed some roughening or pimpling at the calyces. On some of the larger fruits a reddish stippling occurred. The situation in this planting was so serious that an immediate application of an aphidicide was recommended, especially to the lower portions of the trees which at that time were overrun with the insects and were sustaining the most severe injuries.

In other plantings of standard varieties of apples, the multiplication of _pomi_ was not as rapid. The general situation, however,
appeared to be less satisfactory each day and, as it was likely to become serious, a note of warning was again sounded through the Farm Bureau advising apple growers to watch the trees, and, if the young fruits were attacked, to start spraying. Conditions later in the month seem to be more favorable for the trees and only local attacks were recorded; when suddenly, about the middle of July, the onslaught became intensified, and several growers in the vicinity of Holley requested immediate assistance as the green aphids were said to be causing serious losses in their orchards and neighboring plantings.

*Midsummer conditions.*—In response to these demands, the Station assumed the responsibility of advising growers as to the most efficient spraying practices. In order to meet more fully the situation, it was necessary to inaugurate a survey of the principal apple areas to ascertain to what extent the renewed attack was causing damages.

Beginning at the county line road west of Lyndonville and including the territory between the railroad and Lake Ontario eastward to the Monroe County line, the lice were breeding abundantly causing serious injuries in orchards not already sprayed and inflicting damage to a somewhat less extent in sprayed trees. Plantings of old and younger bearing trees were similarly attacked. The younger plantings of apples appeared to be more severely injured than the older trees, which was undoubtedly due to the greater susceptibility of succulent growth to the dwarfing influence of the insects.

The attacks of * pomi* in orchards in the section north of the Ridge road and extending to the railroad appeared to be only of individual significance.

In the section around Medina, Knowlesville and Albion, most of the larger plantings were being damaged by the lice. The infestation was not equally extensive or destructive in all orchards. In some of them single trees or parts of trees were attacked, and these injuries alone were sufficient to cause important reductions in the yields of apples. In such instances applications to the infested portions of each tree often secured the necessary relief. In a number of instances, especially where several varieties were interplanted, the blocks comprising early maturing kinds were likely to be more infested than later ripening varieties in adjoining plats. It was not
uncommon to find individual trees, or parts of trees, severely harmed by the lice, and the balance of the orchard with either no infestation or with a few areas only subject to attacks.

In the region to the east of Albion, and especially in the vicinity of Holley and Fancher, the conditions were apparently most favorable for the rapid development of the insects. In this section nymphs of *pomi* were so abundant during July that it appeared as if the pests were forced to go to the fruits as well as to the less tender foliage in an endeavor to sustain life. On July 18 the fruit clusters, terminals and young fruits were being blackened and deformed thru the activities of the miscreants, and the newer terminal growths were stunted.

In this section, cultivated orchards were badly injured. Neglected plantings or those subjected to less advanced orchard practices were ordinarily little harmed by the pests. Trees that were growing closely together and had interlacing branches with luxuriant foliage were more apt to harbor numbers of the insects than trees of the same age and size but with better air drainage. Plantings of comparatively young, bearing apples were in many instances less affected than larger trees of the same variety. The most notable injuries occurred in the larger bearing orchards where growth was luxuriant, and where the low-hanging branches prevented good air circulation. Coupled with this dense foliage was an abundance of water-sprouts, which are always centers of infestation even in normal seasons. Closely planted trees were invariably breeding centers for extensive numbers of the lice. One of the orchards visited serves to illustrate how the character of planting and succulent foliage present unusually favorable breeding areas for the insects. The trees here were originally set too close, and, eventually growing together, it became necessary to remove the alternate ones throughout the orchard. When the work was undertaken, the trunks were denuded of limbs and branches, and left to be removed as opportunity offered. During the past year these stumps, on account of the abundance of stems and water-sprouts, had again become sizable trees, in many instances occupying a large part of the space taken by the original trees. The woody growth was composed of medium sized succulent stems and older suckers. Such growths were found to be heavily infested with *pomi*, and it was believed that these were centers of infestation from which the lice had spread
to adjacent trees. The timely removal of the stumpy growths aided considerably as a supplementary measure in the work of suppressing the insects.

The apples most affected were Twenty Ounce, King, Duchess, Greening and Baldwin. No variety was immune from attack.

It was an interesting fact that there was a noticeable absence of predaceous and parasitic enemies of *pomi* thruout the entire region. In this respect the conditions were quite similar to those in the neighboring counties. Predaceous enemies and parasites did not increase in numbers until toward the end of July, when maggots of syrphid flies and parasitized *pomi* nymphs became abundant. They did not exert a marked deterrent effect on the lice until about July 22, when practically all the injuries to apples had been accomplished. At this time the force of the invasion was spent, and in orchards where no attention had been paid to the work of the lice little benefit accrued from the activities of these agents.

**CHARACTERISTICS OF THE OUTBREAK.**

*Effects on the foliage.*— The newly hatched nymphs of *pomi*, as is the case with other aphids, were attracted to the tender leaves of opening fruit buds or the more advanced terminal buds on non-bearing trees. As growth advanced, the lice continued to feed on the newer unfolding portions in preference to the older foliage. This feeding habit has, in ordinary seasons, often led casual observers to state that the species is an unimportant factor in the curling of the leaves. Nevertheless, it is evident that, even in those seasons, curling factors largely in the growth of young trees, and may result in serious injuries if, as during the past year, the aphids breed without restriction of their numbers by repressive agents. The colonization of the insects had a noticeable influence on the character of the injuries. During feeding, if only a few lice were on the leaves, little harm to them could be detected, while, in instances of a greater abundance of the pest, curling of the leaves was for the most part quite severe. The condition of early fall apples in the Station orchard was typical of the first attacks of the insects. Here the water-sprouts, attacked by colonies of *pomi*, were on May 25 badly curled and twisted, much like the characteristic work of *sorbi*. On younger trees and in nursery plantings, the leaves were incurred
and blackened, and the terminals became stunted. Where infestations were unusually severe, bushy growths often resulted. The curling was proportionate to the infestation, and varied from a slight incurving of the leaf margins to a pronounced curl, and in some instances a twisted effect was produced.

Bearing Greenings of moderate age became stunted, and the leaves yellowed and dropped. On older trees, the discoloration in most instances was not so evident. Terminal growths and leaf clusters showed marked evidence of dwarfing effects, however, and the development of fruit buds was considerably retarded. Late in the summer, buds on unsprayed trees lacked the plumpness of fully matured ones on uninfested clusters. Some trees exhibited a different type of injury which was indicated by a shriveling and stoppage of growth on the woody stems.

The attack was accompanied by the usual smearing of foliage with "honey dew." Scarcely an orchard was seen where these secretions were not dripping from the leaves, and even covering the ground beneath the trees. Accompanying the sticky condition the "honey dew" fungus was abundant. On trees of all ages this material coated both surfaces of the leaves. Leaf petioles, axils of the stems, buds and woody growths became blackened, which contributed to the generally unhealthy appearance of the foliage. The leaves also assumed a peculiar dark bluish-green color. This appearance was quite characteristic of infested plantings, and, even after the aphids became reduced in numbers, the foliage continued to be abnormal in color.

**Feeding activities on fruits.**—Early attacks by *pomi* on young stems and newly formed apples resulted in a stoppage of growth, and a dwarfing of the fruits. Accompanying the injury was a shortening of the axial diameter which produced a type of injury characteristic of this species. Around the calyx cavity the fruit was pimpled or the surface raised to form warts. Fruits attacked when quite small were usually dwarfed, and hung to the stems as "cluster apples." The stems became fixed, and affected fruits were often removed with difficulty. When the fruits had attained some size before infestation, the calyx was either flattened or pointed, humped or laterally distorted, depending on the variety of apple. Some apples exhibited a transverse flattening, usually on one side, while the opposite sector was always more plump than round. This
condition was more often found where the lice were protected at the points of contact of apples in a cluster or where leaves rested on the fruits. In some cases the surface was pitted or irregular and rough to the touch.

When feeding was of comparatively short duration, external malformations of the surface were not common, altho a dwarfing tendency was evident. In some instances red spots or stippling occurred on the skin of young apples, giving an appearance similar to that of fruits infested with San José scale. All the affected fruits were not stippled, but from the apples examined there was sufficient evidence to indicate that pomí is at least a causal agent in this particular blemish. It appeared that these fruits had been attacked at a period in their growth when the tissues were most susceptible to the reaction of some toxic material secreted at the time the surface was punctured by the aphids. The discoloration was external only, which differentiates this stippling from the spotting by the San José scale. (Plate VII.)

The pulp of pomí apples was of a mealy texture. In such fruits there occurred a distinct watery area just beneath the skin. In a bisected apple it appeared as a narrow marginal line, resembling in some respects the affection known as "water core." This margin was irregular in outline and in width. It almost disappeared in some instances, and seldom extended beyond the outer ring of the fibro-vascular bundles. Similar conditions have been found in apples injured by the rosy aphid.

The arrangement of the carpels, or seed cavities, was noticeably distorted. In cross sections of apples the abnormal structures were found on comparable sides of the fruits. Such carpels were seedless, or the seeds were deficient in strength, as was indicated by their size. Seeds, where present, were much smaller than those of normal fruits.

Injuries which resulted in the dwarfing or misshaping of apples occurred largely between June 15 and July 20. Rome apples infested on July 22 were undersized and blackened, but exhibited none of the curious shapes which accompanied the feeding earlier in the season. On August 1 twelve clusters of Rome apples were infested with a number of colonies of pomí. Each cluster, which comprised two or three fruits, was enclosed in a net bag, insuring a continuous infestation of the apples. These were picked on October 21, at
which time the fruits were coated with "honey dew" and blackened, but it was not apparent that they were on the average smaller than apples which had not been attacked by aphids. The interior structures of all the apples in the test were normal in every respect.

STUDIES ON CONTROL MEASURES.

PLAT EXPERIMENTS.

THE DELAYED DORMANT SPRAY AS A PROTECTIVE TREATMENT.

In our previous bulletins on apple aphids, attention has largely been directed to the benefits derived from the delayed dormant applications in protecting trees from newly hatched lice and their progeny. The migratory activities of the green apple aphis counteract in a measure the benefits from the early spraying as regards this species, altho it is believed that the bud spray exerts a strong repressive action on the multiplication of the insects. That the protection afforded cannot be relied upon to extend beyond the period indicated is shown by the June migration of adults. In view of the fewer cases of extreme infestation in orchards where the early application with nicotine sulphate was thoroly made, attention is directed to conditions which seem to indicate that the delayed dormant spray was in some circumstances a deterrent to the activities of the lice.

Five or more experimental plats in the vicinity of Albion are being sprayed each year to demonstrate rosy aphis control, using lime-sulphur and nicotine sulphate in the delayed dormant application. A slight infestation of pomì occurred in most of the tests. In three orchards only an occasional leaf or fruit cluster was infested. Foliage on terminal growths and water-sprouts was not badly injured and the leaves appeared normal in every respect. In one orchard neither sprayed nor check trees were infested. The fifth plat was a planting in which the only spraying made was to the trees in the experiment. In mid-June the treated trees were free from any infestation, but water-sprouts and terminals of the check trees were being quite badly injured by the pests. On July 18 the lice were being distributed over the experimental trees in sufficient numbers to make a supplementary treatment of the plat advisable. The balance of the orchard was severely injured by this time, but despite the reinfestation of the test rows, the condition of the checks stood out
strongly in contrast to that of the trees receiving the delayed dormant spraying. It is interesting to record in this connection the experience of an orchardist in the town of Kent. His planting is sprayed for aphids each spring, and ordinarily the chief sources of infestation are nearby orchards. In the rush of spraying in a block of 40-year-old Greening apples, three trees were inadvertently left untreated. On June 18 the leaves on these trees were gummy and badly curled, and the young wood was blackened. The lice were so numerous on the fruits that instances were rare where an apple was not entirely coated with the pests. The surrounding trees were consequently rather heavily infested. The attack, however, lessened in intensity as the distance from the center of infestation increased, and while some lice were scattered through the orchard the attack other than mentioned was not large.

Winged migrants were detected in the Station Rome orchard on May 31. A portion of the planting received a protective spraying, but it was observed at the time of picking the crop that the check trees were quite sooty, and gum still adhered to the apples; while the trees receiving only the bud spray were comparatively clean.

TESTS OF SUPPLEMENTARY APPLICATIONS.

Despite the favorable impressions conveyed by our observations in orchards receiving the delayed dormant spray, experience has indicated that the usual contact remedies, while efficient aphidicides, have a limited range of effectiveness when used against the green apple aphis, owing to its migratory habits. To counteract the cumulative injuries by this aphis and to provide some protection in orchards not sprayed early in the spring, it became necessary to find an aphidicide which would combine the insecticidal properties of the contact spray with some irritant preparation not harmful to the plant but objectionable to the insects. During the summer of 1914 a heavy lime wash in combination with nicotine sulphate was used with good results against the pear psylla. Believing that this combination would be of similar advantage in protecting apple leaves during a prolonged attack of pomí, experiments were conducted in the Station plantings during 1915 to test its merits.

Experiment 1.—The trees selected for the experiment were seedlings of standard varieties about five years of age, and, without exception, the foliage was luxuriant. On June 22, 1915, the terminal
growths were generally infested with adults and nymphs of *pomi*. As the lice had not become abundant, very few injuries had been effected. In this test 807 trees were sprayed or left as checks. The sprays applied were nicotine sulphate either with soap or in a heavy lime mixture according to the following formulae:

**Formula 1. Nicotine sulphate-Soap.**

- Nicotine sulphate (Black Leaf 40) .......................................................... 3/4 pint
- Fish-oil soap .......................................................... 4 pounds
- Water to make .......................................................... 100 gallons

**Formula 2. Nicotine sulphate-Lime.**

- Lump lime .......................................................... 60 pounds
- Copper sulphate .......................................................... 4 pounds
- Nicotine sulphate (Black Leaf 40) .......................................................... 3/4 pint
- Water to make .......................................................... 100 gallons

The weather during these tests was generally fair. A heavy rain followed the completion of the first day’s work, but subsequently conditions improved and continued favorable for some days after the treatments were made.

The several tests were:

**Plat I.** Preparations of the foregoing mixtures were applied to a total of 264 trees. Following a rain at night, 67 of these were resprayed with the nicotine sulphate-lime wash.

**Plat II.** The sprays were repeated on 533 trees in adjoining rows.

**Plat III.** On July 20 a block of 270 trees was resprayed, using the heavy lime mixture as before, the mixture being prepared according to the same formula except that the slaked lime was washed before mixing. This washing process consisted of allowing the slaked material to settle, after which the water was run off and fresh water added in the barrel. The washing was repeated twice before the material was applied. Some of the trees had received the earlier treatment with nicotine sulphate and soap.

**Plat IV.** A treatment with the nicotine sulphate-lime combination was repeated on 48 trees August 2. The purpose of this test was to ascertain if additional immunity could be obtained from aphids by a third application of the lime wash.

*Results of the experiment.—* Plat I. The two sprays differed little in effectiveness. The nicotine sulphate-soap spray was immediately effective, and nearly all the insects were destroyed. The only lice
not harmed were some scattering colonies so protected by the leaves that they were not wetted by the spray. The nicotine sulphate-lime wash was somewhat slower in action, but on the next day only scattering nymphs were alive, and these apparently were being bothered by the heavy coating on the leaves. The heavy rain immediately following this spraying washed the trees somewhat, which lessened the protection from subsequent broods of the lice. Counts of curled leaves were made three weeks later, and on trees sprayed before the rain 30 per ct. of the leaves were curled; while on those treated after the precipitation the amount of leaf-curl was reduced to 6.7 per ct.

Plat II. The difference between Plat II and Plat I consisted in the coating of the leaves with lime. The heavy coating continued to act as a deterrent until considerable new terminal growth developed. As the lice migrated from adjacent untreated trees to these terminals, the protection was in a measure lost. When compared with the nicotine sulphate-soap sprayed lot the benefit of the lime was apparent, as the soapy spray in no wise prevented a reinfection of the leaves, lice continuing to cause injuries to the trees during the summer. The leaves coated with lime were, however, free from the lice, and exhibited no tendency to curl. There was also a noticeable lack of "honey dew" and the accompanying blackening from the fungus was absent. The average amount of curled leaves on this plat, which received one application, was 7.5 per ct. for the lime-sprayed trees and 24.2 per ct. for the nicotine sulphate-soap combination. The trees receiving the latter treatment were not very different from the checks as regards the extent of malformed foliage.

Plat III. These trees received a second spraying with the heavy lime-wash, which added considerably to the amount of protection from the lice. In September a count of affected foliage on a number of trees indicated 3 per ct. of curled leaves on the trees sprayed twice as compared with 7.2 per ct. on those sprayed once. The checks in this plat averaged 22.1 per ct. distorted foliage. The application of the nicotine sulphate-lime following the earlier one with nicotine sulphate-soap was quite beneficial and, aside from the original curling, these rows appeared as well as the trees which had received the two lime sprayings. Washing of the lime resulted in almost entire freedom from the tip-burn, which was not uncommon
PLATE I.—EGGS OF Aphis pomi.
Lower, enlarged; upper, much enlarged.
Plate II.—Curling of Apple Shoot by *Aphis pomi*. 
Plate III.—Greening Apples Showing Characteristic Stunting of Fruits by *Aphis poni.*
Plate IV.—Misshaped Twenty-Ounce Apples Showing Roughening of Surfaces.
PLATE VI.—ROME APPLES SHOWING EFFECT OF HONEY-DEW FUNGUS ON LEAVES AND FRUITS.
PLATE VII.—RED STIPPLING OF GREENING APPLES BY Aphis poni.
PLATE X.—UPPER, UNSPRAYED ROME, SHOWING STUNTING OF FRUIT BUD. LOWER, BUD DEVELOPMENT ON ROME SPRAYED WITH NICOTINE-LIME WASH.
on the newer leaves of trees treated with the unwashed preparation. There was, however, an individual variation in this respect. The advantage from the washing was not, as a whole, considered sufficient to pay for the additional labor involved.

**Plat IV.** The third treatment with the lime combination killed all the lice hit by the spray and, as an additional protection, proved advantageous, altho the force of the outbreak was spent, and the season's growth was already quite woody. This application in some seasons would undoubtedly be of value, especially on young trees where the attack was unduly prolonged.

**Experiment II.** Six standard bearing apples were sprayed on July 10, 1915, using the nicotine sulphate-lime formula. One-half of each tree was treated, while the other section served as a check. A second application was made on August 2. All the trees were carrying quite a crop of fruit, and it was interesting to note the differences in the conditions of the sprayed apples and the checks. The unsprayed portions of the trees were considerably blackened, and the leaves were sticky. The apples caught some of the dripping "honey dew," and were likewise discolored. On the other half each tree bore fruit that was clean and of a high quality. The only sediment was some that was forced into the calyces at the time of spraying, and their later inverted positions prevented the rain from removing the particles of lime which continued to adhere in small amounts to the blossom ends of the apples.

**Experiment III.** On July 10, 1915, six apples of standard varieties on dwarf stocks were sprayed with the nicotine sulphate-lime wash. The trees were about 17 years of age, and that year bore a good crop of apples. The test was to ascertain the effects of the spray on the leaves and fruits as well as on the aphids. To provide a check, one-half of each tree was untreated. On August 2 the treated half of each tree was resprayed. In these tests the leaves, especially the terminals, were protected by the application. Curling of the leaves was unimportant, and none were injured after the spray was applied. The coating on leaves and fruit wore off to some extent, but it continued to function until the time of treatment in August. The respraying added appreciably to the protection of the foliage, and after the spraying the lice were not a factor in this planting. The effect of the lime on the fruit was not injurious, and at picking the only traces of the coating were a few granules in the calyx
cavities or at the stem ends of the apples. Whatever deposit remained in no wise affected the marketable value of the fruit.

EFFECT OF LIME ON QUALITY OF APPLES.

Aside from the protective value of the nicotine sulphate-lime spray, some hesitancy may be felt in using the material on bearing apples, due largely to the question of its adhesiveness to the fruits. To provide data on the conditions of treated apples at harvesting, sprayings were made with this wash in comparison with the nicotine sulphate-soap combination. The tests were made during 1916 and 1917 in the Station apple plantings as follows:

Test I. On June 1 and 2, 1916, forty trees about thirty years old were sprayed, using nicotine sulphate with either lime or soap according to the foregoing formulae. In the nicotine sulphate-lime spray two gallons of lime-sulphur solution replaced the copper sulphate as the adhesive. Portions of these trees were resprayed on June 22, using only the heavy lime combination.

Test II. Sixteen Rome apples about twenty years old were sprayed on July 10, 1917, with either lime-sulphur and nicotine sulphate in the usual proportions or the nicotine sulphate-lime wash. Arsenate of lead was added to each mixture for late larvae of the codling moth.

In both tests pomi was not a serious factor. During each year enough lice were breeding on terminal shoots, leaf clusters and water-sprouts to cause curling of leaves and smearing with "honey dew." The fruit on unsprayed trees was usually normal in size, but became more or less streaked and discolored as a result of "honey dew" dropping from the leaves.

In Test I the trees had an abundance of apples. The fruit and foliage were thickly coated with lime as a direct result of the application. The trees sprayed twice had a proportionately heavier coating thruout the summer than those treated earlier. It appeared that, where applications were made as early as June 1 and 2, the covering did not give sufficient protection to either leaves or fruit, altho it provided a film well into August. Lime from the second spraying remained on the fruit thruout the season. The coating, which was heavy during July, gradually disappeared, and at harvesting only that which had collected in the blossom end remained on most apples. On the variety Greening a film of lime
usually remained on the skin, altho this was largely removed by handling at harvest. The lime on these apples in no way affected their marketable value, and some of these fruits were used for exhibition purposes without being cleaned.

Test II was conducted in the Station planting of Rome apples. The attack of pomi was of small proportions, altho the check apples were all more or less discolored from the effects of "honey dew" dripping from the upper centers of infestation. The fruit on the rows receiving lime-sulphur and nicotine was freer from aphids than the checks. The attendant blackening from "honey dew" remained, with the result that, at harvesting, these apples were not much different from the checks. Those treated with lime, however, had an entirely different appearance. The surfaces were clean and of normal coloration, and in October only a few particles of the lime remained. The contrast was quite striking since, when the fruit was sorted, all but a few lime-treated apples were classed as Grade A. When the black, sticky fruit on both the checks and trees receiving lime-sulphur and nicotine was rejected, it was estimated that sufficient loss had been sustained to have paid for spraying the balance of the orchard with the nicotine-lime wash.

LIME AS A DETERRENT TO POMI ATTACKS.

Test No. I. During the first week in June, 1918, breeding of the lice indicated the probable occurrence of destructive numbers of the pests. Warned by their abundance, the Station Rome orchard was sprayed with the nicotine-lime wash as a protective measure. The application was made on June 12 and 13. At this date breeding of the lice was abundant, but there were no injuries except an occasional curled leaf.

Test II. This experiment was a comparative test of the nicotine sulphate-soap and nicotine sulphate-lime combination sprays on young trees. The sprayed block comprised 130 trees about eight years of age, several of which had commenced to bear fruit. The mixtures were applied on June 12 and 13. The foliage injury at this date was unimportant.

Results of the experiment.—In both tests the protection from the outbreak afforded by the lime was striking. The nicotine sulphate-soap application destroyed the aphids originally present, but was of no value as a protective agent. The trees sprayed with the
soapy solution were eventually reinfested, and at the peak of the outbreak were not different from the checks in appearance. The rows in each orchard that received the nicotine-lime combination spray were quite free from lice when they were most numerous on check trees, and the coating was sufficient to act as a deterrent to the insect activities on the trees. The foliage in each instance was flattened and luxuriant, which compared favorably with the sooty curled leaves of trees in the unsprayed block. The new fruit buds on the checks in the older planting became stunted. In September they were undersized, and lacked the vitality of the plump, normal appearing buds of the lime-sprayed Romes. These characteristic differences are shown in Plate X.

The benefit from the treatment to the larger bearing trees was chiefly noticeable at picking, when the check apples were sticky, blackened and streaked like the fruit in Plate VI. The apples from the lime-sprayed block were larger as a rule at the time of harvesting than the checks, and entirely free from discolorations similar to those on the untreated apples. The single spray on the young trees warded off the destructive attacks of the lice until late in July. After that period, and as the unprotected new growth unfolded, much of the benefit of the application was lost. This experience afforded an excellent illustration of the number of treatments young, luxuriantly growing trees may require if the first application is made as the lice appear on the trees in June. The more extended period of immunity of leaves and fruits on the older trees was possibly owing to their size and heavy foliage, which hindered the washing effect of the heavy rains of early summer.

CONTROL OF INSECT IN ORLEANS COUNTY ORCHARDS.

STATION EXPERIMENTS.

In answer to the request for assistance from apple growers in Orleans County, this Station instituted orchard experiments to ascertain whether the soap spray or lime wash would prove effective mixtures in such an emergency. In these tests, the nicotine sulphate was increased to one pint for each one hundred gallons of spray. This change from the standard recommendation was arbitrary, and was prompted by the belief that the additional tobacco would
appreciably aid in ridding the trees of the older lice which might be able to recover from the toxic effects of the weaker spray.

Test I.—The two sprays were applied to twenty-one trees in the orchard of the Donahue, McCrillis, Mack Company, Holley. These trees are about fifty years of age, unusually high, and have widespread branches. The foliage was dense, and was severely injured by the insects. When the sprays were applied on July 19 the apples were black and roughened, and the new fruit buds were backward in development. The lice were so plentiful that on some fruits the color was obscured.

To wet thoroughly both surfaces of the leaves, an average of twenty gallons of the nicotine sulphate-soap spray was applied to each of fifteen trees. The nicotine sulphate-lime mixture having less surface tension, more of it per tree was required on the average, and consequently only six trees were treated with the same amount of spray as was used with the preceding lot of trees. As a result of the drenching they received, both leaves and fruits were rather thickly coated with the material.

Results.—The killing properties of the nicotine sulphate-soap spray effected immediate control of the infestation. The lime-wash was somewhat slower in action, but the next day no differences in the effectiveness of either spray were noted. On the row sprayed with nicotine sulphate and soap the fruit and leaves continued to be blackened with the "honey-dew fungus." The apples and foliage of the other plat were coated with the lime, which remained well into the autumn. On September 17 a film of lime was yet adhering to the fruits, altho it was largely washed from the leaves. These trees, however, looked much more healthy than those having the soap spray. The leaves and fruit on the latter were somewhat oily in appearance. Altho they had recovered much of their normal shape there was, on the whole, a noticeable difference in the condition of the two sprayed blocks. On both plats the apples at picking time had largely become normal in size. Some trees in the orchard served as checks, and the fruit on them was mostly undersized and misshapen. As compared with these, the sprayed rows produced a large crop of high-grade fruit which, if the treatment had been neglected, would have been as worthless as the apples on the unsprayed lot.
**Test II.**—On July 18 forty trees in the fifteen-year-old Greening orchard of Mr. B. G. Wilson, Carlton, were sprayed either with nicotine sulphate and soap or the nicotine sulphate-lime wash. The amounts of lime used in this test were forty pounds in each hundred gallons of spray. The trees, which were well fruited, were, on this date, being seriously damaged by the lice. Aside from the curling of the leaves, the foliage and fruits were dripping with the "honey dew" and were heavily coated with sooty fungus. It was impossible to pick a normal apple, and individual trees were so badly injured that bud development was checked, and terminal growths were stunted. The amounts of materials required to thoroly drench the trees varied somewhat. On the average, there were required $8\frac{1}{2}$ gallons of the soap spray and 10 gallons of the heavy lime material respectively for each tree. This disparity was owing to the difference in the spreading qualities of the liquids, as the trees themselves did not noticeably vary in size.

Results.—After spraying operations had been completed, it was seen that the soap solution had destroyed the pests on trees receiving that application, and on the following day no lice were alive on the lime-sprayed plat. The lime coat was not as heavy as on trees treated with the usual formula, and the deposit was more film-like in general appearance. Both leaves and apples were well coated with the spray.

On July 22 both plats were equally clean. Even in the areas of most severe infestation and in curled leaves the lice were dead. On September 16 the apples had improved greatly in size, and both plats had few fruits which showed injuries from *pomi*. The lime had washed from the apples and leaves, and they were entirely free from the early discolorations. On the soap-sprayed row the dead lice yet adhered to the fruits, which were black, sticky and streaked as when the infestation was at its height.

COOPERATIVE EXPERIMENTS IN COMMERCIAL ORCHARDS.

**Example I. Orchard of the Donahue, McCrillis, Mack Company, Holley.—** This is the planting in which the Station experiment was located, and it comprises about 150 trees of the varieties Baldwin and Greening. The orchard was originally closely planted, and after fifty years the trees had attained considerable height, and had wide-spread branches. As the tree growth became entangled,
the alternate trees in each row were shorn of their branches, but the trunks were allowed to remain. In the course of a few years these were covered with new growth. During the past summer these trunks had become bushy trees of considerable size, and the succulent branches were so abundantly infested with pomp as to cause practically all the leaves to curl and drip with "honey dew." It was evident that these "stubs" were the chief centers of infestation in this orchard, and, at our suggestion, they were removed. Spraying was accomplished on July 18 and 19, using nicotine sulphate and soap in the proportions of one pint of the nicotine solution and four pounds of soap to one hundred gallons of water. The trees were drenched with the spray, and, on the average, each received twenty gallons of the solution. Owing to the extreme height of the trees, it was necessary to use a high pressure equipment to force the liquid to the tips of the highest branches. The interesting feature in these operations was the use of two spray guns instead of one as is ordinarily practised. (Plate VIII.) This outfit made it possible to spray beneath the limbs and on the outside branches simultaneously, thus making a thorough application without causing undue delay.

The results of the treatment in this planting were immediately noticeable, and on July 20 no insects were alive in the sprayed section. By July 27 the trees had begun to recover from injuries, and new leaves were unfolding on terminals that had been previously injured by the aphids. While dead insects and "soot" adhered to fruits and foliage, no new infestations were found. The apples for the most part overcame the lesser injuries so that, at an examination on September 16, such fruits were well developed and had lost the initial deformities. As a rule the fruits were of excellent size, and the crop of apples was one of the best in the section. What might have occurred had no spraying taken place was well illustrated by several trees which were quite difficult to treat. These at harvest bore apples of only inferior grade and size, many of which were typical pomp fruits.

Example II. Orchard of Dayton True, Holley.—In this planting, 183 Duchess and Baldwin apples were being severely attacked by pomp early in July, and at that time it was estimated that 25 per ct. of the fruits were injured. Individual trees between forty and fifty years old had been pruned so that the branches did not overlap to any extent. Other trees of the same age and variety had received
very little attention in this respect, and the woody growths were
more or less intertwined. Water-sprouts were abundant under these
conditions, and the foliage was dense. In such instances, the attacks
of *pomi* were causing serious injuries to apples on July 7, and the
leaves were sticky and discolored. The heavily pruned trees with
more open foliage were less injured by the aphis, and it appeared
that, in this planting at least, air drainage was a considerable factor
in the extent of the infestation by the lice. Water-sprouts under
these conditions had comparatively few centers of infestation.
Spraying was begun on July 7 with nicotine sulphate and soap in
the proportion of one pint of the nicotine and four pounds of soap
to one hundred gallons of water. The plan of treatment adopted
was to spray only the trees or those portions of a tree where the
fruits were being attacked. The aphidicide was applied each day
as was convenient. On July 22 only dead lice were found on the
sprayed trees, and the work had been so thoro that even lice in
curled leaves were destroyed. The fruits, especially those of the
earlier maturing kinds, exhibited considerable roughening on the
surfaces, and many were abnormal in shape, and pimpled. On
September 16 the apples had largely recovered from injuries inflicted
by the aphids, altho the surfaces of the apples in a number of
instances were pitted. Visually, such fruits did not exhibit abnormal
characteristics, and the blemishes were detected only by the sense
of touch. The fruit at picking time failed to show many of the
earlier deformities, and the ultimate losses were comparatively small.

*Example III. Orchard of D. A. Salisbury.*— There were 375
Baldwin trees in this orchard, the majority of which were about
forty years old. As is common in plantings of this age, the trees
had attained an unusual height, and had wide-spread branches.
The foliage was luxuriant, and on it the lice were breeding in remark-
able numbers. So abundant were the aphids that the leaves, twigs
and fruits literally dripped with "honey dew," and had become
coated with the "fungus." On July 16 and 17 about 250 trees
were sprayed with the nicotine sulphate-soap solution, using one
pint of the tobacco extract and four pounds of soap in one hundred
gallons of water. The trees were thoroly drenched, and within
a few hours after the application an examination showed only a
very small number of living aphids. On July 22, in addition to
an improved condition of the orchard, the fruits themselves appeared
to have recovered to some extent, and their uneven surfaces were becoming smooth. By harvest the apples generally had become of good size, and an earlier crop estimate of 10 per ct. shrinkage, owing to lice injury, appeared much too large. Fruits which were pimply had become smoother, but they were not entirely free from blemishes. Apples which were severely injured did not entirely recover from the effects of the insects' attacks, and at the time of picking were thrown out as culls.

Example IV. Orchard of Mrs. George H. Rolffe, Lyndonville.—In this planting some 70 Baldwin apples were badly infested with pomi. The trees, which were about forty-five years old, had been allowed to grow until at the present time the height and interlacing of branches has made it difficult to spray them thoroly. The work of the aphids on leaves was not as severe as in some of the other plantings. The fruits, however, were being attacked, and restricted areas of the foliage bore a sickly appearance. The lice seemed to be increasing in numbers on July 19, and, as a precautionary measure, the orchard was sprayed, using the nicotine sulphate-lime mixture as the aphidicide. Owing to the conditions of the infestation, special attention was given to those parts of the trees which seemed to be the most severely infested. The amount of wash necessary to cover the trees in this manner was 1600 gallons, which averaged 22.8 gallons per tree. When the orchard was examined on July 22 it was estimated that from 85 per ct. to 90 per ct. of the aphids were dead. At harvest the benefit of the whitewash was apparent in the clean appearance and high color of the fruits. Apples from untreated trees were at that time distinctively sooty, sticky and discolored, and in general were below the normal size for the variety.

Example V. Orchard of E. M. Mower, Carlton.—This orchard comprises about 500 Baldwin trees of good size with luxuriant foliage. Owing to the great abundance of the lice, serious injuries were showing on the apples when they were treated early in July. Some doubt existed on the part of the orchardist as to the practicability of sprays on trees of that size, and only one-half of the planting was sprayed. The balance of the orchard received no treatment. The sprayed section was treated with the nicotine sulphate-lime combination spray, which was used in liberal amounts and very carefully applied. When this orchard was examined on
September 16 the difference in the two parts of the orchard was particularly striking. Apples and foliage on the treated section were clean, and showed but slight traces of aphid injury. On the unsprayed trees the apples for the most part were pimpled and distorted, and the remainder of the crop was undersized. The crop on this plat was practically worthless as the apples did not attain normal size, and the flesh, even of those not noticeably affected, was quite coryk in texture. The foliage was black and discolored, and the buds on fruit clusters were undeveloped. The loss occasioned by the failure to make a complete spraying was heavy from a financial viewpoint. On the other hand, an orchardist is seldom given so apt an illustration of the benefits which may be derived from properly timed applications of insecticides where the work is entirely within his control. The results from his own test led Mr. Mower to state emphatically that he was convinced that the entire planting should have been sprayed, and that hereafter he will not hesitate to treat the trees, using the thickened wash as the carrier for the nicotine solution.

OPINIONS OF ORCHARDISTS ON THE SPECIAL SPRAYING.

The application of experimental results to orchard needs is most satisfactorily attested by growers in adopting these newer ideas into spraying practice. The extensive spraying operations by many apple growers in Orleans County against the green apple aphid provided an excellent opportunity to ascertain if the work accomplished in the experimental plats could be repeated under common orchard conditions, or was considered practicable by individual growers. To collect these facts, the Orleans County Farm Bureau issued a questionnaire to be filled out in connection with the regular spraying service report. Nineteen fruit growers reported benefits from spraying, three men made no statement, and one grower reported that the application was detrimental. It is interesting to note in this connection that of those reporting success, eight orchardists were so confident that benefit had been derived that they offered an estimate of the increased value of the apples as a result of the treatment. The reports showed that the operations were conducted without financial losses, and all but one report showed a wide margin of profit.
COMPARATIVE COSTS OF SPRAYING.

The adoption of a regular spraying program depends in large measure upon the outlay for materials and labor. Some growers, thru the exercise of an unwise reliance on the element of chance, sometimes appear to secure large returns for a minimum outlay on spraying. Men who have obtained the greatest success from a financial viewpoint rarely adopt such a precarious program, but aim rather to grow clean apples regardless of the initial expense if it is within reason. To such men, an additional spraying for the green apple aphid was a matter of insurance in which the premium was expected to be amply repaid.

As previously stated, two types of aphidicides were used in the experimental efforts of the season. The nicotine sulphate-lime combination, besides being a killing agent, acted also as a repellant. The nicotine sulphate-soap solution was relied upon for immediate results, especially on trees of great size. The expense connected with either spray depended entirely upon the sizes of the trees and the proportion of smaller ones in plantings of older apples. Obviously some large trees bore a greater initial expenditure than younger or lower-headed trees. The outlay for generous applications to the large trees has been deemed by different growers as excessive. The use of quantities of a contact spray sufficient to secure positive results necessarily does increase the cost, but not usually in proportion to the benefits secured from the treatment. To illustrate the spraying outlay under average orchard management, the expenses in the sixteen orchards and smaller plats in Table II will serve to show the distribution of the charges against the special treatment in representative plantings.

It will be seen that a wide variation exists in the expense of spraying. The individual equation largely functions in these seeming discrepancies, and is responsible in a measure for failures to check insect outbreaks. Despite the differences in amounts of spray applied per tree, these orchardists claim to have controlled the aphids; but it is also evident that on trees of similar size the application of large amounts of spray must have produced a wider margin of safety than where minimum dosages were applied. In the Station experiment (No. 10) the excessive cost of the lime was due to
the extreme size of the trees and the severe infestation which required an extra careful treatment.

Table II.—Relative Costs of Spraying Mixtures.

<table>
<thead>
<tr>
<th>Number of orchard</th>
<th>Number of trees</th>
<th>Age of trees</th>
<th>Materials used</th>
<th>Cost of spray and labor.†</th>
<th>Cost per tree.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>325</td>
<td>6-50</td>
<td>Nicotine sulphate-lime</td>
<td>$23.00</td>
<td>$0.04-$0.13</td>
</tr>
<tr>
<td>2</td>
<td>104</td>
<td>10</td>
<td>“</td>
<td>16.87</td>
<td>.16</td>
</tr>
<tr>
<td>3</td>
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* Station experiments. † Including team hire.

Practicability of Spraying.

To supplement the figures on cost of operations, a personal letter was sent from this Station requesting opinions of fruit growers on commercial factors entering into the problem of aphid control which could be published with this bulletin. From eight replies the following excerpts have been taken:

Letter No. 1.—Mr. Dayton True, Holley, writes: "During the week of July 7, after I had applied the fourth regular spray, the aphid began to appear in such quantities as to seem a serious menace. I sprayed with the usual formula of nicotine sulphate and whale-oil soap, adding arsenate of lead for the benefit of such stray codling moths as might appear. I gave the trees a thorough drenching, using two leads or nozzles, one playing underneath the trees, the other from the tower above, drenching so far as possible contra to each other. From what I could see we killed about 90 per ct. of the aphid by this method. I noticed the trees that are openly trimmed were much less affected than the thick, bushy trees. I
noticed that the ground suckers and main crotch suckers are the starting point for these aphids in every tree, and the deduction to be drawn is obvious."

Letter No. 2.—Mr. Dan A. Salisbury, Holley, replied as follows: "About June 1 the aphid was first noticed in our orchard, and appeared only in some parts, but not covering the orchard as a whole. Not knowing what to do, I used as strong a solution of lime-sulphur as I dared. This had no noticeable effect in checking the spread, and finally, upon close inspection, I found the young fruit literally covered with the green aphids. Upon the advice of Mr. Steele, our county farm bureau agent, I used a solution of 2 pounds vitriol, 1 pint nicotine sulphate and 40 pounds of lime to 50 gallons of water. I think that this spray helped to check the aphid, but about two weeks later I used a solution of whale-oil soap and nicotine sulphate, 10 to 15 gallons to each tree, and the results of this spray were wonderful. This spray was applied on July 4. I harvested a crop of 1608 barrels of Baldwins, three-fourths of which would classify as No. 1. I am thoroughly convinced that, had I not checked the aphids, my crop would have been practically ruined, and I attributed the saving of the apples to the close cooperation of the Experiment Station and the Farm Bureau."

Letter No. 3.—Mr. Thomas Mack, Holley, replies: "The green aphids were getting the best of my apples when I started to spray about the middle of July with lime and nicotine sulphate. The trees in my orchards are so tall that it took too much of this material to cover them, and after spraying several I adopted the tobacco solution with soap, as was recommended. Either spray will kill the lice. I think the lime and tobacco would work better on smaller trees. The spraying destroyed about 75 to 80 per cent of the lice. In fact, they were so well cleaned out that the apples and trees recovered, and very few aphis apples were thrown out of the barrels. The crop was excellent, but the few apples sprayed with lime were somewhat coated at picking time. I would not want to use it on a whole crop. Another year I would spray earlier, using the soap and tobacco, which covers easier and kills quicker on trees the size of mine. My success was due mostly to the use of the large sprayer. In our orchards an ordinary rig does not give enough pressure to spray the tops of the trees. With lots of
pressure and drenching of the trees there can be no question as to
the control of the lice. In my experience spraying certainly paid."

Letter No. 4.—Mr. B. G. Wilson, Waterport, sent the following
interesting letter: "We sprayed four varieties of apples: Greennings, Baldwins, Wealthy and Duchess of Oldenburg. The
trees are 13 years old. Regular sprayings were made, first, when
dormant, with lime-sulphur 1 to 8; second, in the pink, using lime-
sulphur with nicotine sulphate; third, the calyx spray; and fourth,
two weeks later. After that the green aphids came. We sprayed,
using the Station formula for nicotine sulphate and excess of lime.
Where thoroly done, this is very effective. Nicotine sulphate
and soap is good. I haven't the cost of spraying for aphis, but it is
very small in comparison with the results, as our apples were entirely
free from lice injury. I certainly would spray again if we should
have the green aphids, using nicotine sulphate and lime as soon as
I thought they were coming in any quantity. The story was circu-
lated that my crop was spoiled, but I never had such a fine crop of
clean apples as I picked this year."

Letter No. 5.—Mr. Ora Lee, Albion, sent the following description
of his spraying operations: "Early in July the lice appeared
in considerable numbers on a 5-acre, 5-year-old orchard of Greening
and Twenty Ounce apples, and on the insides of old bearing Greening
trees; also a few on Baldwin and others in a 4-acre orchard. They
gradually increased until on July 16 I deemed it advisable to spray.
At that time the young trees and new wood on insides of old Greenings
were quite seriously infested. We applied three tanks (300 gallons
each) of spray as follows: 300 gallons water, 3 pints nicotine sul-
phate, 6 pounds copper sulphate, 150 pounds lime, thoroly drenching
the young trees and giving particular attention in the old orchard to
the insides, especially the water-sprouts. The following day, after a
very careful inspection, I estimated that over 95 per ct. of the lice were
killed in both orchards. They did not reappear in sufficient numbers
to cause any worry. We got them before they had caused apparently
serious injury except to fresh growth of water-sprouts in the shady
interior of old Greenings which, in some instances, they trimmed
completely. After the spraying they did not get to the fruit or
fruiting parts of old trees in serious numbers, and I could not at
any time see that they injured the apples to any appreciable extent.
In fact I credit this and the pink spray which I applied this season, for the first time, for the best quality apples I have ever had. Two or three years ago I had a quite serious infestation in the young orchard, and at that time on the smaller trees got at least 99 per cent. of them with the old lime-sulphur-nicotine sulphate mixture, so that, from my own observations, I am inclined to the idea that success in catching green aphids depends very largely on the ability to hit the lice with nicotine extract regardless of what it is mixed with.”

*Letter No. 6.*—Mr. Robert Burke, Kendall, writes: “We sprayed our 9-year-old apple trees with the nicotine sulphate-lime mixture for green aphids on July 17 and 18. We drenched the trees and killed the aphids with apparently good results to both fruit and foliage. The apples were very fine when picked, and the leaves on the trees were healthy. The material used was 60 pounds hydrated lime, 1 pint nicotine sulphate, 2 pounds blue vitriol, 100 gallons water. The wash was applied with a spray gun.”

*Letter No. 7.*—Mr. William Thiel, Lyndonville, writes: “I can safely say that 60 pounds lime and 1 pint nicotine sulphate to 100 gallons water will control the green aphis. I used this in one of my orchards with good success, just spraying from one way from the ground. I could not get any more lime so I used the nicotine sulphate with the lead and lime-sulphur spray, working from both sides with but little success. I will recommend lime and nicotine sulphate above everything else which I have heard of as yet. It also took the place of the usual July scab spray. From my experience I consider this spray beneficial to the orchard.”

*Letter No. 8.*—Mr. Clarence F. Powley, Lyndonville, replied: “In regard to the green lice last summer, I used nicotine sulphate, lime-sulphur and 32 pounds of lime to 100 gallons of water. The next day I examined some of the trees that were sprayed the day before and I am satisfied that 75 per cent. of the lice were killed. They would have ruined my crop of Greenings and Kings if allowed to continue feeding. As it was, there were 540 barrels of Greenings and 100 barrels of Kings. I can recommend the nicotine sulphate and lime as an aphid spray.”
DISCUSSION OF RESULTS AND SUGGESTIONS FOR FUTURE SPRAYING OPERATIONS.

It was apparent that of the two sprays under consideration the nicotine sulphate-soap solution was the more quickly active. After a few hours from the time of application, no difference in the effectiveness of the two mixtures was noticeable on well-sprayed trees. On account of its greater spreading properties and rapidity as a killing agent, many growers prefer the nicotine sulphate-soap spray, especially on trees of great height and with wide-spread branches.

Small bearing trees sprayed with the soap solution were gummy and black at harvest. This was not as noticeable on trees of great size, and it appeared that the wealth of succulent stems and leaves was responsible for a situation on the younger stocks which was almost beyond comprehension. In the Station test on 13-year-old Greenings the fruits on those treated with nicotine sulphate and soap were no cleaner in September than unsprayed trees in the same orchard.

On trees of moderate size and of an age less than 25 years the nicotine sulphate-lime spray was not only efficient, but the coating served as a repellant, and prevented the harboring of lice, especially on the more tender foliage. Small trees protected in this manner did not produce the bushy terminals common to aphid activities. Older fruiting apples also exhibited a similar freedom from the stunting by the insects, and in addition the fruits were clean and free from the sooty, sticky accumulations that usually accompany attacks by lice. In certain instances mechanical difficulties were responsible for a reduction of the amount of lime in the formula. When thoroly applied it was found possible to decrease the quantity of hydrated lime to 40 pounds in each 100 gallons of water and secure good aphis control on young trees.

A number of growers claimed that the nicotine sulphate-lime wash did not cover the foliage of tall trees as well as nicotine sulphate and soap and not only was more difficult to apply but the actual spraying of a tree took more time. Cost of material entered also into the considerations. From our experience in actual orchard operations on very large trees, these criticisms appear to have been well founded altho the cleansing effect of the lime should have received more attention.
Owing to the greater ease of application and its covering properties, orchardists judge that the nicotine sulphate-soap solution will be most generally used on trees of extreme size. The range of usefulness of the nicotine sulphate-lime wash, due largely to its added cost and lesser surface tension, is apparently restricted to trees of moderate age. Its field is more that of a deterrent and cleansing agent than of a strictly contact remedy. The efficiency of either aphicide is not questioned.

The value of the delayed dormant application is indicated only, and, while plantings having this treatment were apparently better able to withstand the onslaught, this early spray cannot be depended upon owing to the migratory habit of the aphids in late spring.

Orchard operations showed conclusively that important injuries from the green apple aphid may be practically obviated by proper spraying. These tests also served to crystallize the opinions of apple growers as to the comparative merits of special sprays for the control of this pest as well as to demonstrate more clearly than heretofore the conditions under which spraying should be done to obtain efficient results.

REDUCTION OF SPRAYING LOSSES.

Fruit growers have been taught that a mist-like spray is proper for making the usual applications in the spraying schedule. While such treatments with poison sprays are, when carefully made, quite efficient, it is often necessary to use coarser drenching sprays against certain insects, as aphids, pear psylla, etc. Insufficient quantities of spray are often a waste of materials, altho in some instances the failures to control an insect are due as much to lack of care in making the applications as to inadequate amounts of material. Spraying with the nicotine sulphate-lime wash provided a number of interesting examples of such oversight. In these instances the trees, instead of having a whitewashed appearance, were streaked, and invariably such efforts to control lice were ineffective.

Difficulties in covering trees of great size provided an excuse for fruitless attempts in *pomum* control in old orchards. If the season's experiences are reliable criteria, there appears to be little justification for such criticisms. It has seemed that, wherever the men doing
the work were correctly informed as to the purposes of the spraying
and the activities of the insects, greater interest in the work was
aroused, which invariably led to more effective results. Machines
with insufficient power to deliver a large volume of liquid or unsatis-
factory types of nozzles were probably larger factors in spraying
than was generally suspected. Orchardists who gave little attention
to these various details often met with failures to control the green
aphis. An indispensable factor in efforts to combat aphids, how-
ever, is efficient machinery, which, in a measure, will overcome
many unpleasant features connected with ordinary spraying
operations as well as render more effective service.

TIMING SPRAYING OPERATIONS.

The proper timing of spraying operations against the green aphis
is puzzling to many apple growers. The outbreak of 1918 would
in all probability have been checked in its incipiency if control
measures had been adopted at the outset. It is difficult to judge
in early June the extent to which the later breeding of *pomì* may
become a serious factor in orchard economy. Probably in most
seasons spraying of older bearing apples for this pest is unnecessary,
al tho in young plantings some treatment might be profitable.

The flight of winged migrants during the last week in May or the
early days of June is a good indication of the approaching spraying
period. To prevent injuries to the tender stems of young trees,
an application of the deterrent wash at this time will be useful.
The lime mixture should be repeated as the newer terminal growth
appears, and unprotected leaves become reinfested by the lice.
In older bearing orchards the infestation of terminals and leaf
clusters serves as an indication of unusual breeding of the insects,
and applications of the repellent spray under such conditions may
prove helpful. If, however, the green aphids begin to attack the
fruit clusters, the work should not be delayed, al tho from observations
during 1918 it appears advisable to wait until the lice begin to feed
on the stems and young fruits before starting spraying operations.
In any circumstance the grower should not wait until the apples
are gummy or blackened before securing reliable instructions as to
the advisability of making the application.
SPRAYING MIXTURES AND FORMULAS.

Formula 1. Nicotine Sulphate-Soap Solution.

Nicotine sulphate (Black Leaf 40) ..................................... ¼ pint*
Soap ................................................................. 4 pounds
Water ................................................................. 100 gallons


Stone lime ............................................................. 60 pounds†
Copper sulphate ...................................................... 2–4 pounds
Nicotine sulphate (Black Leaf 40) ..................................... ¼ pint*
Water ................................................................. 100 gallons

Slake the lime slowly to make a good milk of lime free from coarser particles. Causticity may be lessened by preparing the lime a day before using. The dissolved copper sulphate should then be passed into the diluted lime wash, after which the diluted nicotine should be added. If the attacks of lice are severe, increase the amount of nicotine sulphate to one pint.

DIRECTIONS FOR SPRAYING.

Rather coarse sprays in copious quantities are essential in order to obtain efficient control of the green aphid. With the lime wash, especial care must be taken to coat both surfaces of the leaves as well as the young apples, or else the grower will not obtain the greatest benefit from this treatment. Thoro applications of either spray are necessary as the insects must be hit by the liquid, or killing will not result.

CONCLUSIONS.

The green apple aphid lives on apple trees thruout the year. On account of a late spring migration of winged forms and the later breeding of the insect, the pest is difficult to control by a single spraying in the season. If control measures are unduly delayed the insect activities may result in severe injuries, as curling of leaves or deforming of fruits.

Curlled foliage and the stems of fruits as well as the clusters of apples afford hiding places for the insects, which are difficult to reach by the spraying mixture unless it is applied generously and with considerable force. Applications of coarse sprays in liberal quantities are necessary to thoroly wet the leaves and the insects.

* During periods of severe attacks increase the amount of nicotine-sulphate to one pint.
† Hydrated lime may be substituted.
Such treatments often reach aphids that escape mist sprays, and by thoro and timely spraying the summer broods of the lice can be controlled even on trees of considerable size.

The delayed dormant spray, by protecting the trees from early infestations of the lice, diminishes the opportunities for serious reinfestations from late spring migrations of the insect.

The nicotine sulphate-soap spray is a very satisfactory aphicide on account of rapidity in killing, ease of application, and its spreading and adhesive properties.

Nicotine sulphate and lime is especially advantageous on trees of medium size with large amounts of succulent growth because of its deterrent influence on the insects in addition to its immediate killing properties.

In planning spraying operations against the green apple aphis, chief dependence should be placed on the nicotine sulphate-soap spray for trees of unusual height. With plantings of younger trees or those newly set, especially where succulent stems are likely to be seriously injured, an application of nicotine sulphate and lime will prove an efficient and satisfactory treatment.