APPLE APHIDES AND THEIR CONTROL.

SUMMARIZED BY
F. H. HALL
FROM BULLETIN BY
P. J. PARROTT, H. E. HODGKISS AND F. H. LATHROP.

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APPLE APHIDES AND THEIR CONTROL.

F. H. HALL.

Plant lice, or aphides, have been a source of irritation to fruit growers and farmers for years; but it is doubtful if the owners of apple orchards realize fully how injurious these pests may be when present in large numbers. Recent studies made by the Station give some data on the different injuries due to plant lice, and prove that steps necessary for their control merit the attention of every orchardist whose trees may be invaded.

The most prominent sign of the presence of the tiny pests is the curling and dwarfing of the leaves. These malformations are often serious enough to be a severe drain on the vitality of the tree and to reduce the storage of food materials needed to nourish the fruit buds for the next year's crop—a factor whose effect is very difficult to estimate for any one season, but sometimes quite evident during the year following a very severe infestation. Were severe aphid attacks to recur annually in any orchard, the result would undoubtedly soon be a marked decline in the general vigor and productivity of the orchard.

But leaf infestation, alone, may have a decided effect even on the fruit-yield of the same season. Exact measurements were made, through the season of 1915, of Rome apples accompanying infested clusters of leaves but not themselves attacked by the insects. These apples, measured late in June, averaged only $\frac{7}{8}$ inch in diameter, and similar fruits uninfluenced by aphides averaged nearly $1\frac{1}{4}$ inches; while in October, when ready to harvest, the average transverse diameter of the apples of aphis-infested leaf-clusters was less than 2 inches,—that is, under market requirements,—while the check fruits averaged almost $2\frac{7}{8}$ inches.

When the fruits themselves are attacked by the plant-lice, the effects are immediate, continuous, and much greater than when only indirectly affected through the leaves. Normal Rome apples are somewhat flattened in the direction of the axis, the flattening becoming slightly more marked as the fruit enlarges; but apples of this variety, when attacked by aphides, showed much less proportional

*This is a brief review of Bulletin No. 415 of this Station on Plant Lice Injurious to Apple Orchards. I: Studies on Control of Newly-Hatched Aphides, by P. J. Parrott, H. E. Hodgkiss and F. H. Lathrop. Anyone specially interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete bulletin. Names of those who so request will be listed to receive future bulletins of the Station, popular or complete edition as desired.
increase in transverse diameter; so that in apples from clusters severely or moderately infested the length, during June and part of July, was greater than the width; and in those from clusters only slightly affected the two diameters were approximately equal. The apples then began to broaden out somewhat; but were always longer, proportionately, than normal Romes.

This interesting peculiarity in the rate of growth was of slight importance, however, as compared with the small size of the injured apples and the very frequent cases of malformation. As already stated, the sound apples averaged practically 2 2/3 inches in diameter and those near infested clusters of leaves slightly less than 2 inches; but those any lice attacked directly averaged less than 1 4/5 inches while those from severely infested clusters were less than 1 1/2 inches across at the end of the season. Many apples from infested clusters were one-sided or otherwise deformed.

When the infested apples were sorted, only two out of forty-nine were found of marketable size and shape; but all of the thirty-one checks were normal in shape and ranged from 2 1/4 to 3 3/8 inches in diameter. These injuries during 1915 in orchards about Geneva were largely due to the work of the rosy aphis, but two other species, the oat aphis and the green aphis, were also found in considerable numbers, though doing comparatively little injury. Through the apple-growing sections of the State as a whole, the damage from plant lice in 1915 was not great, but in occasional orchards near Spencerport and Wolcott and in other localities, as about Geneva, the insects were numerous enough to do much harm,—undoubtedly more than was fully realized by the owners of the orchards.

The first brood of the rosy aphis had probably all emerged from the eggs before the last week in April, when the apple buds had broken so that the tips of the leaves were beginning to project from those most advanced. By the time pink was beginning to show on the cluster-buds the young of the second brood were appearing and clustering on the blossom stems and the under surfaces of the leaves. At this time the oat aphis was more abundant than the rosy aphis, as the females (stem-mothers) of the former species mature earlier and reproduce at a more rapid rate. This species remains on apple only until the middle of May and the succeeding week or ten days, after which the winged forms of the earlier broods then appearing pass to other host plants. The period of activity of the early broods of green aphis coincides quite closely with that of the oat aphis, but its work about Geneva during 1915 was mainly confined to the succulent tissues of the terminal growths and watersprouts. This work was not serious in its effects; as the lice appeared to abandon the aging leaves, in succession, for those newly opened, not seriously curling or injuring any of them. In a Gilli-
flower orchard near Wolcott, however, the green aphis did considerable harm to blossoms and severely damaged the foliage.

Many remedial practices ineffective.

Plant lice generally, and particularly those on fruit trees, are difficult to treat successfully; and many remedies and methods of control formerly, and even currently, recommended have proven ineffective in practice. The eggs of aphis, in which form the insects pass the winter, are exceedingly resistant to the ordinary contact insecticides.

The young appear so early in the season, are so minute and inconspicuous, and so soon become sheltered from spray treatments by entering the opening buds and by the curling down over them of the leaves they attack that they too often escape detection and treatment until it is so late that effective action against them is impossible.

The experience of 1914 and some earlier work indicated that the best chance for success lies in an attack upon the newly-hatched young, before they have found shelter; that is, during a comparatively brief period just before the opening of the buds. At this time the little pests are quite susceptible to spray influence and are readily reached by spraying without using excessive amounts of material. Accordingly the Station tests of 1915 were directed toward ascertaining the time limits for successful spraying, the best materials to use and the extent of the protection secured. The tests immediately under Station observation in its orchards at Geneva were three in number, one on Rome trees about 20 years old, using lime-sulphur and nicotine as an insecticide, one on mixed varieties of apples using various insecticides; and one on young seedling trees with various mixtures, including a preliminary test with nicotine solution and lime.

As auxiliary experiments, the Station cooperated with agents of the State Department of Agriculture in spraying ten commercial orchards in Niagara and Orleans counties.

In all the Station treatments much care was taken to make the applications at the right time to catch the aphis on the buds, with variations of a few days to determine exactly what condition of the buds is the best index of the time to spray. High pressure was used and nozzles of the common type giving a rather coarse spray. Such thoroughness was enforced that the buds were well drenched,—an essential to success in treating these pests.

In the Rome orchard the spraying was done on three days, April 24, 26 and 27, about 10 gallons per tree of lime-sulphur and nicotine (one-to-eight dilution of 32° B. lime-sulphur, with 3/4 pint of 40 per ct. nicotine solution to each 100 gallons). On the first date the buds were still compact with merely the tips of the leaves showing green. At this date, or somewhat earlier, as
other tests proved, the first brood of plant-lice of the three species had all emerged and were in their most unprotected condition, so the treatment at this time was very effective. Those made three days later were equally successful and all without injurious effects on the buds or foliage. On trees of mixed varieties the applications were begun six days earlier (April 18, 19 and 20) when the buds on most of the varieties were still quite compact, but with leaf tips just showing green in some cases. These treatments were as effective against the plant-lice as those made a week later on the Romes, proving that, even in this comparatively short season for bud development, there was a period of about ten days when aphides could be easily and effectively reached. In ordinary seasons this period for successful aphis treatment would probably extend over two weeks. The trees in the orchard of seedlings were affected mainly by the green aphis, with quite a few of the oat aphis early in the season. As the green aphis remains on the apple during the entire season, repeated treatments may be necessary to control the species unless perfect success is secured by the first application. In this orchard, therefore, bud treatments with various insecticides were made on April 19 and 20, with subsequent applications on some plats on June 22, July 10 and August 2.

In the bearing orchards the oat aphis was most abundant when the treatments were made, scarcely a bud being free from the stem-mothers and young of this species, with scattered numbers of the rosy aphis. After treatment both practically disappeared from the treated trees; and very few were found on these trees at any time later in the season. On the check trees, however, the oat aphis rapidly increased in numbers previous to its migration to other host plants; and the rosy aphis, never so numerous as the other species, increased rapidly during late May and early June, so that by the middle of this month they had become plentiful enough to do appreciable damage to both fruit and leaf clusters. The rapid multiplication of this species from the small numbers seen early in the season was a rather surprising feature of the studies. Like the oat aphis, the rosy aphis does not remain on the trees throughout the summer, and in 1915 practically disappeared from the orchards in late June. In work against green aphis in the seedling orchard practically complete eradication of the pests was secured by the bud spraying with various insecticides; but the check trees always showed considerable infestation, and as the season advanced the winged forms migrating from the check trees to the treated ones, with the multiplication of the insects from the few females that escaped the first treatment, reinfested the sprayed trees. Comparatively little injury was done, however, even on the checks, owing to the habit of this species, previously referred to, of shifting to the fresh leaves, not remaining long enough on any to injure them materially. However, the effect
of accumulated injuries became increasingly apparent on the check trees as the season advanced, in the presence of curled and distorted leaves, discolored and smutty from honeydew and sooty fungus, followed by more or less browning of the leaves, some defoliation and occasional instances of dwarfing and killing of the tips of the new growth. The spray treatments of whatever kind effectively protected the sprayed trees.

Some data of results.
It is hardly necessary to discuss the effects of the treatments in detail; but the following table shows a summary of the results of the experiments in the Rome orchard, with interplanted trees of other varieties, and in the older orchard of mixed varieties.

<table>
<thead>
<tr>
<th>Table I.—Summary of Experiment Against Rosy Aphis.</th>
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<tbody>
<tr>
<td>in Rome Orchard with Interplanted Varieties</td>
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<tbody>
<tr>
<td>18 Rome</td>
<td>Sprayed</td>
<td>No. 46</td>
<td>No. 33</td>
<td>No. 172</td>
</tr>
<tr>
<td>10 Mixed varieties</td>
<td>Sprayed</td>
<td>8</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>7 Rome</td>
<td>Not sprayed</td>
<td>319</td>
<td>279</td>
<td>1,323</td>
</tr>
<tr>
<td>Average per sprayed tree, Rome</td>
<td></td>
<td>2.55</td>
<td>1.83</td>
<td>9.55</td>
</tr>
<tr>
<td>Average for all sprayed trees</td>
<td></td>
<td>1.93</td>
<td>1.17</td>
<td>7.17</td>
</tr>
<tr>
<td>Average per unsprayed tree, Rome</td>
<td></td>
<td>45.57</td>
<td>39.85</td>
<td>189</td>
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| in Orchard of Mixed Varieties |

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<tbody>
<tr>
<td>Lime-sulphur and nicotine solution</td>
<td>21</td>
<td>569</td>
<td>299</td>
<td>2,081</td>
</tr>
<tr>
<td>Nicotine solution and soap</td>
<td>17</td>
<td>19</td>
<td>11</td>
<td>41</td>
</tr>
<tr>
<td>Sodium sulphide and soap</td>
<td>5</td>
<td>295</td>
<td>70</td>
<td>1,118</td>
</tr>
<tr>
<td>Carboilic acid emulsion</td>
<td>23</td>
<td>976</td>
<td>710</td>
<td>3,736</td>
</tr>
<tr>
<td>Check, no treatment</td>
<td>14</td>
<td>3,086</td>
<td>2,777</td>
<td>13,320</td>
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<table>
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<tr>
<th>Averages per tree</th>
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<tr>
<td>Lime-sulphur and nicotine solution</td>
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<td>Sodium sulphide and soap</td>
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<tr>
<td>Carboilic acid emulsion</td>
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<tr>
<td>Check, unsprayed trees</td>
</tr>
</tbody>
</table>
Plate II.—Stage of Development of Buds in Experiment at Time of Spraying of Rome Apples.
(Slightly enlarged.)
The table plainly indicates that on both Romes and mixed varieties the lime-sulphur and nicotine gave excellent results, excelled only by the nicotine and soap, which has somewhat better spreading qualities. The latter, also, of the four combinations used on bearing trees, resulted in no injury whatever to foliage or fruit; but the injurious effects from the other mixtures, except sodium sulphide and soap, were practically negligible. The sodium sulphide, though, was decidedly injurious, as the buds treated by it began to show brown within a few days and were retarded a week in blossoming when not killed. On the lower branches where the effects of the treatment were most evident, many of the fruit spurs were killed and the leaves were few and small. The trees recovered somewhat during the season, but gave very small yields of fruit and still showed other signs of injury at picking time.

In the seedling orchard the nicotine and soap spray was somewhat more rapidly effective than lime-sulphur and nicotine, though the final effects of the two combinations were not markedly different. A new preparation, nicotine solution and lime alone, was also tried, in the effort to find something that would serve as a deterrent, if not as an actual destroyer of the aphis, over a longer period than that covering the activity of the other combinations. These have practically no effect after the mixtures have thoroughly dried on the trees. As the green aphis remains on the apple throughout the season and migrates from tree to tree, the foliage and fruit that have been cleared of the pests by the bud spraying may become reinfested. The nicotine and lime combination makes a very adhesive coating on the trees and lasts a long time. It is apparently quite effective, but the investigation has not been continued long enough as yet to justify recommending this combination as an aphicide (plant-lice destroyer).

Auxiliary experiments. In the commercial orchard experiments the work was mainly under the supervision of A. B. Buchholz and L. F. Strickland, Horticultural Inspectors of the State Department of Agriculture, and was designed to test the feasibility and efficiency of bud-spraying in the hands of growers. The same principles governed the work as at Geneva, careful observation of buds to note condition and presence of plant lice, and thorough drenching when the tips of the leaves were just showing (April 21, 22 or 23) with lime-sulphur and nicotine.

In two of the orchards the rosy aphis did not appear, but in the other eight more or less evidence of its work showed on the check trees, while the oat aphis and green aphis were quite abundant in some orchards and in scattering numbers in almost all of them. Aphis injury was decidedly reduced on the sprayed trees in every instance where check trees suffered appreciably, the foliage showing much smaller percentages of curled, brown or yellow leaves, less defoliation and frequently a distinctly better setting of fruit. The
general condition of the sprayed trees was excellent; and had the outbreak of any of the species of plant lice been a bad one, undoubtedly the spraying would have made a notable difference in the crop returns.

**Formulas**  The following insecticides were used in one or more and methods. of the experiments discussed:

(1) Lime-sulphur and nicotine solution:
   - Lime-sulphur solution (32° B.) ..................................................... 11 gals.
   - Nicotine solution (40 per ct.) ..................................................... $\frac{3}{4}$ pint.
   - Water ..................................................................................................... 89 gals.

(2) Soap and nicotine solution:
   - Soap .................................................................................................... 5 lbs.
   - Nicotine solution (40 per ct.) ..................................................... $\frac{3}{4}$ pint.
   - Water ..................................................................................................... 100 gals.

(3) Sodium sulphide and soap:
   - Sodium sulphide (56 per ct. sul.) ..................................................... 15 lbs.
   - Soap .................................................................................................... 5 lbs.
   - Water ..................................................................................................... 50 gals.

(4) Crude carbolic-acid emulsion:
   - Soap .................................................................................................... 15 lbs.
   - Crude carbolic acid ........................................................................... 1 pint.
   - Water ..................................................................................................... 100 gals.

From the standpoint of safety to expanding buds and leaf tissues, and effectiveness against insects, the most satisfactory combination is three-fourths of a pint of nicotine solution (40 per ct.) to one hundred gallons of lime-sulphur solution at winter strength for bud treatment or to one hundred gallons of lime-sulphur at summer strength with arsenate of lead for foliage applications. While this combination lacks somewhat the spreading properties of soap mixtures, oil emulsions or nicotine solution with soap, this deficiency is probably more than compensated by the saving in labor in avoiding an extra application and by the thoroughness of spraying in the bud treatment when lime-sulphur is directed also against the San José scale. Drenching of the trees with this combination as the buds are breaking may injure the tips of the unfolding leaves. However, the damage is usually inconsequential and should cause no apprehension.

Whatever the insecticide selected, great care should be taken to apply it at the proper time, as shown by the condition of the buds and presence of the lice, as discussed on previous pages, and to be thorough in the work, covering every part of the buds and tender tissues near them.