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Connecticut Agricultural Experiment Station
New Haven

CONTROL OF THE WHITE APPLE LEAFHOPPER

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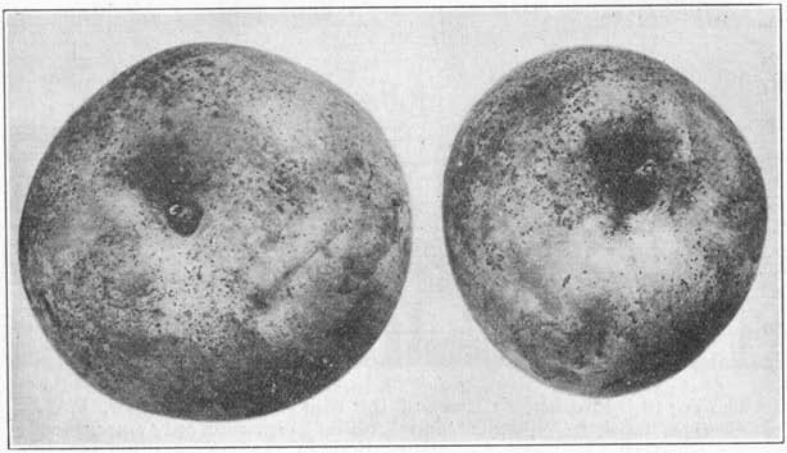

FIGURE 12. Apples spotted and soiled by adult leafhoppers.

THE WHITE apple leafhopper, *Typhlocyba pomaria* McAtee, is a leaf sucking insect which may do considerable damage to apple trees in Connecticut. Ordinarily it is not especially injurious, but when abundant, removes a large amount of chlorophyll from the leaves (Figure 18) and spots the fruit with its excrement (Figure 12). When very abundant, flying adults may annoy the pickers considerably at harvest time.

LIFE HISTORY

The winter is passed as an egg (Figure 14) inserted in the bark of a small twig or branch. The eggs begin to hatch about the first of May or just prior to the time for pink spray application in most orchards.

Leafhoppers then pass through five nymphal stages (Figure 15) and begin to emerge as winged adults (Figure 16) about the first of June. Feeding occurs in all nymphal stages as well as the adult stage. Eggs laid in the midribs and larger veins of the leaves during June, July and August, mostly during July, hatch in late August and September. The insects mature in September and deposit eggs in the bark during late September and October.

The seasonal history, illustrated in Figure 13, indicates the relative abundance of nymphs and adults at different dates and, in addition, the mating and oviposition periods.

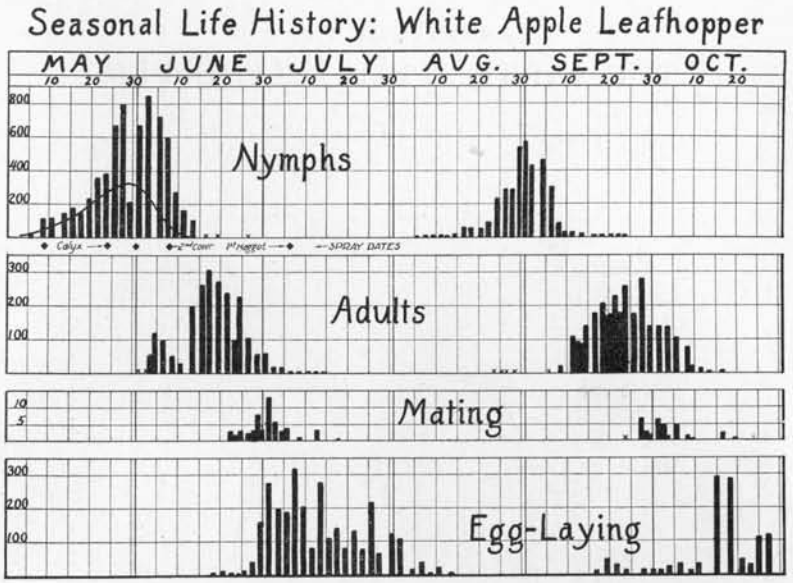

FIGURE 13. Life history chart of the white apple leafhopper, 1932. Sections labeled "Nymphs" and "Adults" represent only emergence periods; x indicates field observations in commercial orchards.

NATURAL ENEMIES

Various enemies are known to feed upon the white apple leafhopper. Chief among them are spiders, the egg parasite, *Anagrus armatus* Ashmead, and the adult parasite, *Aphelopus* sp. (Figure 17). Various insect-feeding bugs have also been observed to capture leafhopper nymphs, and certain diseases* are said to affect them. In fact, so successful is the natural control of the white apple leafhopper in Connecticut that unsprayed trees are rarely, if ever, seriously harmed. The size of an infestation varies with the abundance of natural enemies, and is influenced by weather conditions. Rainy spells at times when adults are emerging and laying eggs may check development and wash the fruit sufficiently so that control measures are unnecessary.

* Thaxter, Roland. Mem. Boston Soc. Nat. History, IV, No. VI, p. 173. 1888.

The relative scarcity of the white apple leafhopper on unsprayed trees has been mentioned. This condition has been observed frequently at the station farm at Mount Carmel where increased populations have apparently resulted from any of the regular applications, as shown in Table 1. It has been argued that leafhopper treatments are therefore worthless; but it is apparent that contact sprays combined with the

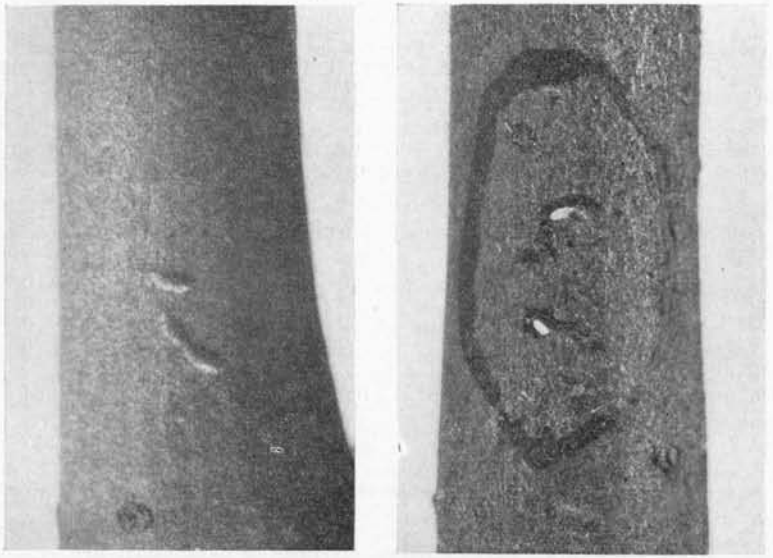

FIGURE 14. Eggs of the white apple leafhopper. Left, egg blisters on twig; right, eggs in twig with outer bark removed. Both enlarged six times natural size.

regular mixtures give reduced populations as compared with sprays in which no contact material is included. In the case of heavy infestations, it is believed advisable to consider treatments at the early as well as the late period of leafhopper development.

TABLE 1. NYMPH POPULATION ON SPRAYED AND UNSPRAYED TREES, 1932

Treatment	June 8 Nymphs per 100 leaves	August 31 Nymphs per 100 leaves	September 19 Nymphs per 100 leaves
Check, unsprayed	172	103	86
Fungicide, lead arsenate and nicotine sulfate spray	14	182	428
Fungicide, lead arsenate but without nicotine sulfate	51	247	608

ACTION OF CONTROL MEASURES ON NYMPHS

Being a sucking insect, the white apple leafhopper requires a contact spray. Nicotine preparations are effective, whether applied as a sulfate, tannate, or free nicotine, with or without soap. Contrary to the general belief, the control is not greatly, if at all, enhanced by the addition of

soaps. We have indicated (Table 2) the residual action of summer oils and nicotine sulfate on the hopper nymphs. Steiner* has shown that the use of a smaller quantity of soap than is usually recommended, results in greater residual action. From Table 2 it will be seen that the delayed action did not continue more than one week.

TABLE 2. EFFECT OF SPRAY ON EMERGENCE OF NYMPHS, 1932

Dates	Tree No. 1		Tree No. 2	
	Sprayed branch, number nymphs	Unsprayed branch, number nymphs	Sprayed branch, number nymphs	Unsprayed branch, number nymphs
Sept. 2*	22	27	59	27
3	6	25	14	17
5	7	45	9	26
6	12	12	2	9
8	2	10	4	6
9	4	4	3	3
10	3	0	0	0
12	1	0	2	2
14	1	2	3	1
17	1	0	1	0
19	0	0	0	0
21	0	2	0	0
23	0	0	0	0
Total nymphs removed after spray	37	100	67	64
Relation to count of Sept. 2	168%	370%	113%	237%

* Count just before spray application.
Spray: Summer white oil emulsion, 1 gallon to 100. Nicotine sulfate, 1 pint to 1600 of this mixture.

Aside from the lower cost, sprays containing less soap are easier to handle. The larger amounts (3 to 4 pounds per 100 gallons) produce so much foam in the spray tank that reduced pressure and loss of materials frequently result. However, it is difficult to detect in field experiments the advantage of mixtures containing even reduced amounts of soap as

TABLE 3. COMPARISON OF NICOTINE SULFATE WITH AND WITHOUT SOAP FOR CONTROL OF THE WHITE APPLE LEAFHOPPER

Year	Orchard	Materials used in 100 gals.	Per cent reduction of nymphs
1933	MacDonald, Wallingford	Nicotine sulfate, 1 pint Coconut oil soap, 2 quarts (35-40% soap)	99.3
1933	" "	Nicotine sulfate, 1 pint	96.1
1934	Exp. Sta., Mt. Carmel	Nicotine sulfate, 1 pint Flake soap, 3 lbs.	92.5
1934	" " "	Nicotine sulfate, 1 pint	98.1
1934	" " "	Nicotine sulfate, ½ pint Flake soap, 3 lbs.	89.8
1934	" " "	Nicotine sulfate, ½ pint	91.7
1935	MacDonald, Wallingford	Nicotine sulfate, 1 pint	94.6
		Flake soap, ½ lb. (two tests)	93.6
1935	" "	Nicotine sulfate, 1 pint (two tests)	95.9 93.7
1935	Exp. Sta., Mt. Carmel	Nicotine sulfate, 1 pint Flake soap, ½ lb.	96.9
1935	" " "	Nicotine sulfate, 1 pint	94.4

* Jour. Econ. Ent. 28: pp. 385-388. 1935.

compared with none. Three experiments in two orchards in 1935 showed no significant difference in the number of leafhoppers killed. A condensed summary of tests since 1933 is given in Table 3.

In all of the above experiments commercial sprayers were used and counts were made shortly before and after the sprays were applied. In the 1935 experiments, counts were made again after one week had elapsed but this showed no significant advantage for the combination of soap and nicotine.

Among other insecticides for control of the white apple leafhopper, anabasine sulfate has proved equally if not more effective than nicotine sulfate at the same strength. This material was used by commercial growers in 1934 with good results but is now off the market and cannot be obtained. Pyrethrum soaps have given satisfactory kills in some tests, but in general both pyrethrum and the derris or rotenone sprays have not equalled nicotine or anabasine in our experiments. Many of the latter preparations are more expensive than nicotine sulfate.

TABLE 4. PERCENTAGE REDUCTION IN LEAFHOPPER POPULATION WITH ANABASINE SULFATE, PYRETHRUM AND OTHER INSECTICIDES. EXPERIMENT STATION ORCHARD, MOUNT CARMEL

Year	Materials in 100 gallons	Per cent reduction of nymphs
1933	Anabasine sulfate, 1 pint	98.5
1933	Anabasine sulfate, 1 pint	99.8
1933	Pyrethrum, 1 pint plus penetrol	95.2
1933	Pyrethrum extract, 1 pint plus coconut oil soap	95.3
1933	Pyrethrum soap, 6 lbs.	98.8
1934	Pyrethrum soap, 6 lbs.	92.4
1935	Derris powder, 1 lb. plus skim milk powder, 1 lb.	84.9*
1935	Thiocyanate (commercial), 2 pints	52.1

* Sufficient control to prevent fruit spotting. Nymph population 200-400 per 100 leaves. See Figure 19.

Time for Applications

Control measures may be applied at both early and late periods, June and September, but if only one is necessary, better success is obtained in September. Unfortunately, the time for the later spray often conflicts with apple picking dates, except for late varieties, and spray operations may result in knocking off a considerable amount of fruit from low hanging trees unless special precautions are taken. Good control may be secured by adding nicotine sulfate to early applications of standard materials except where migration occurs from nearby orchards or trees. In that case the value of the treatment may not be apparent in September. When migration from outside the orchard occurs, it may be necessary to make applications at both periods, and it seems advisable to depend largely on late summer sprays to keep the fruit clean. As complete a clean-up as possible is necessary at the earlier period, even with favorable conditions, in order to reduce the size of the late brood below the danger point. More than one spray may be needed to do this.

Owing to the late hatch of nymphs in Connecticut which may continue in numbers until September 10, it seems advisable to delay controls as long as possible, to be sure of results, unless adults are emerging in large numbers before September first. If there is sufficient rain in early Septem-

ber, it may not be necessary to spray for leafhoppers, but it is unwise to depend too much on expected rainfall, especially when the infestation is severe.

CONTROL OF OTHER STAGES

Control of adult hoppers has not been considered practical because the sprays and dusts available at the present time are expensive or ineffective. None of them has yet proved satisfactory in the field.

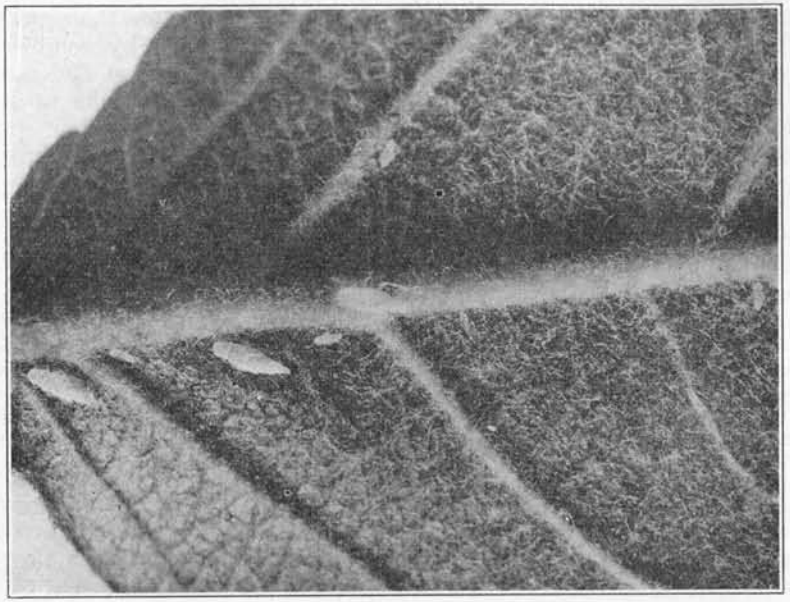

FIGURE 15. Nymphs on the underside of an apple leaf.

Likewise, control by use of dormant sprays has, until now, been thought impractical because the eggs are inserted in the bark and thus protected from the action of spray materials.

AVOIDANCE OF RESIDUES AND USE OF COMBINATION SPRAYS

It is obvious that late sprays leaving residues, such as lime-sulfur and others, are inadvisable. It is also apparent that a combination spray may be needed for control of both European red mite and leafhopper when they occur together. Since the nicotine sprays in themselves have little effect on European red mites, summer (white) oil emulsions with one-half or three-fourths strength nicotine sulfate have been used with considerable success. Some growers have advocated the use of soaps and nicotine sulfate combined for this purpose. It is believed that the most effective control is offered by the oil-nicotine combination, but the latter has the disadvantage of "setting" the arsenical residue that may be present on the fruit at the time of application. The oil-nicotine spray is probably safe on winter varieties, such as Baldwin and Greening, up until the first week of September, provided previous sprays have been sufficiently removed by rainfall. Oil should not be used late on varieties

with a conspicuous bloom, such as McIntosh. Ground derris root applied as a spray shows some promise as a combined control but is still in the experimental stage. For very late sprays (after September 7) the soap-nicotine sulfate combination is probably the best that can be offered.

HOW TO DETERMINE NEED FOR SPRAYS

The main problem in leafhopper control in Connecticut appears to be one of judging how many leafhoppers cause sufficient injury to make treatment worth while. In order to assist the grower in forming an opinion, it may be stated that in all probability it is advisable to use artificial

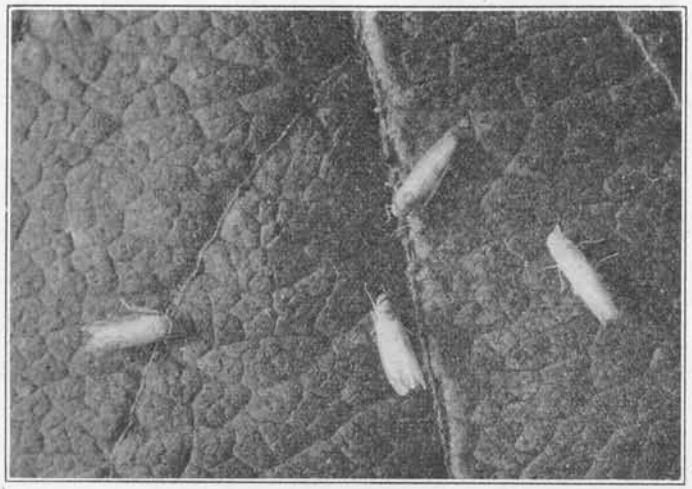

FIGURE 16. White apple leafhopper adults.

controls in dry years, or following a succession of dry years, but that they *may not* be needed at other times. The following table gives a general picture of the connection existing between the amount of rainfall and leafhopper damage.

TABLE 5. SUM OF PRECIPITATION FOR JULY, AUGUST AND SEPTEMBER AND THE RELATIVE AMOUNTS OF DAMAGE FROM LEAFHOPPERS, NEW HAVEN COUNTY

Year	Precipitation for July, August and September inches	Status of the infestation
1928	15.22	moderate
1929	7.92	moderate
1930	4.25	severe
1931	11.81	severe
1932	10.84	moderate
1933	15.53	light
1934	15.60	light
1935	7.93	moderate

It should be stated at this point that white or green apples, such as Greening, Pippin and Winter Banana, are much more conspicuous when spotted by leafhoppers than red varieties. Early kinds, such as Duchess,

Wealthy and sometimes McIntosh, may escape injury from the second brood because they are harvested before the majority of the adults of the second generation appear.

Populations of 50 leafhoppers per 100 leaves (one on every second leaf) may ordinarily be considered dangerous for the first generation. To determine this, examine the undersides of the leaves (except terminal, recently expanded leaves) the last week in May or first week in June.

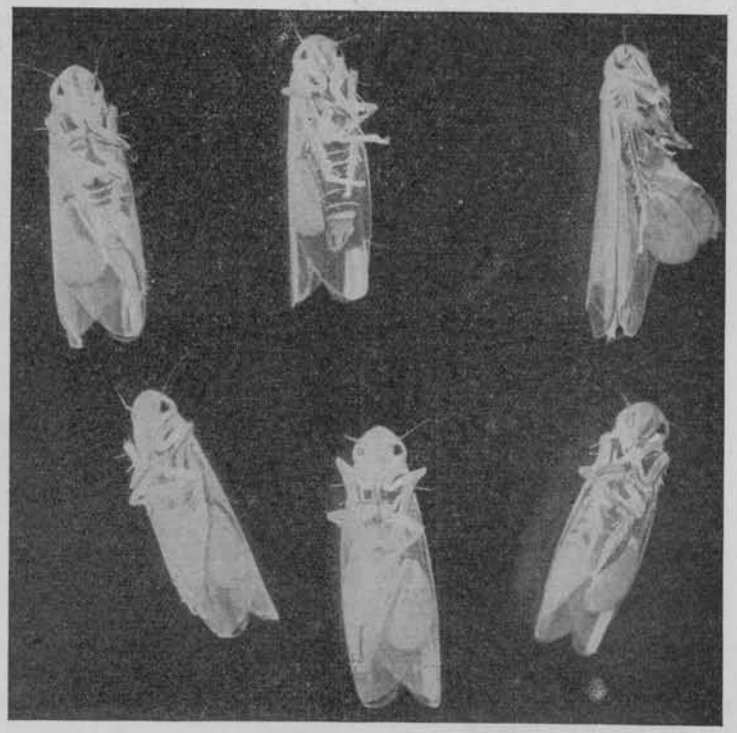

FIGURE 17. Adults of the white apple leafhopper parasitized by *Aphelopus* sp.

Populations of more than two per leaf may be considered dangerous for the second generation, and more than four per leaf usually require control measures, if spotting is to be prevented. Examine the leaves as in spring, avoiding water sprouts in making the count. Water sprouts frequently have a heavier population of nymphs than other parts of the tree, and unusual abundance there, as well as extremely early appearance of numbers of nymphs, may be regarded as danger signals.

Another consideration in determining the necessity of a late spray is the amount of feeding and discoloration of the foliage by the first generation. For example, leaves discolored as much as those shown in Figure 18 may be expected to contain enough leafhopper eggs to produce a heavy infestation later. When the chlorophyll or green color is almost completely removed, as is frequently the case, the owner of the orchard should expect and be prepared for trouble in September.

All sprays for control of leafhoppers should be applied to the undersides of the leaves. Such coverage is not usually difficult to obtain in the early calyx or first cover sprays but is harder in the late summer. If the trees have abundant foliage that reaches the ground, it may be necessary to work from inside the tree, directing the spray outward to secure the best results.

DOES IT PAY TO SPRAY FOR LEAFHOPPERS?

The actual cost of spraying for leafhoppers compared with the reduced value of the fruit, if conspicuously spotted, will, it is believed, pay for itself. For example, to spray 100 trees each bearing 5 bushels of U. S. No. 1 fruit, requiring 10 gallons of spray per tree, would cost $9.30 at present prices for nicotine sulfate used at 1 pint per 100 gallons. With proper equipment, it should require possibly a day and a half for farm

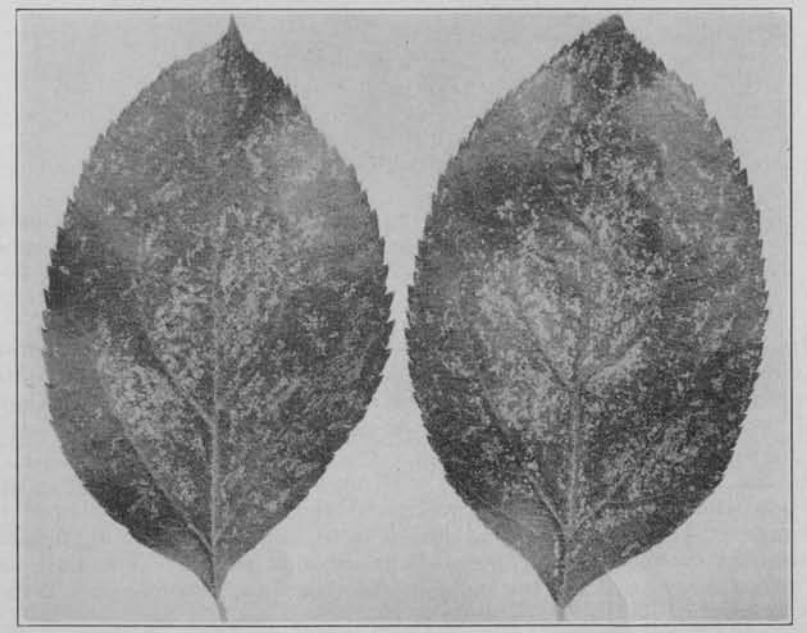

FIGURE 18. Apple leaves spotted as a result of leafhopper feeding.

labor, which, allowing $4.00 per day, would cost $6.00. Miscellaneous expenses might increase the cost to $16.00, a high figure. Loss in value of fruit figured as low as 5 cents a bushel would amount to $25.00, or give a profit of $9.00 on the operation. Two applications of nicotine sulfate would not pay at this rate unless the dilution is doubled (half as much nicotine sulfate used per 100 gallons) in which case there would still be a slight profit in the transaction.

However, if the grower is prepared to clean the fruit, or makes it a practice for other reasons, it might prove more profitable to do this unless the numbers of leafhoppers are so great that the vitality of the trees is impaired for the following year.

RECOMMENDATIONS

The following programs are designed to meet the needs of the Connecticut grower.

A. For heavy infestations, more than one nymph on every other leaf in May and June, or more than two per leaf in August and September.

May 25 to June 7
Nicotine sulfate in the regular sprays—calyx to second cover. Use 1 pint to 100 gallons of mixture.

August 25 to September 7
For populations of 2 to 5 per leaf:
Nicotine sulfate, ½ pint to 100 gallons.

For populations of more than 5 per leaf:
Nicotine sulfate, 1 pint per 100 gallons.

B. For light infestations, one nymph or less for every two leaves in May and June, and two or less per leaf in August and September:

No spray advised.

In case of a heavy infestation as indicated, sprays at both periods *may* not be necessary. This will depend largely on the degree of control secured and the number of leafhoppers developing on the leaves in August and September, as well as migrations from neighboring orchards earlier in the season.

In the case of isolated orchards with no migration of leafhoppers from outside, and where the grower wishes to avoid applications later in the summer, it will probably be advisable to make at least two applications containing contact insecticides such as nicotine sulfate. The best time for these sprays will fall normally at the calyx and second cover periods in Connecticut.

All sprays should be applied thoroughly, especially if lower concentrations are employed.

If part of the orchard is above, and part below the limit at the second generation period, it is suggested that only the heavily infested section receive treatment. In general, severe infestations occur over an entire plot covering several acres or more and may be light in other portions of the orchard. This can easily be determined by systematic examination of the trees.

For the smaller plantation or backyard trees, it is doubtful whether any late treatment for leafhoppers is advisable. The actual damage from late brood hoppers in such cases is not usually great and if spotting

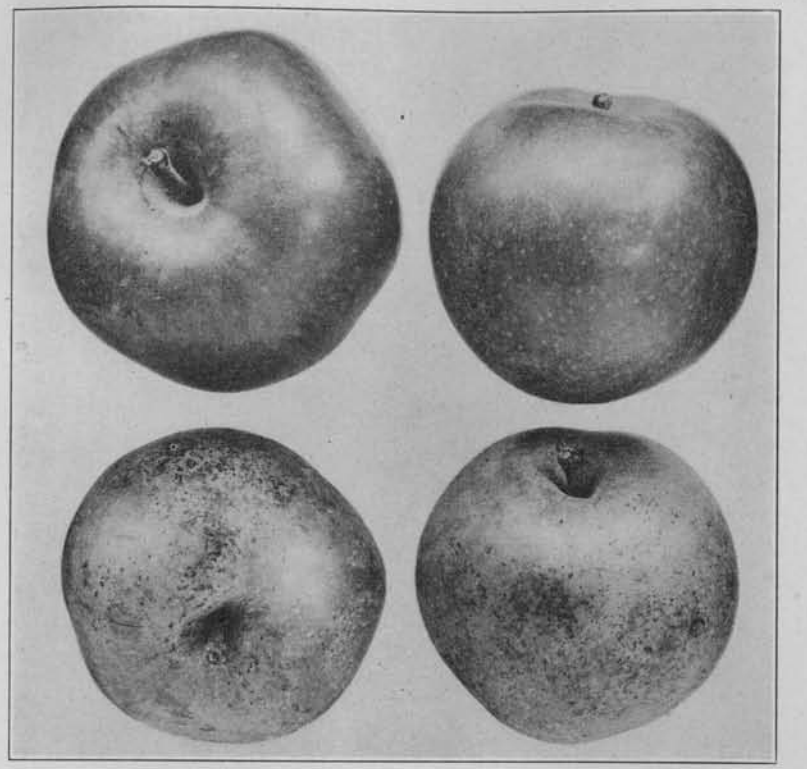

FIGURE 19. The upper apples were sprayed for leafhopper control, September 7; the lower fruits received no spray at this time. Spotting resulted from a population of 200 to 400 nymphs per 100 leaves.

occurs the fruit is easily cleaned with a damp cloth. The cost of having the trees sprayed at this time is usually greater than the benefit derived therefrom.

NOTE. All photographs in this circular were made by Mr. B. H. Walden. Dr. W. E. Britton and Professor H. A. Rollins have examined the manuscript and commented upon it. Much credit is due these gentlemen for their efforts and cooperation.