Circular 126 December, 1938

Control of the Rosy Apple Aphid
In Connecticut Apple Orchards

Philip Garman

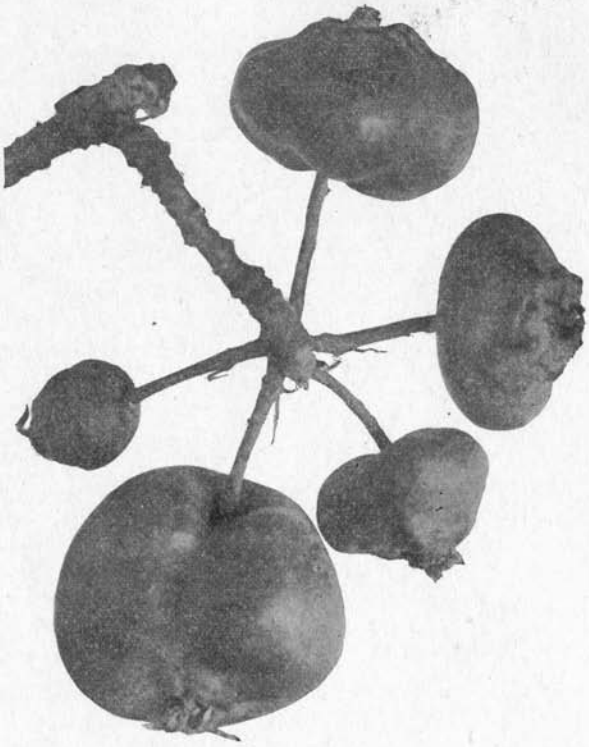

Figure 1. Apples, stunted by feeding of the rosy aphid.

Connecticut Agricultural Experiment Station
New Haven

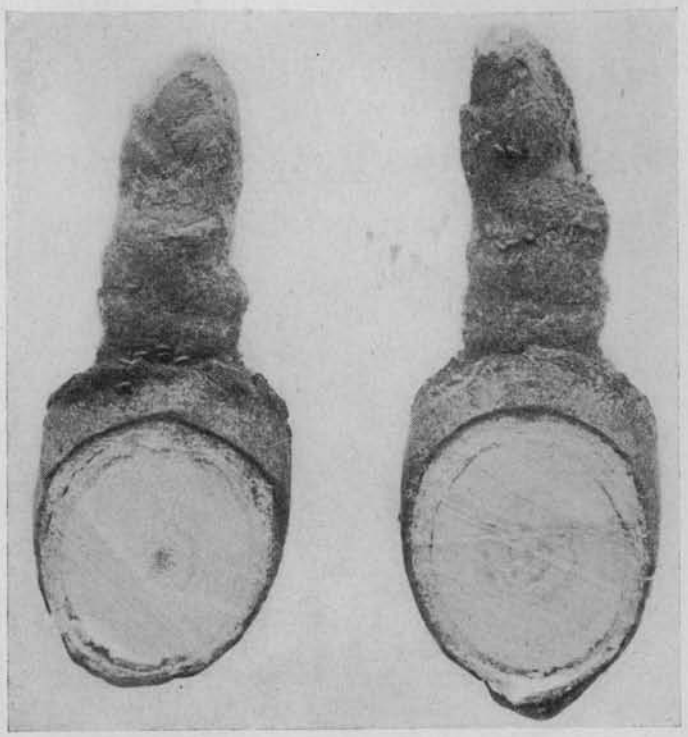

FIGURE 2. Eggs of the rosy aphid on small twigs.

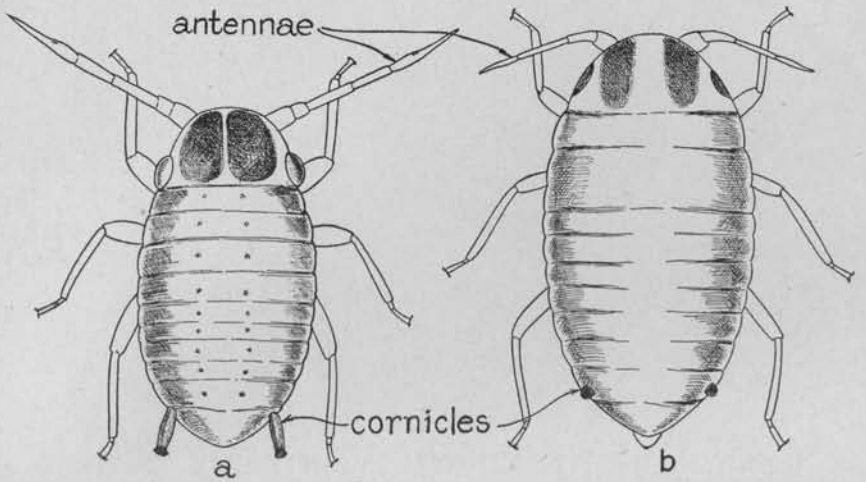

FIGURE 3. Early stages of the rosy apple aphid (a), and of the green apple aphid (b). Distinguishing features are the differing lengths of the antennae and cornicles.

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THE rosy apple aphid (*Anuraphis roseus* Baker) is an insect capable of ruining, on occasion, 50 percent of the apples borne by a given tree. It varies in importance from year to year due to the effect of weather or natural enemies. Because the rosy aphid is a problem only once in two or three years, many growers think it is better to omit control measures. Furthermore, if the amount of damage does not exceed the percentage of fruit normally thinned from the tree, the relief given by measures usually advocated is believed to be of little value. However, serious infestations have appeared in years of light crops when no thinning was done. Also in years when apples are valuable because of scarcity in other localities, even a small percentage of aphid apples above the number thinned off represents considerable loss. It appears, therefore, that collection of information relating to successful control measures or bearing on prediction of outbreaks in threatening years is desirable from an economic standpoint.

The Damage

Apples which have been fed upon by the rosy aphid remain undeveloped and small after the insects have left. They never reach full size and often cling tenaciously to the branches in groups or bunches as shown in Figure 1. Damage to the foliage is not so serious but an infestation with many curled leaves causes the tree to present an unsightly appearance. Blackening foliage due to the growth of a sooty fungus adds to the undesirable condition.

The actual monetary loss from a heavy infestation may be considerable although it is not possible to estimate accurately because of seasonal variations and the fact that not all varieties grown in the State are equally affected. Of the common varieties grown, probably Cortland, Gravenstein, Greening and Baldwin suffer more than others. Rome Beauty, Ben Davis, Yellow Transparent and Astrachan may be seriously infested. Of those lightly infested, the McIntosh escapes with as little injury year after year as any other.

Life History and Habits

The rosy aphid passes the winter in the egg (Figure 2)which is deposited on small twigs and branches. These eggs begin to hatch about the middle

of April and the process continues for approximately two weeks. In terms of tree development, hatching usually begins near the pre-pink stage and may continue as late as the pink stage.

Aphids collect on the opening buds, become mature by the time the blossoms of most varieties are out and then move to the unfolding leaves causing them to curl, as shown in Figures 4 and 5. Frequently there is a decided decline in numbers between bud and leaf infestations so that the grower is lulled into a feeling of security, often believing that weather or other conditions have destroyed the aphids. Then, suddenly, after the stem mothers of the first generation (Figure 4) become mature, about the calyx period, infestations begin to increase rapidly because of the speed of reproduction at that time, and the leaves curl more and more conspicuously around the apple clusters (Figure 6).

FIGURE 4. Colony starting in a curled leaf from two stem mothers, adults of the first generation. Photographed May 4, 1938.

Towards the last of June, especially after warm spells, the aphids develop wings and migrate to narrow-leaved plantain or rib grass (*Plantago lanceolata* L.). Migration is usually complete by the first week in July, or earlier, so that damage after the third week in June is usually negligible. As soon as the aphids leave the trees, new growth pushes out and the foliage takes on a more healthy appearance, (Figure 8).

After several generations, the aphids return to apple from plantain and one generation is produced on apple leaves before winter eggs are deposited. Fall migrants begin to return in late September and eggs are laid following the first frost in October and continuing into November in favorable seasons.

Favorable and Unfavorable Weather

The weather conditions promoting spring development of apple aphids are cool periods, 60 to 68° F., with abundant rainfall, at least .5 inch every 10 days. The rate of growth and consequently aphid development probably depend also on the amount of fertilizer applied, for it will be

seen that uncared for and unfertilized trees do not often carry the infestations that occur in commercial plantations. This is in part due to natural control factors such as parasites and predators, but development of aphids also depends on the quality of their food and this, in turn, on the fertilizer applied.

Unfavorable weather conditions consist of early freezes (10° F. or below) in October and November[1], or hot weather during May or June. Hot, dry weather favors migration from the apple trees and hot, damp weather gives diseases a chance to develop. Dry weather in October and November is also said to be unfavorable.

FIGURE 5. Rosy aphids increase rapidly at the calyx period. These curled leaves are dangerously near the young fruit.

Natural Enemies

Some of the natural enemies of rosy aphids are:

1. Ladybeetles of several species. Both larvae and adults feed on aphids. Figure 12.
2. Syrphus fly larvae. Figure 9.
3. Several species of parasitic wasps.
4. Diseases.

Of the ladybeetles, the two-spotted, *Adalia bipunctata* L. is commonly found feeding on aphids in this vicinity. Another species is the spotted ladybeetle (*Ceratomegilla fuscilabris* Muls.) the adults of which are pinkish with black spots. A third very large species is the 15-spotted ladybeetle

[1]The rosy aphid is said to withstand temperatures as low as 10° F., but egg-laying ceases below 40°.

(*Anatis quindecimpunctata* Oliv.) shown in Figure 12. The syrphus flies, *Syrphus torvus* O. S., that feed on aphids are larvae of a small yellow and black fly (Figure 10) that hovers about the blossoms. Its elongate white eggs (Figure 11) are laid near aphid colonies. The parasitic wasps are small, almost invisible insects. They lay eggs within the body of the aphid and develop there, causing it to swell up and turn brown in color. After a time, the parasite emerges through a small circular hole in the back or dorsal surface. Another species fastens the aphid to the leaf with a cocoon underneath the body of the host. Very little is known about the diseases that kill aphids but they are probably more important than we realize.

FIGURE 6. Rosy aphids go from blossom or leaf buds to opening leaves. Note how the leaves are curling. Spraying should be done before this stage is reached.

In 1935 a Connecticut grower attempted to introduce in his orchard large numbers of the convergent ladybeetle, *Hippodamia convergens* Guer., a species common in California and occurring here in moderate numbers. Two hundred and fifty thousand of these beetles were released in the grower's orchard during May, but they seemed to prefer other species than the rosy aphid and went elsewhere to feed. At any rate, no ladybeetles of the species liberated were recovered later in the summer after aphids became abundant.

Like the aphids themselves, their natural enemies are affected by weather. Diseases, as might be expected, show up in hot, damp periods. Ladybeetles seem to be favored by moderate, clear weather, and the

parasitic wasps develop most successfully in hot periods. The fact that the aphid itself develops in cool, rainy weather, enables it during some seasons to get ahead of its natural enemies.

The effect of sprays on ladybeetles has been studied by a few workers who maintain that such materials as lead arsenate, nicotine sulfate and Bordeaux mixture do not kill appreciable numbers. Derris or cubé, and phenothiazine have been shown to be destructive. Diseases and parasitic wasps are thought to be affected by sulfur, although no positive proof is available. It is known, however, from field experiments at Mount Carmel, that plots sprayed without sulfur are frequently found with fewer aphid apples than those receiving sulfur. Little is known about the effect of sprays on syrphus flies or their larvae.

FIGURE 7. Stunted fruit and curling foliage follow infestations of rosy aphids. Uninfested branch at right. Photographed June, 1938.

Prediction of Outbreaks

Since rosy aphid eggs are laid in late October and November, it is possible to obtain some idea of the density of an infestation during the winter. Unfortunately, we are not yet able to distinguish between rosy and green apple aphid eggs (*Aphis pomi* DeG.) so that mere abundance may not necessarily mean an outbreak of rosy aphids. Inspection of the buds in mid-April will show the latter species if there are any. The distinguishing features of the early stages may be seen with a low power lens (Figure 3), and consist of longer cornicles and antennae in the case of the rosy aphid. When full grown, the cornicles of the two species are about equal in length, but the rosy aphid is gray in color compared with the definite green of other species.

In general, observations in Connecticut show that a heavy infestation the previous season often leaves enough enemies of one sort or another on the trees to prevent an outbreak the following year. There are, of course, exceptions to this, but for the most part it has held true. Thus, if we know that plenty of predators and parasites went into hibernation the previous year and find few or no aphid eggs on the twigs during the winter, we can be fairly certain that the orchard will not be troubled next spring. On the contrary, if the year previous has been a light aphid year with few natural enemies, and yet an abundant crop of eggs appears on the trees as

FIGURE 8. When the aphids leave the apples and migrate to plantain, the trees send out new foliage.
Photographed July 1, 1938.

a result of a mild fall, we can be sure of trouble the following year. The size of the infestation will be influenced, of course, by a favorable or unfavorable spring, or by the degree of control that is obtained with sprays.

Tolerance in Amount of Infested Fruit

It will occur to many that there must be some degree of infestation that may be disregarded since it is a general practice to thin the fruit after

aphids have left the trees. It is believed that infestations producing not more than 15 percent deformed apples are usually in this class; those injuring a higher percentage of fruit probably require treatment. It may be argued, however, that systematic control year after year prevents development of aphids so that fewer migrate to plantain to return in the fall. There are consequently fewer to start an infestation the following spring.

Some orchards are never infested to an extent that requires treatment, and it would be foolish to attempt it under such conditions. There are others, however, that are constantly menaced, and losses are experienced whenever conditions are favorable for outbreaks.

FIGURE 9. Larvae of the syrphus fly, a predator on the rosy apple aphid.

Spray Controls

Nicotine sulfate has been used for a long time to kill aphids. The 40 percent concentrates, diluted 1 pint in 100 gallons of water with the addition of soap or other suitable spreader, are known to be effective against most species. Notwithstanding, many Connecticut growers report poor success in controlling rosy aphids with this insecticide. Rosy aphids are more difficult to kill than many other species so that it is advisable to use full strength nicotine, great care in application, and a spreader to wet the insect because of its waxy coating. Effective spraying should be done before the stage represented in Figure 5, where the leaves are curled and the aphids in the curled portion are out of reach. Nicotine in the form of a free alkaloid water solution has been used and has about the same killing power for rosy aphids as nicotine sulfate. Dusts impregnated with nicotine have, in general, given poor results.

During the last 10 years, the use of dormant sprays has come into considerable prominence and they appear to be fairly successful in control.

Tar oil or creosote oil emulsion used at a rate as low as 2 percent oil is successful in killing the egg at the dormant period. Our experiments indicate that applications about the first of April will result in a considerable reduction in the number of aphid apples at harvest, Table 4. Tar oil emulsions must be thoroughly applied, and the tree sprayed from all angles. They are unpleasant to use so that the operator should protect his face and hands, and horses drawing the spray outfit should be blanketed. There are a number of different kinds of tar oil used in commercial emulsions though all that we have tried seem to kill aphid eggs equally well. However, light, neutral tar oils are reported to be ineffective[1].

Since tar oils are injurious to new growth, they should be applied at the strictly dormant period.

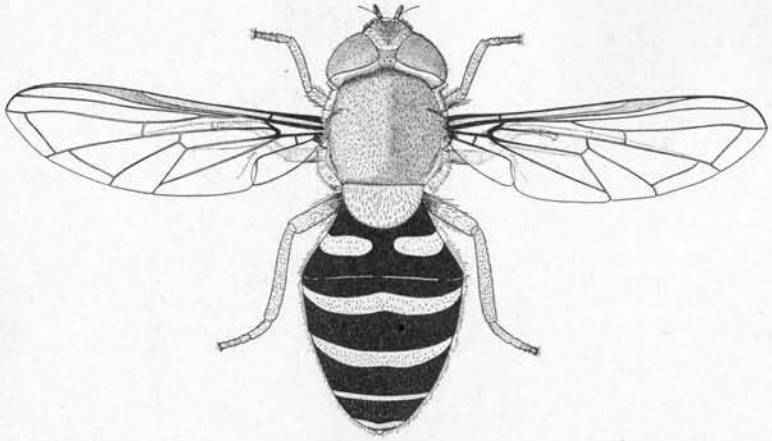

FIGURE 10. Adult syrphid fly (*Syrphus torvus*), enemy of the rosy apple aphid. Enlarged about five times.

Lubricating oils combined with nicotine sulfate have been recommended for delayed dormant use as the buds are beginning to show green and after the aphids begin to hatch. In order to be successful, the nicotine sulfate dilution should be kept up to standard strength, 1 pint to 100 gallons (Table 1), and the same degree of thoroughness of treatment is required as with tar oils. Nicotine sulfate combined with lime sulfur was recommended for years as the most successful treatment.

Lubricating oil emulsions with cresylic acid have been used with some success in New Jersey and Virginia, although we have as yet had little success with them in Connecticut. These mixtures possess some of the same disagreeable features as tar oil in their action on the skin.

Lubricating oil emulsions with 4 percent di-nitro-ortho-cyclo-hexyl-phenol dissolved in the oil[2] have come into prominence during the last three or

[1]The preferred types are the heavier refined oils distilling mostly above 360° F.

[2]Popularly known as Dow oil or D.N. oils. Abbreviations used later include di-nitro-hexyl-phenol, etc.

four years because they don't burn the skin and they kill European red mite eggs as well as aphid eggs. Our experiments since 1936, Tables 1-4, indicate that they possess aphid egg-killing power equal to tar oil and have given substantial reduction in aphid apples wherever it has been possible to do a good job of spraying.

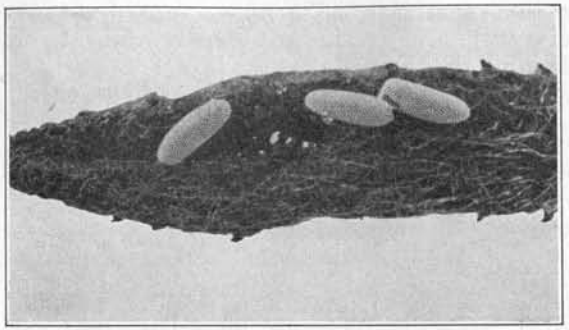

FIGURE 11. The white eggs of the syrphus fly are laid near aphid colonies. Larvae of this fly are enemies of aphids. See Figure 10.

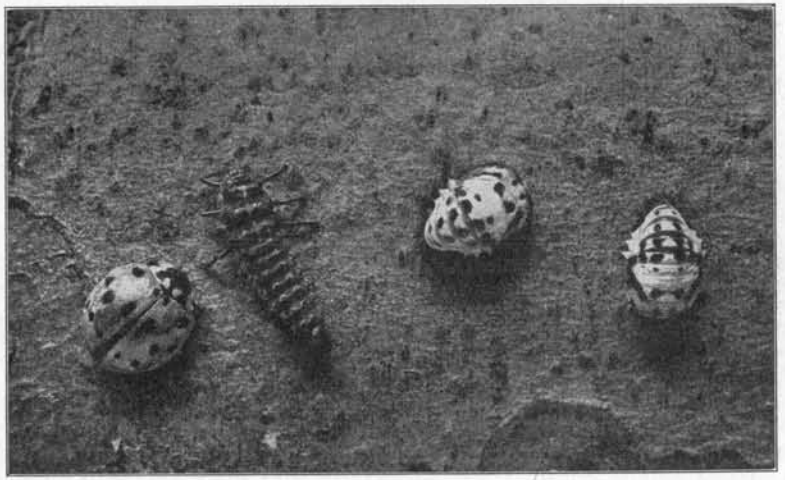

FIGURE 12. Among the enemies of the rosy aphid are certain species of ladybeetles. Above are the larval, pupal and adult stages of the 15-spotted ladybeetle. Natural size.

With any of the above sprays, our observations indicate that it is necessary to kill at least 90 percent, better 95 percent, of the aphids or eggs on the buds and twigs in order to reduce the number of aphid apples at harvest.

As with dormant applications of nicotine in oil, the dosage of summer applications of nicotine should probably not be reduced below 1 pint[1] in 100 gallons, and soap not below 1 pound dry weight per 100 gallons. This means that the 20 to 25 percent soaps sold for the purpose should be used at a concentration of approximately 2 quarts or 4 pounds to 100 gallons in order to wet the aphids and make the nicotine effective. Also, to be most effective, these combinations should be applied at the pre-pink stage, before the leaves curl. They have been used, however, to prevent infestations from spreading to the fruit after the leaves are fairly well grown and the aphids begin to go from one part of the tree to another.

TABLE 1. SPRAY CONTROL OF APPLE APHIDS—1938
RECORD OF BUD COUNTS[1]

Orchard and location	Variety	Percentage reduction in numbers: 2%[2] di-nitro-cyclo-hexyl-phenol in oil	5% commercial miscible oil plus nicotine sulfate	2.5 % tar oil emulsion (2% tar oil)
Shepard Westwoods	Gravenstein	99.5	95.5[3]	—
Townsend Westwoods	Cortland Rome Beauty	100.0 100.0	— —	— 100.0
MacDonald Wallingford	Wagener	97.0	—	—
Burton Mt. Carmel	Miscellaneous Gravenstein, Yellow Trans. and Delicious	99.1	80.8[4]	97.2
Expt. Station Farm Mt. Carmel	Baldwin	98.1	—	100.0

[1]Figured in comparison with reduction on check unsprayed trees.
[2]2% of a 4% oil solution of di-nitro-cyclo-hexyl-phenol.
[3]Nicotine sulfate, 1 pint to 100 gallons.
[4]Nicotine sulfate, .75 pint to 100 gallons.

At least one authority recommends the use of nicotine dusts for aphid control, and occasionally we find growers in Connecticut who favor this treatment. Dusts are reported to be more effective than sprays after the leaves curl, but successes observed in control of the rosy aphid have been few and attempts have been witnessed where complete failure resulted. From what has been seen of the method it is apparent that: (1) The air must be still enough for the dust "fog" to hang in the trees and settle gradually; (2) The temperature should be high enough to make the nicotine effective, preferably above 70° F. during the day. Successful control with dusts is not easy and much depends upon the skill and judgment of the grower using them.

[1]It has been used experimentally by others as low as 1/3 pint nicotine sulfate in 100 gallons with 6 pounds 40 percent potassium oleate soap added. Successful control was reported.

Dormant sprays are effective in killing green aphid eggs and both sprays and dusts are used for their control during the growing season. Dusts are considered to be more effective against the green aphid than against the rosy.

Discussion of Experiments

Tables 1 to 4 give some of the results of experiments to control aphids in experimental orchards during 1938. In general these confirm results obtained in 1936 and 1937. Test trees were thoroughly sprayed with the exception of those at the Mount Carmel farm and at the Shepard orchard. At the MacDonald orchard the dormant oil applied to Wagener, compared with a nicotine soap application at the pre-pink stage, appeared

TABLE 2. APHIS CONTROL—1938. EXPERIMENT STATION FARM, MOUNT CARMEL
VARIETY, BALDWIN

Plot and tree	Treatment and dates	Total apples	Number deformed by aphids	Percent deformed
A 1	Tar oil	1,906	200	10.5
B 1	2.5 percent	3,300	159	4.8
(1) C 1	commercial	5,460	375	6.8
A 2	83 percent emulsion	4,151	549	13.4
B 2		3,720	116	3.1
C 2	April 1	2,249	58	1.5
		20,786	1,457	7.0
A 3	3 percent lubricating oil.	2,398	584	24.3
B 3	Tank mix.	3,214	315	9.7
(2) A 4		2,924	691	23.8
B 4	April 13	5,115	1,492	29.1
C 4		4,759	1,219	25.5
		18,410	4,301	23.3
A 5	2 percent oil with	4,541	575	12.6
(3) A 6	di-nitro-hexyl-phenol	4,729	829	17.5
B 6		1,623	148	9.1
C 6	April 1	2,511	289	11.5
		13,404	1,841	13.7

NOTE: Records indicate that a better job of spraying was done on Plot 1 than on Plot 3. Large trees difficult to spray thoroughly.

to give better results. At the Shepard orchard, control of aphids on Gravenstein with tar oils was satisfactory during 1936 and 1937 although no aphid counts of the fruit were made. Likewise, during 1938, aphid apples were not numerous at harvest, indicating, in general, successful control at dormant and delayed dormant periods. These trees are very large and difficult to spray thoroughly. In years previous to 1936 severe injury from aphid infestations was observed.

Table 2, giving a comparison of three different treatments, shows the value of thorough applications and the general ineffectiveness of tank mix oils without nicotine. Trees in this plot are large and difficult to spray, requiring a quiet day for best results. Records from some of the trees that were thinned showed that 7 to 15 percent of the fruit was removed during the process. In this case 23 percent aphid apples would be above the proportion thinned off during the summer and the advantage gained would possibly average 10 percent of the total fruit. In Plot 1, 2,078 apples, or approximately 10 bushels, were saved at a cost of 50 to 60 cents for materials.

TABLE 3. APHIS CONTROL—1938. TOWNSEND ORCHARD, HAMDEN. VARIETY, CORTLAND

Tree	Treatment and date	Total apples	Number deformed by aphids	Percent deformed	Bud count April 11 Number aphids per 100 buds
B 1	2 percent	1,094	186	17.0	0
B 2	emulsified oil	700	31	4.4	0
B 3	with di-nitro-	1,347	22	1.6	0
B 11	hexyl-phenol	948	6	.6	0
B 13		921	11	1.1	0
B 15	April 2	232	0	0.0	0
		5,242	256	4.8	0
				Excl. B 1, 1.6	
B 5	Check—	1,143	235	20.2	15
B 7	no treatment	386	27	6.9	130
B 9	for aphids	1,309	108	8.2	60
B 17		1,542	158	10.2	—
B 19		885	98	11.1	6
		5,265	626	11.8	52

Sprayed on quiet day, April 2.

In the Townsend experiments, Tables 3 and 4, the trees used are small and a fair job of spraying was done. Here, in the Cortland plot, tree No. B1 is at the end of the row where spraying started. In view of the fact that the count is unusually high for the treatment as a whole, it seems quite probable that either part of the tree was skipped or possibly dilution of the material was affected by water remaining in the pump. The Rome Beauty tests, Table 4, were also on small trees. On these trees no such variation was observed as in the Cortlands, because they were sprayed with material remaining after the Cortlands had been treated. The tar oil sprays were evidently not quite so effective here as at the Experiment Station farm, although reduction in percentage is considerable. No thinning was done on the test trees. In the Rome Beauty experiment, three bushels of apples were saved on five trees at a cost of 25 to 30 cents for materials.

Suggestions for Control

(1) About the first of April and until the gray tip stage, use in 100 gallons of water, 2 gallons of 4 percent di-nitro-cyclo-hexyl-phenol[1] in oil, emulsified with a material giving good spread upon the twigs and branches. Tank mix preparations containing 2 gallons of "di-nitro" oil, 2 pounds of skim milk powder and 1 pint of 25 percent fish oil soap paste in 100 gallons of water gave satisfactory results in 1938.

TABLE 4. APHIS CONTROL—1938. TOWNSEND ORCHARD, HAMDEN VARIETY, ROME BEAUTY

Tree	Treatment and date	Total apples	Number deformed by aphids	Percent deformed	Bud count April 19 Number aphids per 50 buds[1]
H 17	2% emulsified	1,002	3	0.2	0
H 11	di-nitro-hexyl-	598	10	1.6	0
H 5	phenol oil	1,153	0	0.0	0
F 11		483	13	2.6	0
F 7	April 2	878	0	0.0	0
		4,114	26	0.6	0
H 13	Two	674	7	1.0	0
H 9	2.5% tar oil	1,019	60	5.8	0
F 13	emulsion	329	25	7.5	0
F 5		885	30	3.3	0
J 17	April 2	531	0	0.0	0
		3,438	122	3.5	0
J 21	Check—	525	105	20.3	—
J 19	no treatment	461	104	22.5	3
J 15	for aphids	514	229	44.5	11
J 9		364	26	7.1	9
I 20		978	236	24.1	10
		2,842	700	24.6	8

[1]Both green and rosy aphids.
Trees small, carefully sprayed from all sides on a quiet day, April 2.

Or at the delayed dormant period, just before the pre-pink stage, use emulsified petroleum oil (3 percent oil in the diluted emulsion) with ample spreader, plus nicotine sulfate, 1 pint to 100 gallons. Commercial miscible oils seem to have worked better in this combination than the usual oil emulsion. If the infestation appears to be severe, 1.5 pints of nicotine sulfate in 100 gallons may be necessary to control it.

(2)[2] At the pre-pink stage, use nicotine sulfate, 1 pint to 100 gallons with soap spreader at the rate of at least 1 pound dry soap to 100 gallons. It requires about 2 quarts of the 25 to 30 percent paste soaps to wet rosy aphids.

[1]Apply preferably at the dormant period when temperatures are above 40° F. and be sure the agitator is working properly to keep the material emulsified.

[2]If satisfactory control has been obtained with No. 1 or its alternative treatment, No. 2 will, of course, not be needed. In severe infestations both No. 1 and No. 2 may be advisable.

Or combine nicotine sulfate with the usual pre-pink spray. Do not use soap and lime sulfur or soap and lead arsenate at the rate specified. If lime sulfur is used, some of the newer non-soap spreaders, such as "Ultrawet" or "Areskap" or similar materials, should be used in preference to soap. Allow at least two weeks between delayed dormant oil and pre-pink lime sulfur.

Spray thoroughly. If less than 90 percent of the aphids or their eggs are killed the sprays may be wasted.

Further Possibilities

If rosy aphids develop in spite of earlier treatments, dust about the middle of May with 1 percent nicotine-lime or 1 percent nicotine-sulfur, or spray during June with nicotine sulfate and soap. These are, at best, stop-gap measures and should only be resorted to when aphids are very numerous and are getting on the fruit in large numbers. They have been used by growers who report good results, but one's best efforts should be made at or before the pink stage and not later than that period.

If the European red mite is not a problem, tar oils may be used at 2 percent oil dilution (usually 2.5 percent commercial stock). Use them during the strictly dormant period, the usual time for which is between the middle and last of March. Protect the face and hands during the operation and blanket horses used to pull the spray rig.

Cost of Materials

In order to give an idea of the relative cost of the spray materials mentioned above, the following figures for 1938 are offered. They are not intended to be a guide to the market but are given merely to show the relative cost. Freight or express charges are not included, but all materials are obtainable locally or not farther away than Boston, Mass., or Elizabeth, N. J. The amounts given in each case are for 100 gallons. Prices of all except nicotine sulfate are for 50-gallon lots.

Di-nitro-cyclo-hexyl-phenol in oil, 2 gallons	\$1.40*
Tar oil emulsion, 2½ gallons	\$.70 to 1.00
Nicotine sulfate, 1 pint	\$1.08
Lime sulfur, 3 gallons	.51
Total	\$1.59
Nicotine sulfate, 1 pint	\$1.08
Oil emulsion or miscible oil, 4 gallons	\$1.00 to 1.60
Total	\$2.08 to 2.68

*If emulsifier is not furnished with the oil, 15 to 20 cents should be added to the cost per 100 gallons.

Acknowledgments

J. F. Townsend has been responsible for some of the work reported in this circular, particularly bud and fruit counts together with scouting for infestation centers. The photographs are the work of B. H. Walden.