

obtained, however. Lime-sulphur alone can not be regarded as a satisfactory remedy. The addition of arsenate of lead (neutral or basic) or nicotine sulphate to lime-sulphur, and this mixture applied as near the pink stage as possible is considered to be the best control for the peach twig-borer at the present time. If lime-sulphur spraying is not necessary for fungous diseases, nicotine sulphate sprayed at blooming time is recommended.

On account of the fact that there is a second generation, one spraying may not be sufficient. If complete control is not secured in a given district, the flight of surviving moths may scatter and multiply the infestation and "wormy fruit" will be the result. A spray applied the middle of May will probably reduce the fruit damage. The writer is testing the effectiveness of nicotine sulphate and arsenate of lead against the second generation of larvae and will be able to report results at the end of this season.

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### RESISTANCE OF CERTAIN SCALE INSECTS IN CERTAIN LOCALITIES TO HYDROCYANIC ACID FUMIGATION

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In 1915 my attention was called to the unsatisfactory results of fumigation for the citrus red scale, *Chrysomphalus aurantii* Mask., that had been obtained in the vicinity of Corona, California. The red scale was very abundant in several groves in spite of the fact that the trees had been fumigated not only regularly in the fall but the more severely infested trees had been fumigated also in the spring. This condition is known to have prevailed for some years previous to 1915 and still prevails.

Ordinarily, the so-called 100- or 110-percent schedule of dosage is effective in controlling the red scale, but this schedule was considerably increased in the commercial fumigation work in the Corona district with the result as indicated above. In our experimental fumigation work there since 1915, dosages varying from 100 to 200 per cent for the regular period of 45 to 50 minutes, and dosages of from 75 to 100 per cent repeated at the end of the regular period, were given with unsatisfactory results. This experience, together with that of several different commercial firms, led us to suspect that the red scale is actually more difficult to kill in that district, rather than to ascribe the poor

results to insufficient dosage, leaky tents, or lack of attention to the details of the work.

The time and place may very materially affect the results of fumigation, hence in any comparative work it is necessary to eliminate these two variable factors. This was done in the case in question by taking infested fruits from two localities and fumigating them under the same tent in a third locality. The fruits infested with red scale were picked from two localities on the same day, or from one of the localities on the day following. They were placed in the same basket, or two baskets were placed together under the tent, in order to guard against variation in gas concentration in different parts of the tent. Different series of such tests have been made repeatedly since 1915 under tents over "form trees," under tents in experimental fumigation work in the field, and under tents operated in commercial fumigation practice. Since 1915 it has been determined that the red scale in certain districts in Orange County manifests the same apparent resistance to hydrocyanic acid.

In the comparative tests reported below the dosage was varied considerably, but in all cases the scales from the different localities were under essentially identical conditions.

The summary results of a few representative tests are given below in table 1.

TABLE 1. THE EFFECT OF FUMIGATION ON RED SCALE FROM DIFFERENT LOCALITIES

Locality	No. of scales fumigated	No of scales alive	Percentage of scales alive
	SERIES I		
Orange	6,076	35	0.57
Corona	10,176	455	4.47
	SERIES II		
La Habra	1,388	6	0.43
Corona	1,430	280	19.58
	SERIES III		
Riverside	1,386	1	0.07
Corona	1,773	12	0.67
	SERIES IV		
Redlands	2,300	6	.26
Highgrove	2,700	49	1.81
Corona	4,300	173	4.02
	SERIES V		
La Habra	1,500	60	4.00
Corona	1,900	388	20.40

The fact that we have evidence extending over a period of seven years of exceptional resistance in the red scale at Corona, and in a district in Orange County extending over four or five years, would indicate that it is not necessarily a seasonal condition. If it is a case of acquired immunity and the factor of resistance is hereditary, it is necessary that this factor be transmitted through two or three generations of scales since this number intervenes between fumigations. We have some evidence to indicate that the individuals that are alive after

one fumigation are more resistant to a second fumigation than individuals which have not been previously fumigated. Also, that the greatest resistance is shown by scales on trees that have been fumigated regularly, once, or even twice, a year. More satisfactory fumigation results have often been secured on trees that have not been fumigated for two or three years than on trees that have been regularly fumigated where a certain number of the scale escaped being killed.

The variable factors of time and place affecting fumigation results have to do chiefly with meteorological conditions. There is also a variation in the condition of the tree itself, but this may be independent of the time or locality. Differences in the amount of foliage on the tree may influence fumigation results. Foliage absorbs hydrocyanic acid, and the more foliage there is present the more HCN will be absorbed and the less, apparently, will be left in the atmosphere to kill the insects on the exterior of the tree.

A series of tests were made to determine the relation of the foliage to the dosage. An ordinary orange tree with a medium amount of foliage was covered with a tent, and alongside this tree a wooden framework was constructed to support a tent, which enclosed a space identical in form and size with the orange tree. Lemons infested with red scale were placed in the same relative position under each tent. The tents were frequently interchanged to overcome tent variation. The dosage was varied, but was always the same under both tents in any given test. These tests showed that the proportion of scales killed was approximately  $5\frac{1}{2}$  per cent greater under the tent that contained no tree or foliage.

It has been noted in the field that on the heavy foliage-Lisbon type of lemon tree, scales are more likely to survive a fumigation than scales on trees with sparse foliage. Scales are much more difficult to kill on the fruit than on the twigs or leaves. Likewise, they are more difficult to kill on vigorous and thrifty leaves, and on vigorous shoots such as suckers, than on less thrifty leaves and twigs. This difference in resistance on different parts of the tree, or between two trees of different vigor, seems to be related to the food supply of the scale. If a particular locality had a monopoly on the vigorous trees, the resistance of the insects might be explained on this basis, but the red scale is more difficult to kill on unhealthy trees in the areas where it shows exceptional resistance, than on healthy trees in other localities. The tree may constitute one of the variable factors in fumigation results, but that scale resistance is not entirely determined by the tree, is shown by the tests given. Here the resistance persisted after the scale-infested fruit was removed from the tree and fumigated in a different locality.

Certain stages of the red scale show more resistance to HCN gas than others. The molting period, particularly the second molt, and the adult or young-producing period, are the two most resistant stages, and of these two, the molting stage is the more resistant.

Among the variable meteorological conditions, humidity and wind are important, as affecting the results of fumigation. The ordinary canvas tenting material varies greatly in gas-holding capacity according to the dryness of the cloth, which is dependent upon the amount of humidity in the atmosphere, and also, varies according to the movement of the atmosphere. By means of a gas-tight tent we have been able to overcome the effect of humidity on the tent, and have eliminated tent leakage, the most variable factor in fumigation work. By the use of a gas-tight tent in different localities, further proof of exceptional scale resistance in certain localities has been secured.

In the case of the red scale at Corona, definite proof of resistance was lacking until comparative tests were made in which the variable factors of time and place were eliminated. At this time, however, after seven years' experience, observation of experimental and commercial work in the field is sufficient to establish the fact of resistance.

In 1915 our attention was also called to the difficulty of killing the black scale in the vicinity of Charter Oak, California.

Because the black scale does not infest the fruit (at least to any considerable extent) it has not been possible to carry out comparative fumigation tests on it from two or more localities at the same time, and in the same tent, as with the red scale. Infested twigs can be collected from different localities, however, although drying interferes with the results and is difficult to overcome. Our experimental fumigation work, as well as commercial work in the Charter Oak district for the past six years, furnishes ample proof that the black scale is much more difficult to kill with HCN gas there than in most other localities. In general, the black scale is most susceptible to HCN gas when it is small. When it reaches the mature stage fumigation results are much less satisfactory. In the Charter Oak district, however, with dosages greatly in excess of that ordinarily necessary to secure a 100 per cent kill, small scales in considerable numbers will come through the fumigation unharmed. In most other localities 25 per cent less gas would insure very satisfactory results on similar small scales.

There are thus two localities where it seems well established that the red scale is very resistant to hydrocyanic acid gas, and one locality where the black scale is specially resistant. In these localities these scales are

not immune to hydrocyanic acid, but the dosage required for satisfactory results is so large that effective fumigation is unsafe for the tree except under the most favorable conditions.

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## FACTS CONCERNING MIGRATION OF BEET LEAFHOPPER (*EUTETTIX TENELLA* BAKER) IN SACRAMENTO VALLEY OF CALIFORNIA

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### I. INTRODUCTION

According to Ball (1) the beet leafhopper (*Eutettix tenella* Baker) is not found, except in periods of abundance, in the inland regions north of Sacramento. Ball (1) reports that during the serious outbreaks of curly leaf (curly top or blight) in 1914, considerable damage to the beet crops occurred at Hamilton City. After several years of idleness the sugar factory at Hamilton City resumed operations during 1918. This sugar mill was closed after the 1918 outbreak of curly leaf and since then has not operated.

### II. CURLY LEAF

We (2) have published the results of our investigations conducted in the Sacramento Valley during 1918. In the beet fields near Hamilton City, not a single beet leafhopper was captured on June 6, and no blighted beets were found. Spring brood adults, however, were taken on garden beets at Marysville on June 2, but 5% of these beets were diseased, indicating an earlier invasion of the pest. A trip was taken into the Sacramento Valley on August 19-25, and from 66-86% of the sugar beets showed curly leaf symptoms, in the vicinity of Hamilton City. In the southern part of the valley from 36-86% of the beets were blighted.

During 1919, at least one or two trips per month were taken to all of the beet centers in the Sacramento Valley during the beet season. The first beet leafhopper was captured on Silverscale or Fog Weed (*Atriplex expansa*) near Woodland on May 27, but no curly leaf was found in the late planted beet fields. The average percentages of curly leaf in the various beet districts developed as follows during the past season.