The Bulletin Vol. 26 No. 3 July-September, 1937: 369-376

ATMOSPHERIC HCN FUMIGATION FOR LATANIA SCALE ON AVOCADO FRUITS[1]

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INTRODUCTION

The latania scale, *Aspidiotus lataniae* Sign., is probably the most serious insect pest of avocados in California. Before being shipped into certain localities, infested fruits must undergo treatment. At the request of the Calavo Growers of California, the following project was undertaken to ascertain whether absolute assurance of a complete kill, without injury to the fruit, may be obtained by fumigation with hydrocyanic acid gas at atmospheric pressure.

METHODS

A few preliminary tests conducted in a 100 cubic-foot fumatorium with no load factor to take into consideration indicated that 100 per cent kill of latania scale was obtained with a dosage of 10 cc. of HCN. However, only 4,459 scales were counted at this time, and since the experiments were conducted in an air-tight metal fumatorium without a load, they did not correspond to fumigation practices as they are intended to be carried out by the Calavo Growers. Therefore, in the following experiments commercial conditions were duplicated as nearly as possible.

A room 450 cubic feet in capacity and practically gas-tight at atmospheric pressure was used. This room was equipped with a small 10-inch fan to circulate the HCN and an exhaust fan to remove the gas. Unless otherwise stated, the load consisted of 200 avocado boxes containing the usual amount of excelsior but no fruit. The dummy boxes were stacked fifteen to eighteen high, with five stacks along the length of the room and approximately three stacks along the width. Whenever any boxes containing scale-infested fruits were obtained, they were placed in various situations among the dummy boxes. Their positions were indicated by such terms as "stack 1, back-center" and "stack 3, front-top."

Hydrocyanic acid gas was applied with a cold gun applicator such as is used in regular citrus fumigation. Rapid evaporation of the liquid HCN was obtained by the circulation of air afforded by the fan. All exposures were for one hour, the temperature range being between 67° and 72° F.

[1]Paper No. 354, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

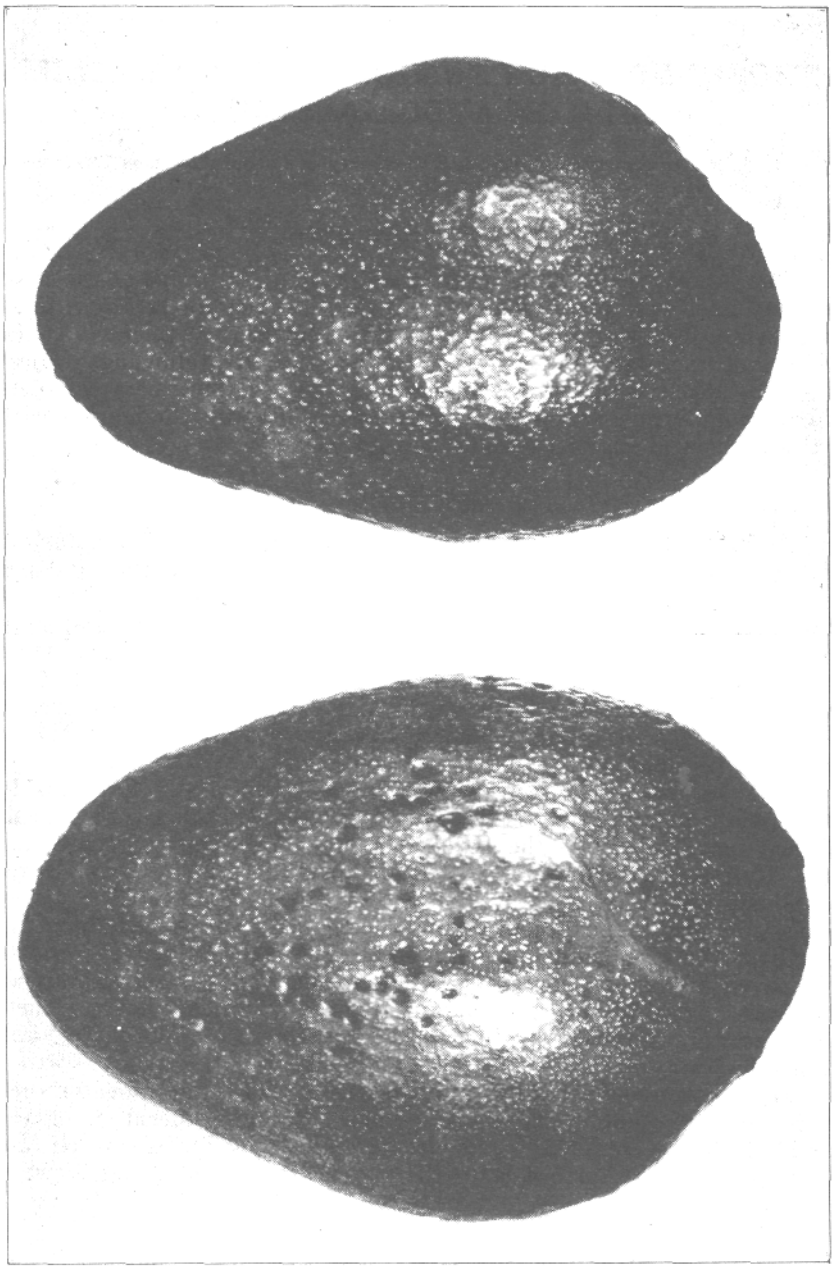

FIG. 1. Left: Fuerte avocado fruit pitted by an excessive dosage (88.8 cc. per 100 cu. ft.) of HCN. Right: Normal fruit.

SCALE KILL AND FRUIT INJURY

Experiment 1.—The highest dosage tried was 400 cc. of HCN per 450 cubic feet, or 88.8 cc. per 100 cubic feet. In experiment 1, two boxes of scale-infested fruits were used. They were held at room temperature prior to fumigation and removed to 45° F. after fumigation. In box 1, the excelsior and fruit were dampened, while in box 2 the excelsior and fruit were dry. Scale counts made ten days after fumigation gave the

following results:

	Scales counted	*Number alive*
Box 1 (wet) stack 2, back-center	754	0
Box 2 (dry) stack 2, back-center	890	0
Total	1,644	0

Experiment 2.—This experiment was similar to the above except that the fruit was held at 45° F. prior to fumigation and returned to this temperature immediately after fumigation:

	Scales counted	*Number alive*
Box 1 (wet) stack 2, back-center	601	0
Box 2 (dry) stack 2, back-center	2,387	0
Total	2,988	0
Check	1,540	342

These tests indicated that a one hundred per cent kill of the scale was obtained, although some fruit injury apparently resulted. However, the fruits were so heavily infected with Dothiorella rot that it was hard to distinguish between the surface rot and fumigation injury.

Therefore a box of perfectly healthy avocados was placed in stack 1, back-center, and subjected to 400 cc. of HCN per 450 cubic feet for one hour; another box was held as a check. Figure 1 shows a fumigated fruit and a check fruit. A definite pitting appeared within twenty-four hours after fumigation. The lesions did not increase in size after they first appeared, nor did they extend further into the flesh of the fruit.

Experiments 3 and 4.—After the extent of fumigation injury had been ascertained, an attempt was made to reduce the dosage of HCN to a point which would assure one hundred per cent kill of the scale without injury to the fruit.

Two experiments were conducted, with 300 cc. HCN per 450 cubic feet or 66.6 cc. per one hundred cubic feet. In experiment 3 the fruit was held at room temperature prior to fumigation and removed to cold storage immediately after fumigation. In box 2 the excelsior and fruit were dry. The results were as follows:

	Scales counted	*Number alive*
Box 1 (wet) stack 2, back-center	113	0
Box 2 (dry) stack 2, back-center	207	0
Total	320	0
Check	35	12

Experiment 4 was similar to 3, with the exception that the fruit was held at 45° F. prior to

fumigation and returned to this temperature after fumigation. Scale counts gave the following results:

	Scales counted	*Number alive*
Box 1 (wet) stack 2, back-center	95	0
Box 2 (dry) stack 2, back-center	191	0
Total	286	0
Check	36	9

A dosage of 300 cc. of HCN gave one hundred per cent kill of the scale with no apparent injury to the fruit.

Experiment 5.—The next dosage used was 200 cc. of HCN per 450 cubic feet or 44.4 cc. per 100 cubic feet. In experiment 5, fourteen crates of scale-infested avocados were held at room temperature prior to fumigation, fumigated at 70° F., and immediately removed to cold storage(45° F.). Counts were made twelve days later. The boxes were placed in the following positions:

	Scales counted	*Number alive*
Stack 1, back-center 2 boxes	1,011	0
Stack 2, back-center 2 boxes	2,646	0
Stack 3, back-bottom 2 boxes	1,795	0
Stack 4, back-top 2 boxes	2,613	0
Stack 3, middle-bottom 2 boxes	1,848	0
Stack 3, middle-center 2 boxes	1,461	0
Stack 5, middle-center 2 boxes	960	0
Total	12,334	0
Check	1,540	342

Experiment 6.—In experiment 6, seven boxes of scale-infested fruits were fumigated with 200 cc. of HCN. The fruit was held at room temperature prior to and after fumigation. The temperature was 70° F., and counts of the scales were made eleven days after fumigation. The positions of the boxes were as follows:

	Scales counted	*Number alive*
Stack 1, back-center	641	0
Stack 2, back-center	178	0
Stack 3, back-bottom	205	0
Stack 4, back-top	190	0
Stack 3, middle-bottom	120	0
Stack 3, middle-center	239	0
Stack 5, middle-center	241	0
Total	1,814	0

No latania scale survived a dosage of 200 cc. HCN per 450 cubic feet. A total of 14,148 dead scales were counted.

Experiment 7.—A dosage of 160 cc. of HCN per 450 cubic feet or 35.3 cc. per 100 cubic feet was tried in experiment 7. The fruit was held at room temperature prior to fumigation and removed to cold storage (45° F.) immediately after the exposure to the gas; scale counts were made twelve days later. Fourteen boxes of avocados were placed among the 200 crates as follows:

	Scales counted	*Number alive*
Stack 1, back-center 2 boxes	576	0
Stack 2, back-center 2 boxes	525	0
Stack 3, back-bottom 2 boxes	569	0
Stack 4, back-top 2 boxes	577	0
Stack 3, middle-bottom 2 boxes	467	0
Stack 3, middle-center 2 boxes	652	0
Stack 5, middle-center 2 boxes	478	0
Total	3,844	0

Experiment 8.—In this experiment, the dosage used was 160 cc., but the fruit was held at room temperature prior to and after fumigation. Scale counts were made within ten days. The boxes containing scale-infested fruits were placed in the following positions:

	Scales counted	*Number alive*
Stack 1, back-center	1,091	0
Stack 2, back-bottom	419	0
Stack 3, back-center	253	0
Stack 4, back-top	911	0
Total	2,674	0
Check	501	105

Experiments 9 and 10.—The lowest dosage tried was 80 cc. or 17.7 cc. per 100 cubic feet. Two experiments were conducted at this concentration, the fruit being held at room temperature prior to and after fumigation. The positions of the boxes containing scale-infested fruits were as follows:

	Scales counted	*Number alive*
Stack 1, back-bottom	279	0
Stack 1, back-center	410	0
Stack 3, back-bottom	526	0
Stack 3, back-center	296	0
Stack 4, back-top	390	0
Stack 4, front-top	397	0
Total	2,298	0
Check	292	96

With a dosage of 80 cc. of cyanide per 450 cubic feet or 17.7 cc. per 100 cubic feet, no latania scale survived. In commercial practice a dosage of 25 cc. of cyanide per 100 cubic feet in an air-tight fumatorium should give complete control of the scale on packed avocados.

ACTUAL CONCENTRATION OP HCN IN THE FUMATORIUM

Samples of gas were taken at regular intervals to determine: (1) the time it took the liquid HCN to evaporate, and the gas to become evenly distributed; (2) whether the gas tended to layer; and (3) the drop in concentration due to sorption,[2] leakage, and other factors. The samples were drawn off at two different places in the room, one at a height of seven feet, and the other at a height of about one foot from the floor. The results of these tests are given in tabular form below. The figures represent the averages of two or more experiments. The average mean concentration was calculated for a fifty-minute period as follows: One-half the concentration at the two or three-minute interval was first obtained, then the average for the concentration at two minutes and seven minutes was multiplied by the time interval of five minutes. Likewise the average for seven minutes and fifteen minutes was multiplied by the eight-minute interval, and so on through the period when the total was divided by the time interval, or fifty minutes.

TABLE I

ASPIRATION OF HCN, PER CENT BY VOLUME. DOSAGE: 160 cc. PER 450 CUBIC FEET

Load	Time of aspiration, minutes	Top 7 feet from floor	Bottom 1 foot from floor
None	2	0.5892	0.5863
	7	.5941	.5928
	15	.5880	.5901
	30	.5783	.5819
	50	0.5625	0.5698
	Mean average concentration	0.5622	0.5655
20 avocado boxes containing excelsior but no fruit	3	0.5600	0.5613
	7	.5200	.5272
	15	.4969	.4993
	30	.4507	.4556
	50	0.4179	0.4203
	Mean average concentration	0.4460	0.4496
200 avocado boxes containing excelsior but no fruit	2	0.3409	0.3361
	7	.2235	.2243
	15	.1854	.1863
	30	.1578	.1571
	50	0.1336	0.1336
	Mean average concentration	0.1740	0.1738

[2]Sorption : refers to both absorption and adsorption.

As shown in table 1, there is very little leakage or adsorption of hydrocyanic acid gas when the fumatorium is empty. After fifty minutes the concentration was only 4.5 per cent less than after two minutes. With the same dosage but with a load of twenty avocado boxes (table 1), the concentration after fifty minutes was 25 per cent lower than after three minutes. With a load of 200 boxes (table 1), the concentration at fifty minutes was 60 per cent less than after two minutes. In other words, 55.5 per cent of the gas was lost through adsorption and absorption by the boxes and excelsior, while only 4.5 per cent of the gas was lost through leakage and adsorption to the surface of the fumatorium. The mean average concentration with a load of 200 boxes was almost 70 per cent lower than with no load in the room.

TABLE II

ASPIRATION OF HCN, PER CENT BY VOLUME. LOAD: 200 AVOCADO BOXES CONTAINING EXCELSIOR BUT NO FRUIT

Dosage, per 450 cu. ft., in cc.	Time of aspiration, minutes	Top of room	Bottom of room
80	3	0.1470	0.1482
	7	.1068	.1068
	15	.0862	.0862
	30	.0680	.0668
	50	0.0571	0.0558
	Mean average concentration	0.0757	0.0750
200	2	0.4871	0.4920
	7	.3304	.3304
	15	.2551	.2539
	30	.1956	.1907
	50	0.1555	0.1543
	Mean average concentration	0.2303	0.2284
300	3	0.5759	0.5710
	8	.4300	.4288
	15	.3705	.3681
	30	.2976	.2988
	50	0.2684	0.2672
	Mean average concentration	0.3254	0.3246
400	3	0.8650	0.8626
	8	.5200	.5200
	15	.4179	.4240
	30	.3547	.3547
	50	0.2927	0.2891
	Mean average concentration	0.3889	0.3893

Table 2 shows the drop in concentration and mean average concentration with dosages of 80, 200, 300, and 400 cc. of HCN. When a dosage of 80 cc. per 450 cubic feet (17.7 cc. per 100 cubic feet) is used, the mean average concentration is about the same as that obtained when a 20 cc. dosage is applied in the field under a canvas tent. The mean average concentration with a dosage of 400 cc. and a load of 200 boxes (that occupy about one-half of the space in the fumatorium) is less than the mean average concentration when a dosage of 160 cc. of HCN is used in the empty room. The dosage should not be reduced when the load is increased; the reverse should be the rule if the load is such that it may take up large amounts of the gas. In all the experiments, there was very little difference in the concentration at the top and at the bottom of the room.

FUMIGATION OF PACKED AVOCADOS

At the suggestion of D. B. Mackie, Supervisor of Entomology, State Department of Agriculture, two experiments were carried out in which a load of 150 boxes of packed fruit, together with 50 boxes containing only excelsior, were fumigated with a dosage of 108 cc. of HCN per 450 cubic feet (24-fcc. per 100 cubic feet). These experiments were conducted to duplicate commercial practices. The fruit was held at room temperature prior to and after fumigation, and the positions of the boxes containing scale-infested fruits were as follows:

	Scales counted	*Number alive*
Stack 1, back-bottom 2 boxes	1,109	0
Stack 4, back-top 2 boxes	2,082	0
Total	3,191	0
Check	105	19

No latania scale survived in the above experiments.

TABLE I

ASPIRATION OF HCN, PER CENT BY VOLUME. DOSAGE: 108 cc. PER 450 CUBIC FEET

Load	Time of aspiration, minutes	Top of room	Bottom of room
150 boxes containing avocados, and 50 boxes with excelsior	3	0.2332	0.2295
	7	.1688	.1676
	15	.1360	.1348
	30	.0983	.0995
	60	0.0874	0.0874
	Mean average concentration	0.1234	0.1233

Results of HCN Aspirations.—Table 3 shows that the drop in concentration of HCN is no greater with a load of packed avocados than it is with a load of boxes containing only excelsior. A mean average concentration of .0753 was obtained with a dosage of 80 cc. HCN (table 2) for a load of 200 boxes containing excelsior. With a dosage of 160 cc. of HCN (table 1), a mean average concentration of .1739 was obtained. Therefore, a mean of .1097 should be obtained with a dosage of 108 cc. However, a mean of .1233 was actually received when a load of packed avocados was fumigated. It may be concluded from this that the fruit did not increase the adsorption of HCN over that of the boxes of excelsior in the previous experiments.

CONCLUSIONS

In the 450 cubic-foot fumarorium with a load of 200 boxes filled with excelsior (but without fruit, excepting what was placed in key positions for the determination of scale kill and fruit injury), the dosage of liquid hydrocyanic acid varied from 80 cc. to 400 cc. or from 17 cc. to 88 cc. per 100 cubic feet. The highest dosage, 88 cc. per 100 cubic feet, was greatly in excess of that necessary to kill the latania scale, but it was given to determine what injury to the fruit might occur. The injury that resulted was slight in view

of the excessive dosage used (see figure 1). The experiment involved mature, sound fruits of the Fuerte variety.

The lowest dosage, 17 cc. per 100 cubic feet, resulted in a complete kill of the latania scale. Two experiments were conducted with a load of packed avocados. A dosage of 24+ cc. of hydrocyanic acid gas resulted in complete kill of the scale.

As a result of all of the tests, the authors feel justified in concluding that latania scale on avocado fruits can be killed, under the conditions indicated, by atmospheric fumigation.

A dosage of 25 cc. of liquid hydrocyanic acid, or its equivalent, per 100 cubic feet is recommended. With a load of fifty avocado boxes per 100 cubic feet, exposure should be for one hour, with electric fan circulation.