FUMIGATION OF NURSERY STOCK.

S. A. BEACH.

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INTRODUCTION.

The best known way of killing San José scale on dormant nursery stock is by fumigation with hydrocyanic acid gas. ¹ This treatment is valuable not only against San José scale but against all scale insects which do not winter in the egg stage. It will doubtless also check the spread of some other kinds of injurious insects which are liable to be distributed on nursery stock.

Plain directions for fumigating dormant nursery stock with hydrocyanic acid gas will first be given, after which suggestions will be made as to the location and construction of fumigation houses or chambers.

THE EQUIPMENT.

The things needed for fumigating nursery stock with hydrocyanic acid gas are: (1) The chemicals; (2) a suitable dish in which to mix them; and (3) an air-tight box or chamber to hold the stock while it is being fumigated.

CAREFUL WORKMEN NEEDED.

It is not hard to kill the San José scale; the difficulty is to kill it without injuring the plant upon which it is living. The scale insect is fastened immovably to the plant with its mouth parts stuck into the bark so that it may suck the plant juices which constitute its food. It cannot be given poison in its food but must be killed by something which comes in contact with its body. Exposing it to hydrocyanic acid gas kills it if the fumigation is properly done. Too great an amount of the gas will injure the

¹ This substance is commonly known in liquid form by the name "prussic acid."
plant. If the gas is too weak or the time of exposure too short, the scale insects may not all be killed. It is very important, therefore, that the work be done only by intelligent and careful workmen.

DANGER TO HUMAN LIFE!

But there is a still stronger reason for keeping this work always under the direction of a competent person, and that is because hydrocyanic acid gas is most deadly poison. One full breath of it may at once stop the action of the heart. A large dose may cause instantaneous death.

THE CHEMICALS.

Water, sulphuric acid and potassium cyanide are the chemicals needed for making hydrocyanic acid gas.

Sulphuric acid (\(H_2SO_4\)).—A good grade of commercial sulphuric acid should be used. Its specific gravity should not be less than \(1.82\). At present it costs less than two cents a pound, wholesale. Care should be used not to spill the sulphuric acid upon either the clothing or the person. It eats the clothing and burns the flesh.

Potassium cyanide (KCN).—The fused cyanide, 98 to 99 per cent. pure, should be used. It is now supplied by the manufacturers in wholesale quantities for about 30 cents per pound. Somewhat higher prices are quoted by dealers. It is a white, solid substance, which absorbs moisture and gradually vaporizes unless it is kept from the air. It is best to keep it in air tight cans, plainly labeled "poison" and put where children, or others who may not know its deadly character cannot get it.

Potassium cyanide is one of the most poisonous substances known! Instances are on record where adult persons have been killed by five grains, which would make a lump about the size of a large pea. The vapor from the can in which potassium cyanide is kept is also poisonous.

THE FUMIGATION.

When the stock has been put into the fumigation chamber, place a glazed earthen-ware dish having a capacity of a gallon, at least, on the floor near the middle of the room. If the room is large use one large gas generator in each 1000 cubic feet of space, or use several smaller ones properly distributed.
To generate the gas, first pour into the dish the required amount of water, then add the sulphuric acid. This process should not be reversed because when the water is poured into the acid a more violent action takes place and the acid is liable to be spattered upon the person doing the work. Lastly drop into the dish the paper containing the potassium cyanide. Get out of the room and close the door as quickly as possible being very careful not to get a breath of the gas. From the time fumigation begins till the room has been thoroughly ventilated a danger placard should be displayed at the door.

Time.—The entomologists who have investigated this subject are not yet agreed as to the length of time which should be recommended for the fumigation of dormant nursery stock but they generally give from 30 to 50 minutes. Sirrine advises that, when using the formula given below, the stock be fumigated for one hour. In Johnson’s tests, well matured stock of apple, plum, etc., stood treatment one hour with gas at a strength far above the standard used; so that in general with the standard strength, no damage need be feared from an over dose with well matured stock. It is well to be on the safe side and continue the fumigation long enough to secure the full benefit of the operation.

Ventilation.—After the stock has been fumigated the room must be ventilated for at least ten minutes before entering it. This rule must be strictly enforced because anyone who enters the room before it has been properly ventilated endangers his life.

THE FORMULÆ.

The following formula is recommended by Sirrine for general use in fumigating well-matured dormant nursery stock. For each 100 cubic feet of space in the room use:

Formula for well-matured stock.

Potassium cyanide, 98 to 99% pure... 1½ oz. (avoir.)
Sulphuric acid\(^3\) .......................... 1½ to 1½ fl. oz.
Water\(^1\) ........................................ 4½ fl. oz.


\(^3\)In this formula Mr. Sirrine recommends more sulphuric acid and water to each ounce of potassium cyanide than is called for in some other formulæ which have been recommended by other entomologists.
Fumigate for one hour and then ventilate the room ten minutes before entering it.

Sirrine’s experiments with different amounts of the cyanide lead him to the opinion that for general use with well matured nursery stock the amount should not be less than $1 \frac{1}{6}$ oz. per 100 cubic feet, which is the amount given in the above formula. He finds, however, that stock, under some conditions, is injured by even as small a quantity of the cyanide as this. Johnson reports similar results and recommends for peach whips, June budded peach trees, bud sticks and in general all stock which is not well matured, that the amount of potassium cyanide be reduced to 18 grams (approximately $\frac{5}{8}$ oz.) per 100 cubic feet. When stock is to be fumigated which is not well matured it is doubtless best to reduce the amount of the cyanide as Johnson recommends, even if it is necessary to lengthen the time of fumigation to get satisfactory results. Following Sirrine’s ideas in regard to the proportionate amounts of sulphuric acid and water the formula for each 100 cubic feet of space would be as stated below.

Formula for immature stock, bud sticks, etc.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium cyanide</td>
<td>$\frac{5}{8}$ oz. (avoir.)</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>$\frac{3}{4}$ fl. oz.</td>
</tr>
<tr>
<td>Water</td>
<td>$2\frac{1}{2}$ fl. oz.</td>
</tr>
</tbody>
</table>

REFUMIGATION.

Johnson finds that the peach will not stand a second fumigation. Apples, pears, etc., are not injured by it, but it is well not to expose stock a second time to the gas after it has been once properly fumigated.

FUMIGATION OF STOCK NOT DORMANT.

Stock which has passed out of the dormant condition cannot be safely fumigated with gas at the strength given for dormant stock, neither can it in the fall before the leaves have dropped.

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4 Other entomologists recommend less amounts of the cyanide. Johnson’s formula calls for approximately $\frac{5}{8}$ oz. per 100 cubic feet; Alwood uses 1 oz., Marlatt 1 oz., and Webster $\frac{3}{4}$ oz. per 100 cubic feet for well matured stock.

5 Johnson, W. G. l. c.
Fig. 1
Fumigating House Showing Doors.

Fig. 2
Fumigating House Showing Ventilators.
THE FUMIGATION HOUSE.

The first essential in building a room or box to be used in the fumigation of nursery stock is to make it air tight. If the room is not air tight the results will be uncertain and surely unsatisfactory.

It is also important that the room or house be so located that it can be readily ventilated without having the escaping gas interfere with other work. It is best to provide for ventilation by flues opening through the roof. This is especially desirable where the fumigation chamber occupies a portion of a packing shed or any other building which is filled with workmen during the fumigating season.

Figures 1 and 2 give different views of a very satisfactory fumigating house used by the R. G. Chase Nursery Co., Geneva, N. Y. It is modeled after the house described in Bulletin 57, Maryland Agricultural Experiment Station, pages 92 and 93. A somewhat detailed description of it is herewith given because it represents a very good type of air tight construction.

The outside dimensions of the building are 16 ft. x 32 ft.; posts 7 ft. and peak of roof 9 ft. high. The studding, which is 2x4 inch hemlock, is covered outside with building paper lapped one-half, then with upright boards battened with 4 inch strips as shown in the cut. The studding is covered inside with 5/8-inch ship-lapped lumber; following this is a course of building paper lapped one-half and then the ceiling of matched boards. The floor beams are first covered with matched boards, then with building paper lapped one-half and lastly with matched flooring. The ceiling beams are covered above with 5/8-inch ship-lapped lumber, and beneath with a course of building paper lapped one-half and then with ceiling of matched boards. The roof is made of surfaced hemlock laid on 2x4 inch rafters and covered with roofing paper. For a permanent building a shingled roof with steeper pitch would doubtless be more economical.

The doors are made after the manner of doors used for cold storage rooms. They should fit perfectly and it is well to provide weather strips or felt for the edges to press against when the doors are closed. The doors should be firmly supported with
strong hinges. At the top of each large room opposite the entrance is a small door 3x2½ ft. as shown in Fig. 2. These are made quite similar to the doors at the entrance. They aid in securing rapid and thorough ventilation. Flues from each large room leading through the roof are made for the same purpose. These are fitted with air tight covers at the top, which are opened from the roof as shown in Fig. 2. They are closed at the bottom by a slide which is reached from the roof through the flue.

The interior is divided into two large rooms and one small one by partitions made of two thicknesses of matched lumber with building paper between. The large rooms are each 15x13 ft. and hold about 3,000 apple trees of ¾ inch caliper. The small room, 4x15 ft., is for fumigating smaller lots of stock.

Every detail of work should be performed with the idea constantly in mind of making the building air tight. The sheathing paper must be laid smoothly and evenly and the sheathing boards and ceiling must be free from warps, knots or other defects which impair their value for the purpose for which they are intended.

It is convenient to have a box which will hold about 50 cubic feet for use in fumigating very small lots of nursery stock, bud sticks, cions, etc., then the chemicals can be used at one-half the strength given for 100 cubic feet. A very convenient form has the inside dimensions 2 ft. x 3 ft. x 8 ft. It is long enough to hold ordinary sizes of nursery trees. It may be made air tight by using building paper and matched boards after the manner just described for the fumigating house. It should have an opening low down on one side through which the cyanide may be dropped into the acid after the top of the box has been tightly closed. This opening should be closed by a tight fitting slide as soon as the cyanide has been put into the acid.

Some fumigating houses are made large enough so that a wagon loaded with nursery stock can be run into the fumigating room. Where this plan is followed the floor of the wagon box or rack should be open enough to allow the gas to pass readily to the lowest part of the load. The fumigation requires no less amounts of the chemicals when there are not enough trees to fill
the room. In such a house as this the cost of filling the empty space with gas is so great that some nurserymen believe it is more economical to unload the wagon and fill the room with stock, leaving the wagon outside.

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The writer desires to acknowledge with thanks the courtesies extended to him and assistance rendered in the preparation of this bulletin by Mr. F. A. Sirrine, Entomologist for this Station at Jamaica, N. Y., Mr. E. B. Hart, Asst. Chemist, Geneva, N. Y. Professor W. G. Johnson, Entomologist of the Maryland Agricultural Experiment Station and Mr. C. L. Marlatt, First Assistant in the Division of Entomology, Washington, D. C.