AN INVESTIGATION
OF THE DIPPING AND FUMIGATION OF NURSERY STOCK

by

Knowles Clark Sullivan B. S. A.

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Introduction.

Over one hundred years ago the first nursery was started in Missouri. At that time Missouri was a part of the Great West and was settled only along the water courses. The fruit industry at that time was undeveloped. Today there are in Missouri about one hundred and fifty nurseries. One of the largest, if not the largest, nurseries in the World is located in Missouri, and the acres of some of the others run well up into the hundreds. At the present time there are more bearing fruit trees in Missouri than in any other state in the Union, and it ranks fifth in the production of apples. The growth of the fruit industry and the nursery industry in Missouri has been remarkable. Also, the increase in the number of injurious insect pests of the fruits has been equally remarkable; in fact, they have increased so rapidly that in some sections farmers are abandoning the fruit industry and entering some other line of work in which insect pests are not so troublesome.

Some of the most injurious insect pests and

fungous diseases of fruit trees, that we have to contend with, were first introduced and scattered over the country on nursery stock. The most noted and most injurious one of these is the San Jose scale. San Jose scale is so bad that every state in the Union and the Federal Government have passed very stringent laws regarding its distribution and control. Missouri has a law which forbids any one in the state to distribute or dispose of nursery stock of any sort upon which there is San Jose scale; nor is any one from outside the state allowed to ship infested plants into the state. In many states there is a law which requires that all plants badly infested with San Jose scale be destroyed and that those which are not badly infested be treated with the best known remedies for the destruction of the scale.

The San Jose scale has become so widely distributed in Missouri that strong measures have been taken to stop further distribution. San Jose scale is usually carried from one section of the country to another upon nursery stock. Practically every infestation in Missouri has started from scale brought into the community upon nursery stock. Since the San Jose scale is usually carried into a non-infested district upon nursery stock, the logical thing to do is to produce clean stock; that is, nursery stock upon which there is no scale. This is very difficult to do, especially where the scale has once obtained a foothold.

From time to time, various remedies have been recommended by which nursery stock can be treated and the scale destroyed. Some of the treatments recommended killed the trees as well as the scale; others did not always kill the scale, and others cost so much that they were not practical, especially with the smaller nurserymen.

During the past two years the writer has been constantly in touch with all the Missouri nurserymen and it has been his pleasure to make personal visits with practically every nurseryman in the state, and especially with those located in communities where San Jose scale is prevalent. He has worked with them and helped them treat their nursery stock for scale, and other injurious insects. While engaged in the work, many problems, confronting the nurserymen, concerning the eradication of San Jose scale from nursery stock, have been brought to his attention. As a result, a number of experiments have been made to test the effect of the different materials commonly used upon infested and non-infested stock, with the object in view of determining which remedy is the most practical, from all standpoints, under Missouri conditions.

FRUIT INDUSTRY IN MISSOURI.

Missouri is so located that it is almost an ideal state for the production of fruit. There are several factors that tend to make it a good state in which to grow fruit.

1. The Soil. In Missouri we have many general types of soil - loess, flat prairie loam, shelby loam, silt loam, Crawford red lime stone, Clarksville gravelly loam, Clarksville stony loam, union silt loam and the lowland.

Of these soils, the loess and Crawford red lime stone are the best for the growth of fruit trees, and the production of fruit, and it is in the sections of the state where these two types of soil prevail, that the large fruit producing centers are found.

The loess soil dominates along the Mississippi and Missouri Rivers. This soil extends away from the rivers on either side from one to several miles. It is a soil without a subsoil. In places it is a hundred or more feet deep, and in some cases roots penetrate to this depth. It is of alluvial formation, very fertile, light and porous, with almost perfect drainage and is the best fruit soil in the world. This soil is found in only two other places besides along the Mississippi and Missouri Rivers - along the Rhine, in Germany, and the Yang-tse-Kiang, in China. The value of this soil is just beginning to be fully appreciated by the fruit growers of Missouri.

The Crawford red lime stone soil is found in the south and southwestern portions of Missouri and comprises a large part of that section commonly known as the Ozark region of southwest Missouri. This section of the Ozarks is famed the country over, on account of the high

quality of fruit which it produces.

Good orchards are found in sections of the state where other types of soil dominate, but the bulk of the fruit produced in Missouri comes from orchards located in the sections where the loess and Crawford red lime stone soils prevail.

2. The Climate of Missouri is very good for the production of fruit. The winters are seldom cold enough to cause a failure by freezing, and spring frosts are rarely serious. The average annual rainfall is about 36 inches, and this is sufficient to produce the average crop of fruit.

3. Location. Missouri is very favorably located, both from the standpoint of shipping facilities and markets. St. Louis and Kansas City afford excellent markets, and these cities are large railroad centers from which it is easy to reach the principal markets in other parts of the country.

The following data, from the 1910 Census Report, (31) gives an idea of Missouri's rank as a fruit state as compared with the other states.

Missouri ranks second in total number of orchard fruit trees, having 28,876,266. California ranks first, with 30,895,257.

In number of apple trees, Missouri ranks first, having 17,984,306. New York ranks second with 14,076,718.

Peaches - Missouri fifth, with 7,992,463;

Georgia, Texas, California and Arkansas rank above Missouri.

Pears - Missouri ninth, with 879,186. New York, California, Michigan, Ohio, Pennsylvania, Indiana, Illinois, New Jersey rank above Missouri.

Plums and prunes - Missouri seventh, with 1,101,679; California, Oregon, Iowa, Texas, Wisconsin and New Jersey rank above Missouri.

Cherries - Missouri ninth, with 869,757; Ohio, Pennsylvania, Iowa, Illinois, Indiana, Michigan, New York and Kansas rank above Missouri.

Apricots - Missouri ninth, with 22,115; California, Kansas, Oklahoma, Texas, Washington, Utah, Nebraska and Colorado rank above Missouri.

Quince - Missouri fifteenth, with 26,501; Ohio, Pennsylvania, New York, California, Indiana, West Virginia, Michigan, Virginia, Illinois, Kentucky, Oklahoma, Kansas, Maryland and Alabama rank above Missouri.

Grapes - Missouri sixth, with 3,512,580 vines; California, New York, Michigan, Ohio and Pennsylvania rank above Missouri.

Missouri also ranks high in the production of the small fruits, being third in the total acreage of strawberries, having 9,048 acres. Blackberries and dewberries, first, acreage, 5,975; raspberries and loganberries, eleventh, acreage 1,333; gooseberries, second, acreage 555.

Missouri also ranks sixth in the production of nuts.

From the above figures, it is readily seen that the fruit industry in Missouri is of prime importance.

The Missouri orchardist is learning to put into practice better systems of management; he is learning to control the insect pests and fungous diseases that prey upon the fruit and the trees; he is learning to market his fruit so as to obtain the highest profit; he has learned the value of cooperation, and as a result the fruit industries in Missouri are growing by leaps and bounds, and are going to continue to grow. The "Big Red Missouri Apple" is famed the country over. The Elberta peach from the Ozarks has a similar reputation, and during the season strawberries from Missouri can be purchased from all of the big markets of the country.

NURSERY INDUSTRY IN MISSOURI.

The nursery industry in Missouri has kept pace with the fruit industry. The first nursery in the state was established in 1816 at Louisiana, Mo., and ever since that time the growth of the nursery business has been rapid. Today there are one hundred and thirty-five nurseries in Missouri, with an acreage which totals about 3000.

Missouri is just as favorably located for the production of nursery stock, as it is for the production of fruit. Practically every kind of fruit stock is extensively propagated in Missouri nurseries.

The soil is ideal, especially along the Mississippi and Missouri River hills, and in the southwest part of the state. The rainfall is sufficient and the growing season is long enough for the production of fine nursery stock. Railroad facilities are good and nursery stock grown in Missouri is shipped to all parts of the world.

According to the 1910 Census,⁽³¹⁾ Missouri ranked thirteenth in acreage of nursery stock, and in the total value of the nursery stock produced, Missouri ranked sixteenth, with \$524,394.00 of stock. Since 1910, the amount and value of nursery stock produced in Missouri has constantly increased. At the present time, the amount of nursery stock used in Missouri is much greater than it has ever been heretofore. The main factor that has been responsible for this increase in the use of nursery stock is the education of the people to a plane where they desire and demand that their homes and communities be made as beautiful and as pleasant as possible. This has brought about the planting of a great deal of ornamental shrubs and trees around the home; communities have gone together and planted trees along the roadsides. Cities have built parks, boulevards and thoroughfares, in the construction of which they have used large quantities of ornamental nursery stock. The farmer has begun to realize the value of a home orchard, and every year a marked increase is noted in

the number of home orchards. Large commercial plantings are also being made. The value of the loess soil as a fruit producing soil is just beginning to be recognized and as a result the number of commercial orchards along the Mississippi and Missouri Rivers, is increasing very rapidly.

During the past few years the demand for ornamentals has become so great that three or four nurseries in the state have devoted practically all of their time, while most of the others are devoting some time, to the growing of this type of stock.

Another thing which has increased the planting of fruit trees in the past few years, is the better understanding of the control methods necessary to practice in subduing the dangerous insect pests and fungous diseases which prey upon fruit trees and other plants. The spray pump has had about the same effect upon the fruit industry as the cotton gin had upon the cotton industry. It has almost revolutionized the fruit industry. Effective spray materials have been discovered by means of which the fruit pests can easily and cheaply be controlled, providing the material is properly applied.

THE SAN JOSE SCALE IN MISSOURI.

The most dangerous pest that the nurserymen and orchardists in Missouri have to contend with is the San Jose scale. This pest does thousands of dollars worth of damage

every year in Missouri. Unlike other pests, the San Jose scale works both upon the tree and upon the fruit. Where the tree is badly infested with the scale, the fruit produced on that particular tree also becomes so badly infested that it is unmarketable, and every year thousands of bushels of apples are allowed to go to waste because of being infested with scale. The markets discriminate against apples with scale on them, and in some states there are laws which prevent the sale and transportation of scale infested fruit.

It requires from one to several years for the San Jose scale to kill a tree, depending upon the vigor of the tree when first attacked. The insects multiply so fast that in the course of one or two years the entire tree is covered with them, and with these millions of little insects sucking the sap, death is bound to be the final result.

Thus the San Jose scale collects its toll in two ways - from the plant itself, and from the fruit.

Up to the present time, San Jose scale is present in 59 of the 114 counties in Missouri; some of the remaining 55 counties are undoubtedly infested also, but there have been no infestations reported to the Missouri Experiment Station, from these counties. The largest infestations in Missouri are in the counties along the Mississippi and Missouri Rivers and especially those counties in which a fairly large town is located. St. Louis County is the worst

An Infested Nursery

The kind in which San Jose scale is usually found. Notice the weeds.

An Infested Tree in the Above Nursery.
Marked by the inspector.

infested county in the state at the present time. There is scarcely an orchard in the entire county that is free from San Jose scale.

The first outbreak of San Jose scale in Missouri was reported by Professor J. M. Stedman, of the Missouri Experiment Station, in 1896. At that time but six apple trees were found infested. They had been purchased from a New Jersey Nursery less than two years before the time they were found. Professor Stedman reported that these trees were dug and burned. However, the destruction of these few trees, it seems, did not help matters a great deal, for two years later (1898) another report was made by Professor Stedman in which he says that the San Jose scale had been found in twenty privately owned commercial orchards, some of which were already ruined. Besides being found on fruit trees it was also found on shade and ornamental trees, Osage orange hedge and some forest trees. Every one of these infestations, with the exception of one, were introduced upon nursery stock from one or the other of two New Jersey nurseries. The one exception came from Pennsylvania.

History of San Jose Scale.

San Jose scale was first found in the United States on the premises of Mr. James Lick, of San Jose, California, in the early seventies. Mr. Lick was a great lover of plants and he imported many plants from foreign countries which he set out on his home ground. It is thought that he

introduced San Jose scale into this country on some of the plants thus imported. Before an investigation was started to determine definitely the native home of the scale, Mr. Lick died. However, it is generally conceded that the San Jose scale is a native of China. In 1901-2, Mr. C. L. Marlatt, ⁽¹⁶⁾Entomologist for the United States Department of Agriculture, made an exploration trip to Japan, China and other eastern countries to determine definitely, if possible, the native home of this scale. Mr. Marlatt came to the conclusion that San Jose scale is a native of the interior of China, and that it was imported to America most probably upon the flowering peach, by Mr. Lick.

The spread of the scale from San Jose, California, was very rapid. Prior to 1887, it had extended its range up and down the Pacific Coast and east to the Rocky Mountains and had become a serious pest to the orchard industry.

It was not discovered in the east until 1893 when a pear growing at Charlottesville, Va., was found to be infested. This infestation was traced to a New Jersey nursery. Upon further investigation, it was found that this New Jersey nursery had become infested from stock shipped from San Jose, California. Two of the important nurseries in New Jersey were found to be infested and all of the early infestations of San Jose scale in the east, including those in Missouri, were from these two New Jersey nurseries.

At the present time there is not a state in the Union that is free from San Jose scale, and in some of the states every county contains infested orchards. This extensive infestation has taken place in the last twenty years. Thousands of fruit trees have fallen prey to it, and millions of dollars of damage has been done. If better control methods are not put into practice, and the ravages of the scale stopped, there is no telling what it will do in the next twenty years. A great deal of legislation has been done to prevent the spread of this pest, and it has been fairly effective, but unfortunately these laws were not passed soon enough to prevent its spread, and as is usually the case, the scale had become well established before a need of such laws was felt by the public.

Life Cycle of San Jose Scale.

The mature San Jose scale is yellow in color with a sac-like body which is covered with a soft, waxy secretion - the scale. This covering serves as a protection to the pest. The insect passes the winter in a half-grown stage, all other stages being killed by winter conditions. These half-grown insects are found under a small black scale just visible to the naked eye. About 95 per cent or more of these are male insects, they being greatly in excess. In the spring, about the first of May, the males pupate and in a short time emerge as delicate two-winged insects. The females at this time have arrived at

the stage of impregnation, and in a few days the males disappear. The females reach maturity about a month later and begin to give birth to living young.

Most of the other scale insects deposit eggs which later hatch, but this is not true of the San Jose scale. The young are developed in a membranous sac which corresponds to an egg, but they usually burst out of this before being born. Thus the San Jose scale is usually ovaviviparous, but it may be partially oviparous. A single female is capable of giving birth to 600 young in a period of about six weeks. It is very doubtful, however, if a female gives birth to over 100 or 200 insects, and many of these are male. Even at this rate of reproduction, from one single female the total number of offspring at the end of a season runs up into the millions. The newly born insects are very tiny, yellow in color and have six legs. They soon push their way out from under the scale of the mother and crawl around for a day or so finding a suitable place to settle down. On the apple the young scale seem to push out towards the tender growing tips to settle down, while on the peach they stay more on the old wood. It is at this stage, while the young are crawling about, that the pest is likely to be scattered from one place to another upon the feet and bodies of birds, beetles and other objects. If the branches of two trees intermingle, it is very easy for the young to crawl from one tree to the other, and it is often in this

manner that the pest spreads.

When a suitable place is found, the young settle down and begin to work the long proboscis, which is three or four times the length of the insect's body, into the bark, folds the antennae and legs beneath the body, and begin developing a scale covering. Within two or three days, this covering of cottony and waxy fibers becomes matted into a pale grayish scale which gradually becomes darker.

Male and female scales are similar in size, shape and color until the first molt, which takes place in from twelve to fourteen days after the emergence of the larva. Up to this time the male and female are indistinguishable in appearance, but after the first molt they lose all resemblance of each other. The females lose their eyes, legs and antennae and become almost circular with indistinct segments. They resemble very much a minute flattened, yellowish sac. Springing from beneath the body, near the center, they have a set of long, needle-like mouth parts with which they obtain nourishment from the plant. After the first molt, the male insects change in appearance also. They lose their legs and antennae but instead of losing their eyes they develop large purple ones and they become elongated and pyriform in shape. At this time the scale covering of the body of both sexes has a decidedly grayish tint mixed to some extent with yellow.

In about eighteen days after birth, the male

changes to the pro-pupa or first pupal condition and the scale covering assumes a longer shape which sometimes tends to be curved. At this stage the male begins to look more like an insect. Two or three terminal segments can be seen, the posterior one bearing two short spines, The antennae, legs and wing pads are visible. The purple eyes are set close together.

About two days later, or about twenty days from birth, the male insect transforms to the true pupa. The matted skin at this time instead of forming a part of the scale covering, as in the preceding molt, is pushed out from beneath the scale. The last or third molted skin is also pushed from beneath the scale.

The male insect becomes mature in twenty-four to twenty-six days from birth and pushes out backward from beneath the scale.

In from three to five weeks from the larva, the females molt the second time. The skin splits around the edge of the body. The upper half adheres to the scale covering and the lower half forms a sort of ventral scale between the insect and the bark. The female insect becomes full grown in from thirty to forty days from birth.

The adult male insect appears as a very small, delicate two-winged fly, about 0.6 mm. long, and is capable of flying from place to place. The mature female does not develop as the male does, but remains concealed beneath her

Another Infested Nursery.
Full of scale and weeds.

Scale Infested Trees From the Above Nursery.
These trees would have gone on the market if there had
been no inspection laws.

scale as a small, yellowish, almost circular insect about 0.8 mm. wide and 1 mm. long. No eyes, legs, wings or antennae are developed.

The scale covering of the female is almost circular and slightly raised in the center. The exuvia is central or nearly so. In diameter the scale varies from 1 to 2 mm. The color of the scale is gray, excepting the part covering the exuvia, which is a pale or reddish yellow and the ring effects which are often noted between the center and outer edge of the scale, marks the edges of the molts of the larval scale.

The scale covering of the male is darker than that of the female and especially in the winter, when it is black. In shape, it is oblong-oval and just about half as wide as long. It ranges from 0.5 to 1 mm. in length. There is a nipple-like prominence located between the anterior margin and center of the scale which marks the position of the larval scale.

In Missouri there are four generations a year and probably five, especially in a favorable season. The generations overlap to a great extent.

Owing to the smallness and the color of the scales, the insect is hard to detect by the untrained eye, and in many cases the writer has known the lenticels, or small knots on a tree, to be mistaken for the San Jose scale. When a plant becomes encrusted with the insects,

it looks grey in color and upon rubbing the hand along the trunk or branches large flakes of the dead scales become loosened and fall off. The tree looks sick and does not leaf out so early in the spring as a normal tree, and usually dies within a season or two. Where there is only a scattering of scale on the plant, it can usually be detected by the sunken places in the bark caused by a lack of food material which has been used by the insect instead of by the tree. Also immediately around the scale the bark takes on a reddish tinge, which is supposed to be caused by a toxin which the insect injects into the plant. This red-like blotch is very characteristic of the San Jose scale, especially on the apple and peach.

Damage.

It is impossible to estimate the amount of damage done by the San Jose scale in Missouri orchards because at present no one knows exactly how extensively Missouri is infested, but it is a known fact that many large commercial and small orchards have been completely destroyed by it. However, in the nurseries of Missouri in the past two years, the damage caused by this insect has amounted to the tremendous sum of \$20,000.00 and this is but a drop in the bucket as compared with the damage to the orchards in Missouri.

Control in the Orchard.

The San Jose scale can be controlled in the orchards, if proper precautions are taken. The most success-

ful method which is practiced today is the use of lime sulphur as a dormant spray. Certain of the miscible oils are also used to a greater or less extent, with good results. Commercial lime sulphur can be purchased on the market, which, when mixed with water, one gallon of lime sulphur to seven gallons of water, makes a most efficient spray.

A miscible oil makes a good spray when mixed with water at the rate of one gallon of the oil to twelve gallons of water. The lime sulphur spray is the cheaper spray of the two and is recommended by the United States Department of Agriculture, and by the state experiment stations.

As the San Jose scale is a sucking insect, it is impossible to destroy it by using a poisonous spray, so a contact spray must be used. The spray must be strong enough to either destroy the scale outright, that is, consume its body, or have great penetrating power, like the oil emulsions which burn and smother the insects.

According to Lodeman,⁽¹³⁾ lime sulphur spray was first used for the control of insects in 1851, by a Frenchman by the name of Grison, a gardener at Versailles, France. Grison used the following formula at first but later reduced the amount of lime to half.

Flowers of sulphur 500 gms.

Freshly slaked lime 500 "

Water 3 liters

Boil for ten minutes, draw off the clear liquid and use 1 to

100 parts of water. This mixture was used as a fungicide and is one of the few early spray preparations still in use.

Regarding the first use of lime sulphur washes
(13)
in America, Lodeman says: "A mixture similar to the following was originally used in California as a sheep dip, but as fruit trees began to drive out the sheep, the applications of the compound were transferred to the trees, and thus it has been very generally used, and has proved to be of value in the orchards as well as on the sheep. It is used against insects and fungi.

Lime (unslaked)	25-40 lbs.
Salt	15 "
Sulphur	20 "
Water	60 gals.

To mix the above, take 10 pounds of lime, 20 pounds of sulphur and 20 gallons of water. Boil until the sulphur is thoroughly dissolved. Take the remainder, 15 pounds of salt and 15 pounds of lime, slake and add enough water to make the whole 60 gallons. Strain and spray on the trees when milk warm or somewhat warmer. This can be applied when the foliage is off the tree and will have no injurious effect upon the fruit buds or upon the tree itself."

(16)
Marlatt says: "The early experience with lime sulphur and salt washes for San Jose scale was unfavorable, largely due apparently to the fact that the observations on

Whole Wagon Loads of Condemned Nursery Stock.
Before the days of inspection laws, this sort of stock was
sold to the unsuspecting farmer for fabulous prices.

Another Lot of Condemned Stock.

the trees treated were not continued long enough to note the effect of the late summer results. Good results were obtained with the kerosene emulsions and particularly with the soap washes and the fish oil soap washes."

Hydrocyanic acid gas was also tried in controlling San Jose scale on orchard trees, and at the present time is used upon citrus trees for controlling citrus scales.

Where care was taken this method proved very successful when used on the deciduous fruit trees, but the cost of fumigating an orchard as compared with spraying was so great that the former method has been abandoned altogether. An air tight box had to be constructed in such a way that it could be moved from over one tree to another, or a large tent had to be placed over the tree to be treated and the gas generated beneath. Each tree had to be treated for about one hour.

The treatment for San Jose scale must be applied while the tree is in a dormant condition for the scale is so difficult to kill that a treatment, to be effective, must be made so strong that it will also kill foliage. While the tree is in a dormant condition, the insects are easily reached and a strong spray can be applied without any fear of damaging the foliage. Also, as the insects pass the winter in a half grown state, they are more easily killed during the dormant season.

In applying a spray for the scale, thoroughness

of the application is of the utmost importance. If a twig here or there is left without getting a coat of the spray material, the insects which are on them will soon reinfest the tree.

At the present time the standard spray for the control of the San Jose scale upon deciduous orchard trees is lime sulphur. Commercial concentrated lime sulphur has a specific gravity of approximately 1.28. One gallon of it is used to seven gallons of water which reduces the specific gravity to 1.04. This solution is then applied with either a barrel or power spraying machine during the dormant season.

Besides controlling the San Jose scale with a dormant spray of lime sulphur, many other pests, such as Forbes scale and aphides are also controlled.

One of the important reasons why the San Jose scale is difficult to control is the fact that it attacks so many of the deciduous plants including fruits, ornamentals and shade trees.

The following is a list of plants upon which the scale thrives, according to C. L. Marlatt,⁽¹⁶⁾ of the United States Department of Agriculture, quoted from Britton.

List of Hardy Trees, Shrubs, and Vines.

Commonly or Badly Infested.

Acacia sp. Lintner.

Akebia sp.

Akebia quinata Decaisne.

Amelanchier canadensis Medic., and other species. Shad-bush,
Juneberry.

Citrus trifoliata Linn.

Cornus alba Linn. var. sibirica Lodd.

Cornus baileyi Coult & Evans.

Cornus sanguinea Linn.

Cotoneaster sp.?

Cotoneaster vulgaris Lindl.

Crataegus sp. Hawthorn.

Crataegus cordata Soland.

Crataegus oxyacantha Linn. English hawthorn.

Crataegus coccinea Linn.

Crataegus crus-galli Linn.

Cydonia vulgaris Pers. Common quince.

Cydonia japonica Pers. Japanese or flowering quince.

Fagus sylvatica Linn. var. purpurea Ait. European purple-
leaved beech.

Juglans sieboldiana Maxim. Japanese walnut.

Ligustrum vulgare Linn. Common privet.

Populus sp. Poplar.

Populus deltoides Marsh. Carolina poplar.

Populus nigra Linn. var. italica Du Roi. Lombardy poplar.

Prunus amygdalus Stokes. Almond.

Prunus armeniaca Linn. Apricot.

Prunus avium Linn. Sweet cherry.

Prunus pumila Linn.

Prunus pumila var. besseyi Waugh. Sand cherry.

Prunus cerasifera Ehrh. var. atropurpurea Dipp. (P. pisardi).

Purple-leaved plum.

Prunus domestica Linn. European plum.

Prunus hortulana Bailey. Wild goose plum.

Prunus japonica Thunb. Flowering almond.

Prunus maritima Waugh. Beach plum.

Prunus persica Sieb. & Zucc. Peach.

Prunus triflora Roxbg. Japanese plum.

Prunus serotina Ehrh.

Prunus virginiana Linn. Chokeberry.

Ptelea trifoliata Linn. Hop tree.

Pyrus communis Linn. Pear.

Pyrus Sinensis Lindl. Sand pear including Kieffer.

Pyrus baccata Linn.

Pyrus malus Linn. Apple.

Pyrus sp. Crab apple.

Ribes oxycanthoides Linn. Gooseberry.

Ribes aureum Pursh. Missouri or flowering currant.

Ribes rubrum Linn. Currant.

Ribes nigrum Linn. Black currant.

Rosa sp.

Rosa carolina Linn.

Rosa lucida Ehrh.

Rosa virginiana Mill.

Rosa rugosa Thunb.

Salix sp. Willow.

Salix lucida Muhl.

Salix pentandra Linn. Laurel-leaved willow.

salix vitellina Linn.

Salix babylonica Linn. Weeping willow.

Salix humilis Marsh.

Salix incana Schrank.

Sorbus sp. Mountain ash.

Sorbus americana Marsh. American mountain ash.

Sorbus aucuparia Linn. European mountain ash.

Sorbus melanocarpa C. Koch. (Aronia nigra Koehne)
Black chokeberry.

Symphoricarpos racemosus Michx. Snowberry.

Syringa vulgaris Linn. Common lilac.

Syringa persica Linn. Persian lilac.

Tilia sp. Basswood, linden.

Tilia americana Linn. American linden or basswood.

Toxylon pomiferum Raf. Osage orange.

Ulmus sp. Elm.

Ulmus americana Linn. American elm.

Ulmus campestris Smith. English or European elm.

Occasionally or Rarely Infested.

Acer. sp. Maple.

Acer saccharinum Linn. Silver maple.

Acer saccharinum. Weir's cut-leaved.

- Acer platanoides Linn. Norway maple.
- Actinidia arguta Miq. (A. polygana).
- Aesculus hippocastanum Linn. Horse-chestnut.
- Alnus sp. Alder.
- Ampelopsis quinquefolia Michx. Virginia creeper.
- Betula sp. Birch.
- Betula alba Linn. Cut-leaved white birch.
- Buxus sp. Box.
- Castanea americana Raf. Chestnut.
- Catalpa sp.
- Catalpa bignonioides Walt. Common catalpa.
- Ceanothus americanus Linn.
- Celtis occidentalis Linn.
- Cercidiphyllum japonicum Sieb. & Zucc.
- Citrus aurantium Linn.
- Cornus alternifolia Linn.
- Cornus stolonifera Michx.
- Cornus circinata L'Herit.
- Cornus amomum Mill.
- Cornus candidissima Marsh.
- Cornus florida Linn.
- Cornus florida. Red flowering.
- Deutzia sp.
- Diospyros virginiana Linn. Persimmon.
- Elaeagnus sp.
- Elaeagnus longipes Gray. Silver thorn.

Eucalyptus sp.

Euonymus sp.

Ficus carica Linn. Fig.

Forsythia sp.

Fraxinus sp. Ash.

Fraxinus americana Linn. White ash.

Gleditschia triacanthos Linn. Honey locust.

Hibiscus syriacus Linn. Shrubby althea.

Hicoria pecan Britt. Pecan nut.

Juglans nigra Linn. Black walnut.

Juglans regia Linn. Persian or English walnut.

Kalmia latifolia Linn. Mountain laurel.

Kerria japonica DC. Globe flower.

Ligustrum ovalifolium Hassk. California privet.

Lonicera sp. Honeysuckle.

Morus sp. Mulberry.

Morus sp. Tea's weeping mulberry.

Physocarpus opulifolius Maxim.

Picea alba Link. White spruce.

Prunus cerasus Linn. Sour cherry.

Photinia villosa DC.

Rhodotypos kerrioides Sieb. & Zucc.

Rhus sp. Sumac.

Rhus cotinus Linn. Smoke bush.

Robinia sp. Locust.

Rubus strigosus Michx. Red raspberry.

Rubus nigrobaccus Bailey (R. villosus). Common blackberry.

Rubus villosus Ait. (R. canadensis). Dewberry.

Sambucus sp. Elder.

Sassafras officinale Nees. Sassafras.

Sorbaria sorbifolia A. Braun (Spiraea sorbifolia L.)

Spiraea sp.

Thuja occidentalis Linn. Arborvitae.

Viburnum sp.

Viburnum cassinoides Linn.

Viburnum opulus Linn.

Vitis sp. Grapes.

Not Infested.

Ailanthus glandulosa Desf. Tree of heaven.

Amorpha fruticosa Linn.

Andromeda sp.

Aralia spinosa Linn. Hercules' club.

Aristolochia macrophylla Lam. Dutchman's pipe.

Asimina triloba Dun. Pawpaw.

Baccharis halimifolia Linn. Groundsel tree.

Benzoin odoriferum Nees. (Lindera benzoin Blume). Spicebush.

Berberis (all species). Barberry including Mahonia.

Bignonia sp. Trumpet vine.

Calycanthus floridus Linn. Carolina allspice, sweet-scented
shrub.

Carpinus sp. Hornbeam.

Cedrus sp. Cedar.

Celastrus scandens Linn. Bittersweet.

- Cephalanthus occidentalis Linn. Buttonbush.
- Cercis canadensis Linn. Judas tree, redbud.
- Chamaedaphne calyculata Moench. (Cassandra) Leather leaf.
- Chionanthus virginica Linn. Fringe tree.
- Cladrastis tinctoria Raf. Yellowwood.
- Clethra alnifolia Linn. Sweet pepper bush.
- Corylus sp. Filbert, hazelnut.
- Daphne mezereum Linn.
- Diervilla sp. Weigela.
- Dirca palustris Linn. Leatherwood, moosewood.
- Exochorda grandiflora Lindl. Pearlbush.
- Gaylussacia sp. Huckleberry.
- Genista tinctoria Linn. Dyer's greenweed.
- Ginkgo biloba Linn. Maidenhair tree.
- Gymnocladus canadensis Lam. Kentucky coffee tree.
- Halesia tetraptera Linn. Silver bell, snowdrop tree.
- Hamamelis virginiana Linn. Witch hazel.
- Hedera helix Linn. English ivy.
- Hicoria sp. (excepting H. pecan Britt). Hickory.
- Hydrangea (all species).
- Hypericum moserianum Andre. Gold flower.
- Ilex sp.
- Itea virginica Linn. Virginian willow.
- Jasminum nudiflorum Lindl. Yellow jasmine.
- Juglans cinerea Linn. Butternut.
- Juniperus sp. Juniper.

- Koelreuteria paniculata Laxm. Varnish tree.
- Laburnum vulgare Griseb. Golden chain.
- Larix sp. Larch.
- Liquidambar styraciflua Linn. Sweet gum.
- Liriodendron tulipifera Linn. Tulip tree.
- Lycium halimifolium Mill. Matrimony vine.
- Magnolia (all species).
- Myrica cerifera Linn. Wax myrtle.
- Nyssa sylvatica Marsh. Tupelo, pepperidge, black gum, sour
- Ostrya virginica Willd. Hornbeam, iron wood. (gum.
- Paulownia imperialis Sieb. & Zucc.
- Phellodendron sp.
- Philadelphus coronarius Linn. Mock orange, syringa.
- Pinus sp. Pine.
- Platanus occidentalis Linn. American plane, buttonwood.
- Potentilla fruticosa Linn.
- Quercus (all species). Oak.
- Retinispora (all species). Japan cypress.
- Rhamnus sp. Buckthorð.
- Rhododendron sp.
- Sciadopitys verticillata Sieb. & Zucc. Umbrella pine.
- Shepherdia sp.
- Smilax sp.
- Sophora japonica Linn. Japan pagoda tree.
- Staphylea sp. Bladder nut.
- Stephanandra flexuosa Sieb. & Zucc.

Styrax japonica Sieb. & Zucc.

Tamarix sp.

Taxodium distichum Rich. Bald cypress.

Taxus sp. Yew.

Tecoma radicans Juss. Trumpet creeper.

Tsuga canadensis Carr. Common hemlock.

Vaccinium sp.

Wistaria sp.

Xanthoceras sorbifolia Bunge.

Xanthoxylum americanum Mill. Prickly ash.

Control on Nursery Stock.

As has been previously explained it was through the infestation of nursery stock that the San Jose scale has become so widely distributed, and naturally the first place to start in the control of the pest is upon nursery stock.

Probably the most important means of controlling the scale upon nursery stock has been the passing of laws requiring that all infested stock be destroyed, and the remainder treated under the direction of a competent man.

Before 1913 Missouri had no law controlling the growing and transportation of infested nursery stock, and as a result much infested stock was dumped off on the Missouri farmer. In 1913 an effective law was passed and has been rigorously enforced. The following extracts include those sections which regulate the control of infested nursery stock.

The Results of Careless Nursery Practice.

Rubbish, Weeds and San Jose Scale.

None of this stock was allowed to go on the market.

Fumigating Box

possessed by owner of the above nursery.

Poorly constructed and full of cracks. The Nursery Inspection service of Missouri would not tolerate its use.

Sec. 4. That on or before the first day of July each year, each nurseryman or other person or corporation within the state engaged in growing nursery stock for distribution, sale or for use in public parks, shall file in the office of the agricultural experiment station an application for the inspection of such nursery stock. Before September 15th of each year or as often as the agricultural experiment station deems necessary, it shall cause to be examined by the chief inspector and other assistants the nursery stock of each person whose application for inspection has been filed. The failure to file such application or the disposal of uninspected stock by sale or gift shall be a violation of this section. Each nurseryman or other person importing plants or nursery stock from foreign countries shall notify the agricultural experiment station of such shipment, the date of arrival, nature of the shipment, name and address of the shipper and shall hold such shipments until duly inspected and released by the agricultural experiment station. Such inspection to be made as soon as notification of arrival of shipment is received by the agricultural experiment station: Provided that perishable stock may be unpacked but not disposed of until released. The provisions of this section shall not apply to greenhouse plants grown wholly under glass, and cuttings thereof, bulbs, flowers and vegetable plants. If, upon examination, the nursery stock and premises of such appli-

cant appear to be free from dangerous insect pests and dangerous plant diseases, the agricultural experiment station shall before September 15th issue to the owner or lessee thereof a certificate of inspection valid for one year from that date unless revoked for reasons as hereinafter stated provided there has been received from each applicant the sum of \$5.00 and the actual necessary expenses incurred in making such inspection. If, upon examination, any dangerous insect pests or plant diseases are found upon such nursery stock, the agricultural experiment station shall order and enforce such treatment as it deems sufficient. As soon thereafter as the efficiency of treatment can be determined, such nursery stock shall be re-inspected upon the owner filing application for the same. If the agricultural experiment station shall have reason to believe that a nursery is liable, by reason of its proximity to infested or infected premises, to become so infested or infected before the next annual inspection, it may prescribe in writing such conditions as to the use of its certificate, as may in its judgment be necessary, and may withhold said certificate until such conditions have been accepted in writing by the owner of said nursery; and the use of such certificate without taking such measures of precaution or observing such conditions shall subject the owner of said nursery to the penalties prescribed in section 7 for a violation of this act. Whenever any nurseryman or seller of nur-

sery stock shall ship or deliver any such stock he shall place and send on each car, box, bale, bundle or piece a true copy of a valid certificate of inspection issued by the agricultural experiment station of Missouri showing that such stock has been carefully inspected and found apparently free from dangerous insect pests and plant diseases. All persons who shall deliver or consign nursery stock without such certificate attached or who shall use such certificate in connection with nursery stock, any and every part of which has not been inspected and certificated as aforesaid, or who shall alter or deface such certificate or who shall use an imperfect copy of such certificate shall be liable to the penalties prescribed in section 7 for violation of this act. If the agricultural experiment station shall find that its certificate of inspection has been used in violation of the law, it shall have power to revoke or annul said certificate by written notice to the owner thereof and such notice shall take effect forthwith and the use of said certificate after it has been revoked or annulled, and before such revocation has been withdrawn by the agricultural experiment station, shall subject the owner of said certificate to the penalty prescribed in section 7 for a violation of this act. It shall be the privilege of the nurseryman to ship, under the certificate issued to him, nursery stock grown for him elsewhere or purchased by him from other states or countries: Provided, that all such stock be re-

Air tight canvas is placed over the frames shown in the above cut. The Hydrocyanic acid gas is generated in a tank and conducted through a pipe to the enclosure. A car load of stock is fumigated at a time. Very successful results are obtained.

A spraying machine rigged up to spray nursery stock in the row. Lime sulphur or miscible oil can be successfully applied to dormant trees with this machine.

ceived under a certificate, satisfactory to the agricultural experiment station, stating that it has been inspected where grown and found to be apparently free from dangerously injurious insects and plant diseases. The agricultural experiment station shall send once each year, not later than July first, to all nurserymen in the state known to it, a list of official inspectors of other states and foreign countries whose certificates of inspection may be accepted in this state for one year from date thereof as equivalent to its own certificate. Annually every nurseryman or firm outside of Missouri shipping nursery stock into Missouri shall file, with the agricultural experiment station, a copy of a valid certificate, issued by a state or government inspector, showing that said stock has been duly inspected and is apparently free from all dangerously injurious insects and plant diseases, together with a statement under oath that no nursery stock will be shipped into Missouri which has not been properly inspected and certified. Annually, each agent, or other person engaged in the sale or delivery of nursery stock within this state, who is the authorized representative of any nursery or dealer in nursery stock, shall file in the office of the agricultural experiment station a statement under oath, that such nursery stock was received by him accompanied with a valid certificate of inspection or fumigation, together with a copy of said certificate, and proper credentials from the nurseryman or dealer represented.

Annually, each dealer, person or firm engaged in the sale or delivery of nursery stock within the state, who is not the authorized representative of any nurseryman, shall file in the office of the agricultural experiment station a statement under oath, that such stock will be procured only from nurserymen holding valid official certificates of inspection or fumigation. Such statement shall contain the names of nurserymen or the sources from which stock will be procured and the location of the packing or sale grounds from which the stock will be distributed. This statement must be accompanied by a fee of \$5.00, upon receipt of which a dealer's certificate shall be issued by the agricultural experiment station. This certificate may be attached to all shipments of nursery stock made to points within the state and shall become invalid on July first, following the date of issuance. The failure to pay the required fees, to file such statements or the delivery of nursery stock after the certificate under which it was received has become valid shall be a violation of this section.

Sec. 5. That whenever any nursery stock is shipped from place to place in Missouri or shipped into Missouri from another state, country or province each car, box, bale, bundle, package or piece thereof shall be plainly labelled on the outside with the name of the consignor, the name of the consignee, brief statement of the contents and a certificate signed by a state or government inspector

A Fairly Good Fumigating House

Placing the Trees in the
House for Fumigation

Trees Heeled In After
Fumigation

showing that the contents have been inspected by such an inspector or by his authority since the first day of July last preceding and that the nursery stock there present and therein contained appears free from any dangerous insects and diseases. This certificate accompanying nursery stock shipped or conveyed into the state shall be prima facie evidence of the fact therein stated but if the agricultural experiment station has reason to believe that such stock is infested or infected it may cause said stock to be inspected and for such purpose the chief inspector or other duly appointed assistants may enter any car, depot, warehouse, or other structure containing such nursery stock. If found to be infested or infected, with dangerous insect pests or plant diseases the shipper shall be notified and the same shall be declared to be a public nuisance to be abated as prescribed in section 3 of this act. Whenever nursery stock arrives in this state without such certificate plainly fastened to the outside of every package, box or car containing same the fact must be reported within 24 hours to the agricultural experiment station by the railroad, express or steamboat company or other person or persons carrying the same, and it shall be unlawful to deliver any such property until it has been inspected by a duly appointed agent of the agricultural experiment station and by it certified to be free from dangerous insects or contagious diseases. Any person receiving nursery stock brought into this state from outside

this state and not accompanied by a valid certificate as above prescribed shall at once notify the agricultural experiment station of that fact and shall not allow such uncertified stock to leave his possession until it has been duly inspected and released by the agricultural experiment station. Any agent of any railroad, steamboat or express company or any person or persons carrying such property who shall fail to give notice to the agricultural station, as above provided shall be deemed guilty of a violation of this act and subject to the penalty prescribed in section 7.

Sec. 8. That the term "nursery stock" as used in this act shall include all trees, shrubs, vines and other plants, plant parts or plant products commonly known as nursery stock which are grown or offered for sale or distribution, which may be susceptible to or which may harbor dangerously injurious insect pests and plant diseases which are liable to be spread or transported on such stock to orchards or other premises where said stock is stored or planted. In this act the term "nursery stock" shall not apply to plants, flowers, or cuttings commonly known as greenhouse stock and grown wholly under glass or to vegetables: Provided, that should any plants, flowers, cuttings, vegetables or plant products now exempt from inspection, in the future become the source of a dangerous public nuisance, they shall be considered as nursery stock. The terms "dangerous insect pests" and "plant diseases" as used in this act shall in-

clude San Jose scale, brown tail moth, gypsy moth, peach yellows and other dangerously injurious insect pests and plant diseases.

Every state in the Union has similar laws and they have done much to prevent further spread of San Jose scale and other dangerous insect pests and diseases as well.

Practically all the states require the use of hydrocyanic acid gas in the control of the scale on nursery stock and up to the present time it is most widely used.

Some nurserymen prefer to dip their trees in a miscible oil rather than fumigate and this method has, to a great extent, been successful.

In fumigating with hydrocyanic acid gas the trees are dug in the fall or early spring, all excessive moisture allowed to dry from the tree and then placed in an air tight box or room. The gas is generated in the room and the trees are left exposed to it for from 45 minutes to one hour. Special preparations must be made, such as building an air tight box or house, in using hydrocyanic acid gas. The gas is very poisonous, and the chemicals are costly, and it is easy to make a mistake in mixing them. Under certain conditions the gas is apt to injure the stock, especially the more tender species. This is also true in using liquid dips.

The following is what some of the most successful and prominent Missouri nurserymen say of hydrocyanic

said gas and dipping solutions.

The following is a synopsis of our experience:
Our experience with sulphuric acid gas has been very satisfactory. We believe it is proper that it will

kill anything that is in the house. It is that stock must be removed.

some injury to the stock as it is on peach as

on apple, it is without

moisture. It is

1 ounce eye

and 4 ounces

contact with

the ground

The water

box, then

bag, thus

to person doing the work

pipe running in

In the

pressure of air

into the house

to the operator

The above fumigation is done from the fact that

a number of the states require fumigation regardless of

A Well Constructed, Air Tight Fumigating Box.

acid gas and dipping solutions:

"The following is a synopsis of our experience: Our experience with hydrocyanic acid gas has been very satisfactory. We believe if handled properly that it will kill anything that breathes. Our experience is that stock must be reasonably dry when fumigation is done, otherwise some injury. It is dangerous to use as strong on peach as on apple, unless stock fully matured and done without moisture.

Our formula for the past several years has been: 1 ounce cyanide potassium 98% pure, 2 ounces sulphuric acid and 4 ounces of water to each 100 cubic feet of space.

To handle the formula without coming into close contact with the trees, we have buried a box 3 feet deep in the ground, in which to place the formula in an earthen jar. The water and sulphuric acid being mixed and placed in the box, then the cyanide is dropped in the mixture, in a paper bag, thus allowing cover to be put on the box without danger to person doing the work. From this box we have a 6 inch pipe running to center of our house on an incline. In the rear end of this pipe, we have an air jet. By turning on pressure of air, it forms a suction, which conveys the gas into the house. The lid can then be removed without danger to the operator.

The above fumigation is done from the fact that a number of the states require fumigation regardless of

whether or not you have injurious insects on your stock and as we are not in position to carry stock for these special state requirements, we find it best to fumigate all of our stock in order to conform with the few state laws.

For root aphid, we would recommend dipping in black-leaf forty of the following mixture: 1 gallon black-leaf forty, 200 gallons of water, 8 pounds soap; soap should be cut up fine and dissolved in hot water. This formula is very effective for aphid and we have never noticed any injuries from same, much less dangerous than kerosene emulsion or concentrated lye."

Another says: "The states of Pennsylvania, Colorado and a number of others require that all stock be fumigated before being shipped out and that a certificate to this effect be attached. We believe this is an effective precaution. It insures clean nursery stock and is especially effective with all forms of aphid and scale. We think it is a precaution that nurserymen should practice on everything that they plant on their own premises, and we make it a rule to fumigate all stocks that we import, and all seedlings that come to us from any source whatever, also all scions. We believe it is about the most effective precautionary method against getting any pests or diseases into the nursery. We believe all nurserymen who are following this practice are enabled to send out clean stock in so far as the troubles that can be eliminated and prevented by fumigations, are con-

cerned.

Our experience with dipping has not been satisfactory, except for fungicide. We usually dip the tops of our seedling stocks in Bordeaux Mixture. This gives them a thorough spray before they are planted, but many of the preparations recommended for dipping the roots, we have found, will injure the vitality of the stock. This is especially true of some of the oil preparations."

Another: "We have never tried dipping nursery stock, other than to dip some peach buds last year, a special variety which we wished to ship to one of our plants where we budded about fifty thousand peach.

We used lime sulphur or regular formula as is used in spraying dormant trees, and the result was the buds were very badly damaged. As soon as the damage was reported, we reduced the formula to about 4 to 1 and we found this did not seem to injure the buds.

We have never dipped matured nursery stock, but have received some from other nurseries that appeared to be in first class condition. The stock was dipped because it was infested with San Jose scale. We examined the stock thoroughly with a magnifying glass, and failed to find any live scale. We have also had some experience and observation in fumigating infested stock, and if the work is done thoroughly, we believe it will kill all of the scale.

In the fumigating that we have been doing, we

followed your formula (1-1-3) and instructions, and feel sure that the work has been done successfully. If any damage has been done to the stock in fumigating, we have never been able to detect it."

A fourth says: "Our experiments in fumigation under the prescribed strength has been that the stock has been seriously injured in many cases. We now have some trouble that we are positive is due to fumigation. We received a car load of apples and other stock from a nursery outside of Missouri early this spring and the stock opened up in very nice condition, plenty of moisture. The roots looked as though they were nice and fresh as were also the tops. Part of these trees were heeled in on our packing grounds, well watered at time of heeling in; the balance were put in storage, from which we filled orders. The reports received from our customers were that these trees were forcing a very weak insignificant growth. We had some of these trees left over on our packing grounds; also some in storage. The trees in the storage house did likewise, forcing a few buds up near the tip. The roots were noticed to have formed a tightness between the outer bark and the wood. We are positive that these trees were injured by fumigation as we have had previous experiments along this line to convince us that this is the trouble.

It seems that where fruit trees are subjected to fumigation at the prescribed strength, and they go into

the fumigating room in a damp or moist condition, there is great danger of serious injury. If the roots and the body of the trees are comparatively dry, there seems to be less injury. We have also found that by leaving the stock in the fumigating room 10 or 15 minutes longer than really required, that will also hurt the vitality of the stock so fumigated. Personally, we are against fumigation for nursery stock, as we believe that there is entirely too much danger of injury to the stock that will first be noticed months after.

We had this same experience with a shipment we made to Salt Lake City, Utah, some years ago. These trees were freshly dug, run into the fumigating room during a cloudy day when there was an occasional fine misty rain, fumigated, packed and shipped. Upon receipt of the trees we received a letter from the party stating that the trees were the finest he had ever seen, excellently packed and that he was highly pleased with them, and that the inspector had passed them as A #1. About sixty days later we received a letter from this same party complaining that none of the trees seemed to be showing any vitality although they had been irrigated, severely pruned according to their methods, but that instead of breaking bud, they were gradually drying up. We were unable to collect a dollar on this account, and understand that few, if any, ever started to grow. We fumigated according to the prescription sent us by the Utah

State Entomologist, before making this shipment."

Hydrocyanic Acid Gas First Used.

Hydrocyanic acid gas has been used in collecting jars for years by entomologists to kill insects, but was first used for the destruction of scale insects by D. W. Coquillett, (16) in the orange groves around Los Angeles, California. His first work with hydrocyanic acid gas was in September 1886, and was carried on at this time for the control of the cottony cushion scale on citrus trees. Such materials as tobacco smoke, sulphur fumes, concussion from gun powder, heat, muriatic acid, carbonic acid gas, chloroform, arsenic, bisulphide of carbon and other fumes and gases were tried but none were so successful as hydrocyanic acid gas. Dr. F. W. Morse (17) of the University of California, also began studying the control of the cottony cushion scale in 1887 and as a result the University gave to the public, in Bulletin 71, the first knowledge of the use of hydrocyanic acid gas. In doing this first work, a tent was thrown over the tree and the gas generated beneath the tent, by putting together in one vessel sulphuric acid, water and dry potassium cyanide.

All of this work done in California was upon citrus trees which were in full foliage and a great deal of burning and injury took place. However, the method of using hydrocyanic acid gas has been so well perfected that at the present time it is comparatively safe to fumigate citrus trees which are infested with scale.

A Poorly Constructed Fumigating Box.
The timber has shrunk leaving large cracks and the lid has warped, making it necessary to put weights on it in order to hold it down. Good results are impossible.

Chemicals Used in Fumigating.
After the nursery stock is placed in the box the water and H_2SO_4 are mixed in the earthen jar and the jar placed in the box through the small door at the bottom. The KCN is then dropped in the mixture and the door quickly closed.

The California Agricultural Experiment Station,
 under the direction of Morse,⁽¹⁷⁾ conducted experiments with
 other gases as insecticides with special reference to the
 white scale (Icerya purchasi). The following is a summary
 of the results obtained, as set forth in Bulletin No. 70 of
 the California Agricultural Experiment Station.

Chlorine, carbon bisulphide, sulphuretted hydrogen, ammonia, carbon monoxide, aloxie acid, carbohic acid and hydrocyanic acid gas were tried and it was found that hydrocyanic acid gas was the only one that produced sufficiently fatal effects as to warrant a more thorough determination of the time of exposure and quantities of material which would produce the best results.

Hydrocyanic acid gas was not used upon deciduous trees until 1894, when the San Jose scale was found upon deciduous fruit trees in Charlottesville, Virginia, and
⁽¹⁶⁾
 Coquillett was detailed by the United States Department of Agriculture to conduct experiments with hydrocyanic acid gas on these infested trees. The results of the first experiments were so satisfactory that the work was continued.

It was in 1898 that it was first suggested that hydrocyanic acid gas could be used in mills, elevators, and warehouses for the destruction of injurious insects.

Use Up To The Present Time.

Since the discovery of hydrocyanic acid gas as an insecticide, it has been used in a number of different ways.

1. To fumigate citrus trees infested with all sorts of scale insects.
2. To fumigate deciduous fruit trees, including nursery stock, for the destruction of San Jose scale.
3. To fumigate greenhouses for the destruction of white fly, red spider and other pests on greenhouse plants.
4. To fumigate warehouses, elevators, mills and other buildings for the destruction of weevil.
5. To fumigate dwelling houses, railroad coaches, street cars, hotels and similar places, for the destruction of lice, bed-bugs, clothes moths, and other household pests.

The use of hydrocyanic acid gas as a fumigating material is becoming more extensive and the United States Department of Agriculture, and all of the state experiment stations recommend it.

Method of Using. The most general method practiced at the present time, in using hydrocyanic acid gas, is as follows:

One fluid ounce of sulphuric acid having a specific gravity of at least 1.83 is placed in an earthenware crock, wooden bucket or tub; then 3 fluid ounces of water are added. Into this mixture 1 ounce, by weight, of fused cyanide of potassium, 98-99 per cent pure, is added. The above amounts are used for every 100 cubic feet of space. In fumigating tender growing plants, the above formula is too strong and has to be weakened. For dormant trees,

mills, elevators and the like the 1-1-3 formula is recommended by both the United States Department of Agriculture and practically all of the state experiment stations.

In fumigating nursery stock an air tight box or house is necessary. The trees are placed in the box or house. The water and sulphuric acid are mixed in an earthen jar and the jar placed in the box or house. The hydrocyanic acid gas is then dropped in and the box or house closed just as quickly as possible. The hydrocyanic acid gas which is generated is deadly poisonous and the person doing the fumigating must be very careful not to breathe any of it. It requires about 45 minutes to fumigate nursery stock, although some authorities say that better results can be obtained by letting the stock remain an hour. At the end of this time the fumigating box or house is opened and the gas allowed to escape and in from 15 to 20 minutes the trees can be safely removed.

It is never advisable to fumigate trees while they are damp or wet. It is claimed that under such conditions the gas is more likely to injure the stock. However, the writer's experiments, to date, fail to corroborate this, though they do show that less scale is killed under those conditions.

Some states require by law that all nursery stock grown within its borders or shipped in from outside nurseries be fumigated, and, as a result, all of the larger

nurseries in the United States have constructed special fumigating houses or boxes.

Chemical Composition of Hydrocyanic Acid Gas.

In fumigating work hydrocyanic acid gas is generated, as has already been explained, by placing together potassium cyanide (KCN), sulphuric acid (H_2SO_4) and water (H_2O).

The sulphuric acid which is sold commercially has a strength known as 66° Baume which corresponds to the 96 per cent pure sulphuric acid. Commercial sulphuric acid, however, contains some impurities and is very seldom over 93 or 94 per cent pure.

The potassium cyanide which is purchased on the market runs about 98 per cent pure.

When the sulphuric acid and the potassium cyanide are brought together, the chemical reaction that takes place is as follows:

In the above reaction, 1 ounce (avoirdupois) of potassium cyanide (100 per cent pure) requires .75 ounce (avoirdupois) sulphuric acid or .81 ounce of commercial sulphuric acid containing 93 per cent sulphuric acid which would be equal to .42 fluid ounces.

Under conditions met with in fumigating work, the above reaction cannot be obtained, and result in the best yield of hydrocyanic acid gas. More sulphuric acid

must be used and this material should be prepared as is shown in the following equation:

In this reaction 9.5% of the weight of the material is lost.

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with reference to the work at Columbia.

Fumigating Box
used in carrying on the work at Columbia.

found to be satisfactory for the work at Columbia where the experiments were conducted.

The primary object of the investigation was to determine if possible the most practical, efficient and

must be used and this causes acid potassium sulphate to be formed as is shown in the following equation:

In this reaction 0.84 fluid ounce of 93 per cent sulphuric acid is required for each ounce (avoirdupois) of potassium cyanide. This amount in round numbers equals 1 part cyanide to 1 part acid which gives the best results in field work. In order to get the best yield of hydrocyanic acid gas only two parts of water should be used but in field practice when only two parts of water are used, the residue in the generating jar often solidifies and in order to prevent this, three parts of water are used. Thus the 1-1-3 formula is used in fumigating nursery stock.

Results of Experiments With Hydrocyanic Acid Gas.

Because of the large amount of damage being done in Missouri by the San Jose scale, and in order to help the fruit grower and nurseryman to better control the scale and thus lessen the danger of further dissemination of the pest, the writer began a series of experiments in the fall of 1915 with reference to the control of the scale upon nursery stock.

All of the nursery stock in the state which was found to be infested with San Jose scale was brought to Columbia where the experiments were conducted.

The primary object of the investigation was to determine if possible the most practical, efficient and

cheapest method to use in controlling the scale on nursery stock with the least injury to the trees or plants.

In Missouri there are a number of nurserymen who grow nursery stock on a small scale and do not care to go to the expense of building an expensive fumigating house or box and besides, many object to using hydrocyanic acid gas because of its very poisonous nature. Several of these nurserymen have asked repeatedly about the possibilities of dipping nursery stock in a lime sulphur wash or a miscible oil, for the control of San Jose scale.

Method of Procedure.

First, the following number of fruit trees and plants were obtained: apple, 356 trees; peach, 164; pear, 52; plum, 52; cherry, 52; currant, 26; gooseberry, 44; blackberry, 34; Lombard poplar, 95; Spiraea Vanhouttei, 17; Japanese quince, 26 and Goldenbell 17. All of the fruit trees were two years old. The currants, gooseberries, Japanese quince, goldenbell and Spiraea Vanhouttei were also two years old. The blackberry plants were one season's growth from the cuttings. Of the apple trees obtained 260 were heavily infested with San Jose scale and 86 of the peach trees were also heavily infested. The trees were dug in the fall after the leaves had fallen and shipped to Columbia. Most of the scale infested trees showed marked weakness caused by the ravages of the pest; otherwise all of them were in good condition. The trees were heeled in

Very Heavily Scale Infested Nursery Stock.

These trees were collected from the scale infested nurseries in Missouri in 1915, shipped to Columbia and used in conducting the experiments set forth in this paper.

Trees used in the experimental work at Columbia.

Trees used in the experimental work at Columbia.

in the fall and left until March 21 and 22, 1916, when they were given the different treatments. None of the trees died during the winter.

The work was continued during 1917. On April 5, 1917, the following two year old trees were obtained, all of which were heavily infested with San Jose scale: apple, 58 trees; peach, 58; plum, 5. These trees had just been dug from the nursery row. They showed weakness from the effects of the scale, but were otherwise in excellent condition. A part of these trees were treated with hydrocyanic acid gas on April 10, 1917.

The following table shows the number of plants treated with hydrocyanic acid gas.

TABLE I

Fruit	Insect-icide	Strength	Condi-tion of trees	Length of treat-ment min.	No. scaley trees		No. non-scaley trees
					1916 3/23	1917 4/9	1916
Apple	HCN	1-1-3	dry	45	20	8	8
	HCN	1-1-3	wet	45	20	8	8
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	dry	45	20	0	8
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	wet	45	20	0	8
	Check				20	4	8
Peach	HCN	1-1-3	dry	45	8	4	6
	HCN	1-1-3	wet	45	8	4	6
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	dry	45	8	0	6
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	wet	45	8	0	6
	Check				8	6	6
Pear	HCN	1-1-3	dry	45	0	0	4
	HCN	1-1-3	wet	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	dry	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$	wet	45	0	0	4
	Check				0	0	4

Plum	HCN	1-1-3	dry	45	0	1	4
	HCN	1-1-3	wet	45	0	1	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	4
	Check				0	1	4
Cherry	HCN	1-1-3	dry	45	0	0	4
	HCN	1-1-3	wet	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	4
	Check				0	0	4
Currant	HCN	1-1-3	dry	45	0	0	2
	HCN	1-1-3	wet	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	2
	Check				0	0	2
Goose- berry	HCN	1-1-3	dry	45	0	0	4
	HCN	1-1-3	wet	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	4
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	4
	Check				0	0	4
Black- berry	HCN	1-1-3	dry	45	0	0	2
	HCN	1-1-3	wet	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	2
	Check				0	0	2
Poplar	HCN	1-1-3	dry	45	0	0	7
	HCN	1-1-3	wet	45	0	0	7
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	7
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	7
	Check				0	0	7
Spiraea	HCN	1-1-3	dry	45	0	0	1
	HCN	1-1-3	wet	45	0	0	1
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	1
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	1
	Check				0	0	1
Japanese Quince	HCN	1-1-3	dry	45	0	0	2
	HCN	1-1-3	wet	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	2
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	2
	Check				0	0	2
Golden- bell	HCN	1-1-3	dry	45	0	0	1
	HCN	1-1-3	wet	45	0	0	1
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	0	0	1
	HCN	$\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	0	0	1
	Check				0	0	1

It was impossible to obtain a sufficient number of scaley trees in 1917 to completely duplicate the work done

in 1916 so the trees that were available were used to confirm the more important work done the preceding season. The object of using non-infested stock was to determine the physiological effect of the treatments upon the plants.

As has already been explained one fluid ounce 66° Baume sulphuric acid, 1 ounce KCN, three fluid ounces water for 100 cubic feet is most commonly used in fumigating nursery stock. Some of the nurserymen of Missouri had complained of severe burning of the stock when used this strong so two strengths of hydrocyanic acid gas were used in the work. The regular 1-1-3 formula was tried and a formula just half as strong ($\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$) was also tried.

A fumigating box was constructed from 1 inch cypress lumber. The box was made 7 feet long, 3 feet wide and 2 feet deep, having a total capacity of 42 cubic feet. The top of the box was hinged on so as to form a lid. Cleats were nailed on to the lid so as to fit tight against the inside of the box when closed and these cleats were covered with felt so as to make the box just as nearly air tight as possible.

The number of plants to be treated dry with the 1-1-3 formula were dug, the dirt removed from the roots and placed in the box. The sulphuric acid was weighed out and placed in an earthen jar, then the required amount of water was added slowly so as to prevent sputtering. The jar was then placed in the bottom of the fumigating box in such a

way as not to come in contact with the nursery stock. The potassium cyanide, 98 per cent pure, which had been broken up into small pieces, was then added to the mixture and the lid quickly closed and clamped down. The stock was allowed to fumigate for 45 minutes, when the box was opened, the gas allowed to escape, which took about 10 or 15 minutes, and the plants removed, and set about 2 feet apart in rows 3 feet apart. The residue left in the jar is very poisonous so it was removed and buried so as to prevent anything from getting hold of it.

Just as soon as the above set of trees were removed from the fumigating box, a second set containing the same number of plants was taken. This set of plants was treated in exactly the same way as the above set with the exception that they were thoroughly dampened, both roots and tops, before being placed in the box.

The object in fumigating this set of wet plants was to find out exactly, if possible, to what extent the plants would be injured and also if the effect upon the scale would be the same as upon the scale on the dry plants.

The third set of plants was treated exactly the same as the first except the $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ formula was used.

A fourth set of plants, which were wet, was also treated with the $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ formula.

Effect of Hydrocyanic Acid Gas upon San Jose Scale.

As is shown by the following table, eighty apple

trees infested with scale, were treated with hydrocyanic acid gas in 1916.

TABLE II

Date	Treatment	Condi- tion of trees	Length of treat- ment min.	No. trees treat- ed	% scale dead 1916	% trees dead 1916 5/26	% trees dead 1917 4/4
1916							
Mar.21	HCN 1-1-3	wet	45	20	77.8	15	40
	HCN 1-1-3	dry	45	20	100	10	30
	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	20	72.6	10	30
	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	20	97.5	25	55

On May 14, 1916, a count was made to determine the effectiveness of the hydrocyanic acid gas. In making the counts on these trees, several heavily infested twigs were collected from several of the different trees. The twigs were placed under a high power binocular and the numbers of dead and live insects counted. From these numbers, the percentage of live insects was determined. On May 25, 1916, a second count was made and on May 26, 1916, the number of trees which were dead was counted.

The results obtained show clearly that hydrocyanic acid gas used at the strength of 1-1-3 and $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ will kill San Jose scale on dry plants better than on moist plants. Also the dry plants suffered more from the treatment than the wet ones. The hydrocyanic acid gas gave best results when used at the rate of 1-1-3 upon dry trees. Upon

the other three sets live scale was found, the larger percentage being upon the trees treated while damp. All of these trees were heavily infested with the scale at the time of treating and their vitality had been weakened a great deal, and this is undoubtedly the reason why such a large percentage died. The normal mortality of scale on the check trees was 38.9 per cent and the high mortality of the trees was undoubtedly due to the effects of the pest.

On April 9, 1917, the following trees were treated with hydrocyanic acid gas, 1-1-3.

TABLE III

Date	Treatment	Condition of trees	Length of treatment min.	No. of trees treated	Per Cent Scale Dead April 20
1917					
Apr. 9	HCN 1-1-3	wet	45	8	100
	HCN 1-1-3	dry	45	8	100
	Check	---	--	4	75

This test in 1917 was made in order to check or substantiate the results obtained in 1916. On April 20, 1917, the trees were thoroughly examined for scale and no live scale whatever could be found on either the trees treated wet or dry. In comparing the above treatments with the check it is clearly shown that good results were obtained, but the best results were secured with the hydrocyanic acid gas used at the rate of 1-1-3 upon dry trees.

Effect of Hydrocyanic Acid Gas Upon Scale on Peaches.

Somewhat better results were obtained on peaches. From counts made on May 25, as is shown by the table, three of the treatments gave perfect results so far as controlling the scale was concerned.

TABLE IV

Date	Treatment	Condi- tion of trees	Length of treat- ment min.	No. trees treat- ed	% scale dead 1916	% trees dead	
						1916 5/26	1917 4/4
Mar. 21	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	8	95.4	37.5	87.5
	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	8	100	37.5	62.5
	HCN 1-1-3	wet	45	8	100	12.5	50
	HCN 1-1-3	dry	45	8	100	87.5	87.5
	Check			8	100	25	62.5

Hydrocyanic acid gas used at the rate of $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ on damp trees gave the poorest results. A larger number of the trees treated dry were dead May 26 than was the case with those treated wet.

TABLE V

Peaches Treated in 1917

Date 1917	Treatment		Length of treatment	No. trees treated	% scale dead 4/20/1917
April 9	HCN 1-1-3	wet	45 min.	4	100
	HCN 1-1-3	dry	45 "	4	100
	Check			6	50

In 1917 hydrocyanic acid gas proved to be effective in killing the scale on peaches upon both wet and dry trees. Fifty per cent of the scale on the check trees had passed the winter in safety.

Effect of Hydrocyanic Acid Gas Upon San Jose Scale on Plum.

TABLE VI

Plums Treated in 1917					
Date 1917	Treatment	Length of Treatment	No. trees treated	% scale dead 4/20/1917	
April 9	HCN 1-1-3 wet	45 min.	1	100	
	HCN 1-1-3 dry	45 "	1	100	
	Check		1	57	

Hydrocyanic acid gas proved effective for the scale upon plum when treated both wet and dry.

As to the effectiveness of hydrocyanic acid gas upon San Jose scale, the above results show that it might not in every case kill all of the scale, especially when used at a strength weaker than 1-1-3. When used at a weaker strength it will kill a large percentage of the insects but not enough to recommend its use.

Effect of Hydrocyanic Acid Gas Upon the Plants.

Nurserymen could control the scale with ease providing they did not have to take into consideration the possibility of injuring the plant when treating it for scale. A large number of complaints are made every year by nurserymen, of injury to stock by hydrocyanic acid gas and one of

the main objects of this investigation was to determine the amount of injury the different insecticides were likely to cause upon the different kinds of stock. For this purpose a large variety of non-infested nursery stock was obtained, including apple, peach, pear, plum, cherry, currant, gooseberry, blackberry, Lombard poplar, Spiraea Vanhouttei, Japanese quince and goldenbell, and was treated in the same manner as the infested stock and at the same time.

TABLE VII

Effect on Apple - Trees Treated Mar. 21, 1916.

Treatment	Condi- of trees	No. treated	Length of treat- ment min.	% dead 5/26/16	% dead 4/4/17	Condi- tion of growth
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	8	45	12.5	25	fair
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	8	45	0	0	good
HCN 1-1-3	wet	8	45	0	12.5	good
	dry	8	45	0	25	good
Check		8		0	0	good

On May 26, 1916, all the trees were living except those treated wet with the $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ formula; of those, 12 $\frac{1}{2}$ per cent were dead. However, at the end of a year, a larger number of the trees treated with the stronger formula were dead, also more trees treated while wet were dead than was the case with those treated while dry.

TABLE VIII
Effect on Peach.

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	6	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	6	45	0	16.6	med.
HCN 1-1-3	wet	6	45	0	0	good
HCN 1-1-3	dry	6	45	16.6	16.6	med.
Check		6		0	0	good

None of the peaches treated while wet died, while 16.6 per of both dry sets died.

TABLE IX
Effect on Pear.

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	4	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	4	45	0	0	good
HCN 1-1-3	wet	4	45	0	25	med.
HCN 1-1-3	dry	4	45	0	25	med.
Check		4		0	0	good

Twenty-five per cent of the trees, both wet and dry, treated with the stronger formula failed to live through the first year. Those treated with the weaker formula lived.

TABLE X
Effect on Plum.

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	4	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	4	45	25	25	med.
HCN 1-1-3	wet	4	45	0	0	fair
HCN 1-1-3	dry	4	45	0	0	fair
Check		4		0	0	good

Of all the plum trees treated only one failed to live through the first year.

TABLE XI

Effect on Cherry.

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth ⁶
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	4	45	100	100	
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	4	45	100	100	
HCN 1-1-3	wet	4	45	100	100	
HCN 1-1-3	dry	4	45	100	100	
Check		4		75	75	very poor

All of the cherry trees treated died and 75 per cent of the check trees died. The cherry trees when received from the nursery were in poor condition, and this is probably the reason for so many failing to live.

TABLE XII

Effect on Poplar

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	7	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	7	45	0	0	good
HCN 1-1-3	wet	7	45	0	0	good
HCN 1-1-3	dry	7	45	0	0	good
Check		7		0	0	good

All of the poplars were very hardy and all were doing fine after one year's growth.

TABLE XIII

Effect on Japanese Quince.

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	2	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	2	45	0	0	fair
HCN 1-1-3	wet	2	45	0	0	good
HCN 1-1-3	dry	2	45	0	50	good
Check		2		0	0	good

Only one failed to grow.

TABLE XIV

Effect on Goldenbell

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	1	45	100	100	
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	1	45	100	100	
HCN 1-1-3	wet	1	45	0	0	good
HCN 1-1-3	dry	1	45	100	100	
Check		1		100	100	

All but one, including the check, failed to live.

TABLE XV

Effect on Gooseberry

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	4	45	0	0	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	4	45	0	0	good
HCN 1-1-3	wet	4	45	0	75	good
HCN 1-1-3	dry	4	45	0	0	good
Check		4		0	0	good

The gooseberries were very hardy and all but one

made fine growth.

TABLE XVI

Effect on Currant

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	2	45	0	100	good
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	2	45	0	0	good
HCN 1-1-3	wet	2	45	0	100	good
HCN 1-1-3	dry	2	45	0	100	good
Check		2		0	0	good

One succeeded in getting through the first year.

TABLE XVII

Effect on Blackberry

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	2	45	50	100	med.
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	2	45	0	100	good
HCN 1-1-3	wet	2	45	50	100	good
HCN 1-1-3	dry	2	45	0	100	fair
Check		2		0	100	good

All were dead at end of the first year.

TABLE XVIII

Effect on Spiraea Vanhouttei

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	1	45	100	100	
HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	1	45	100	100	
HCN 1-1-3	wet	1	45	0	0	good
HCN 1-1-3	dry	1	45	100	100	
Check		1		0	100	poor

Only one lived through the first year.

The following tables show a comparison of the hydrocyanic acid gas used at different strengths and also show the results obtained by treating wet and dry plants.

TABLE XIX

HCN 1-1-3. Non-scaley Plants Treated Wet, 3/21/16

Kind of Tree	No. of trees	% trees dead 5/26/16	% trees dead 4/7/17	Growth
Apple	8	0	12.5	good
Peach	6	0	0	good
Pear	4	0	25	med.
Plum	4	0	0	med.
Cherry	4	100	100	
Poplar	7	0	0	good
Japanese quince	2	0	0	good
Goldenbell	1	0	0	good
Gooseberry	4	0	0	good
Currant	2	0	100	good
Blackberry	2	0	100	good
Spiraea	1	0	0	good

TABLE XX

HCN 1-1-3. Non-scaley Plants Treated Dry, 3/21/16

Apple	8	0	25	good
Peach	6	16.6	16.6	med.
Pear	4	0	25	med.
Plum	4	0	0	med.
Cherry	4	100	100	
Poplar	7	0	0	good
Jap. quince	2	0	50	good
Goldenbell	1	100	100	
Gooseberry	4	0	75	good
Currant	2	0	100	med.
Blackberry	2	50	100	med.
Spiraea	1	100	100	

TABLE XXI

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$, Non-scaley Plants Treat Wet, 3/21/16

Apple	8	12.5	25	fair
Peach	6	0	0	good
Pear	4	0	0	good
Plum	4	0	0	good
Cherry	4	100	100	
Poplar	7	0	0	good
Jap. quince	2	0	0	good
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	100	
Blackberry	1	30	100	med.
Spiraea	1	100	100	

TABLE XXII

HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$, Non-scaley Plants Treated Dry, 3/21/16.

Apple	8	0	0	good
Peach	6	16.6	16.6	med.
Pear	4	0	0	good
Plum	4	25	25	med.
Cherry	4	100	100	
Poplar	7	0	0	good
Jap. quince	2	0	0	fair
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	0	good
Blackberry	2	0	100	good
Spiraea	1	100	100	

Results with Check Plants

Apple	8	0	0	good
Peach	6	0	0	good
Pear	4	0	0	good
Plum	4	0	0	good
Cherry	4	75	100	very poor
Poplar	7	0	0	good
Jap. quince	2	0	0	good
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	0	good
Blackberry	2	0	100	good
Spiraea	1	0	100	poor

TABLE XXIII

Summary of Foregoing Tables.

Date	Treatment	Condi- tion of plants	No. plants treated	% dead 5/26/16	% dead 4/4/17
1916					
Apr. 21	HCN 1-1-3	wet	45	8.8	22.2
	HCN 1-1-3	dry	45	15.5	40.0
	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	wet	45	17.7	26.6
	HCN $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$	dry	45	15.5	20.0
	Check		26	8.8	11.1

From the summary it is readily seen that more of the trees died when treated with the stronger hydrocyanic acid gas than with the weaker at the end of one year's growth. After only one month's growth, however, more of the plants treated with the weaker strength were dead. The season of 1916 was a very unfavorable season for the growth of young trees, on account of the dry, hot summer. It is a known fact that plants treated with a high strength of hydrocyanic acid gas will be injured and if the hydrocyanic acid gas is too strong it will kill the trees. Whether or not it takes the gas longer than a month to effect a tree enough to kill it, is not known but it stands to reason that if the gas does injure a plant, the 1-1-3 strength would cause more injury than the $\frac{1}{2}$ - $\frac{1}{2}$ - $1\frac{1}{2}$ strength.

As has been shown the greater strength gave better results in controlling the scale than the weaker and as far as killing the trees is concerned, there is not enough

difference in the two strengths to amount to a great deal. Since the control of the scale is of the most importance, it is undoubtedly advisable to use the 1-1-3 formula when fumigating nursery stock.

Another very important thing that was brought out in this work is the effect of hydrocyanic acid gas upon wet and dry plants. It is the general belief among nurserymen that if plants are treated with hydrocyanic acid gas while wet, or damp, the moisture on the plant will absorb a large quantity of the gas which in turn will cause a great deal of burning and injury to the plant. It will be noticed that in this work a larger percentage of those plants treated dry, died, than those treated wet which is contradictory to the general belief of nurserymen and experiment station workers.

In treating plants with ether to stimulate growth, a larger dose of ether must be used if the plants are damp or the exposure must be longer if the same results are derived as would be obtained if the plants were dry. This may also be true of hydrocyanic acid gas and as the results obtained indicate, a larger dose of hydrocyanic acid gas must be used on damp plants to obtain the same results as on dry plants with a smaller dose. Also, fewer scale were killed upon the damp trees than on the dry, which indicates that possibly the same thing holds true in regard to animals as to plants.

Since the scale was killed better on stock treated dry than on stock treated wet, and as the destruction of scale is of prime importance, nursery stock should not be fumigated with hydrocyanic acid gas when wet, even though the injury to the plants may be greater when treated dry.

Carbon Bisulphide First Used.

Carbon bisulphide was first used as an insecticide by Louis Dayere, former professor of Agriculture at the Institute of Versailles, in 1856 and 1857. He used small amounts of the liquid on grain to destroy the weevils and their eggs. He also demonstrated that carbon bisulphide would not injure the grain. In 1876, Cornu and Moulleferet, both French investigators, demonstrated that carbon bisulphide could be successfully used upon grape phylloxera, caterpillars, butterflies, cicadas, wasps and plant lice.

Use up to Present Time.

After 1876 the popularity of carbon bisulphide as an insecticide became great and many experiments were carried on with it. It was found to be an effective and cheap insecticide and easy to use. Today carbon bisulphide is very widely used for the following:

1. To kill grape phylloxera on the roots of the grape.
2. Root maggots of different sorts on the roots

of different plants.

3. For destruction of ants.
4. To kill grubs and mole crickets.
5. For the destruction of burrowing animals
such as moles, prairie dogs, gophers, etc.
6. For the destruction of sucking insects upon
small plants.
7. For fumigating buildings containing stored
cereals to destroy the insect pests.
8. For destroying household pests, museum pests,
and similar pests.

In fact carbon bisulphide is the most extensively used fumigant today for destroying the more easily killed insects.

Method of Using.

Carbon bisulphide is easy to obtain and easy to use. Any one who is willing to take a few precautions can use carbon bisulphide with perfect safety. Carbon bisulphide is put up in tight tin cans or steel drums and can be purchased in small quantities. It is very volatile and diffuses through the air very rapidly. The gas is heavier than air and this factor is taken advantage of when using carbon bisulphide. In fumigating bins containing cereals or similar places, shallow pans are usually employed. The pans are set on top of the grain or on anything near the ceiling. Better results are obtained if the place to be

fumigated is made air tight and the temperature is 70° F. or above. The carbon bisulphide is poured in the pans, the doors closed and the cracks stopped so as to prevent the gas produced from escaping from the building. Different authorities vary as to the rate at which carbon bisulphide should be used. In Kansas the following amounts have been recommended and other stations report similar amounts:

At 90° F.	1 lb.	CS ₂	is sufficient for every 500 cu.ft.
" 80° F.	1	" " "	" " " 400 " "
" 70° F.	1	" " "	" " " 300 " "

If used in an open bin, the above amounts should be greatly increased.

At a temperature below 60° F. it is not advisable to fumigate with carbon bisulphide at all for it does not evaporate sufficiently fast below this temperature.

The bin or building should be allowed to fumigate for from 36 to 48 hours.

For fumigating seeds with carbon bisulphide, from 1 to 1½ pounds should be used to every 1000 cubic feet.

Carbon bisulphide has been tried a number of times upon nursery stock for destroying scale insects, but up to the present time has proven unsatisfactory.

Chemical Composition of Carbon Bisulphide.

(10)
According to W. E. Hinds, in United States Department of Agriculture Farmers' Bulletin No. 145, "the chemical symbol of carbon bisulphide is CS₂. Its molecules

consist of one atom of carbon united with two atoms of sulphur. The specific gravity of the liquid is 1.29. The vapor is 2.63 times as heavy as atmospheric air. The pure article volatilizes rapidly and completely when exposed to the air. The liquid boils at 115° F.

The vapor takes fire in air at about 300° F. and burns with a faint blue flame, with difficulty visible in daylight, but evolving considerable heat and decomposing the carbon bisulphide into carbon dioxide (CO_2) and sulphur dioxide (SO_2). The latter is the familiar gas given off by the burning of sulphur matches and is a strongly poisonous suffocating gas, which should not be inhaled. Carbon bisulphide vapor mixed with three times its volume of oxygen, or an amount of air containing that amount of oxygen, forms a mixture which is very highly explosive upon ignition. As 21 per cent of the air is oxygen, one volume of liquid carbon bisulphide evaporated in 5,357 volumes of air would form such a mixture. An atmosphere composed of one volume of carbon bisulphide vapor to approximately 14.3 volumes of air is liable to violent explosion in the presence of fire of any kind whatever, or a temperature of about 300° F. without flame. This is about the maximum danger point from explosion in the use of carbon bisulphide."

The higher the temperature, the more carbon bisulphide will be taken up by the air.

Results of Experiments with Carbon Bisulphide.

As has already been pointed out carbon bisulphide is probably the most generally used insecticide for fumigating, especially for such insects as grain weevil. It has been tried to some extent upon nursery stock for the control of San Jose scale but so far satisfactory results have not been reported. Carbon bisulphide is cheaper than hydrocyanic acid gas, easier to handle and, used as a poison, does not act in an effective way so quickly which makes it less dangerous for the person handling it.

Object.

The idea in using carbon bisulphide was to determine if possible, whether or not it could be used at all for destroying San Jose scale upon live plants without injury to the plants. Owing to its cheapness and the ease with which it can be used as compared with hydrocyanic acid gas, carbon bisulphide would be a great deal more desirable provided the same results could be obtained.

Procedure.

The same fumigating box was used with the carbon bisulphide as with the hydrocyanic acid gas and, as shown by the following table, the same number of trees were used. The first dry and the first wet set of trees were treated for an hour with carbon bisulphide at the rate of 1 pound of the insecticide to 100 cubic feet of space. Sets No. 3 and 4 were treated for an hour also, but the carbon bisulphide

was used at the rate of $1\frac{1}{2}$ pounds to the 100 cubic feet.

In treating the trees each set was placed in the fumigating box separately, as with the hydrocyanic acid gas. Near the top of the box a shelf was constructed upon which a shallow pan was placed. The nursery stock was placed in the box, the required amount of carbon bisulphide poured into the pan and the lid closed.

TABLE XXIV

Effect Upon San Jose Scale

Fruit	Insect-icide	Strength	Condi- tion of trees	Length of treat- ment. min.	No.		
					scaley 1916	trees 1917	non-scaley 1916
Apple	CS ₂	1-100	dry	60	20	0	8
	CS ₂	1-100	wet	60	20	0	8
	CS ₂	$\frac{1}{2}$ -100	dry	60	20	8	8
	CS ₂	$\frac{1}{2}$ -100	wet	60	20	8	8
	Check				20	4	8
Peach	CS ₂	1-100	dry	60	8	0	6
	CS ₂	1-100	wet	60	8	0	6
	CS ₂	$\frac{1}{2}$ -100	dry	60	8	4	6
	CS ₂	$\frac{1}{2}$ -100	wet	60	8	4	6
	Check				8	6	6
Pear	CS ₂	1-100	dry	60	0	0	4
	CS ₂	1-100	wet	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	4
	Check				0	0	4
Plum	CS ₂	1-100	dry	60	0	0	4
	CS ₂	1-100	wet	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	4
	Check				0	1	4
Cherry	CS ₂	1-100	dry	60	0	0	4
	CS ₂	1-100	wet	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	4
	Check				0	0	4

Currant	CS ₂	1-100	dry	60	0	0	2
	CS ₂	1-100	wet	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	2
	Check				0	0	2
Goose- berry	CS ₂	1-100	dry	60	0	0	4
	CS ₂	1-100	wet	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	4
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	4
	Check				0	0	4
Black- berry	CS ₂	1-100	dry	60	0	0	2
	CS ₂	1-100	wet	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	2
	Check				0	0	2
Poplar	CS ₂	1-100	dry	60	0	0	7
	CS ₂	1-100	wet	60	0	0	7
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	7
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	7
	Check				0	0	7
Spiraea	CS ₂	1-100	dry	60	0	0	1
	CS ₂	1-100	wet	60	0	0	1
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	1
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	1
	Check				0	0	1
Jap. quince	CS ₂	1-100	dry	60	0	0	2
	CS ₂	1-100	wet	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	2
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	2
	Check				0	0	2
Golden- bell	CS ₂	1-100	dry	60	0	0	1
	CS ₂	1-100	wet	60	0	0	1
	CS ₂	$\frac{1}{2}$ -100	dry	60	0	0	1
	CS ₂	$\frac{1}{2}$ -100	wet	60	0	0	1
	Check				0	0	1

Eighty apple trees heavily infested with San Jose scale were treated with carbon bisulphide as is shown by the following table.

TABLE XXV

Date	Treatment	Condi- tion	Length of treat- ment min.	No. trees treated	% scale dead 5/14-5/25	% trees dead 1916 5/26	% trees dead 1917 4/4
1916							
Mar.	CS ₂ 1-100	dry	60	20	92.3	30.5	70
21	CS ₂ 1-100	wet	60	20	88.2	15	50
	CS ₂ 1½-100	dry	60	20	77.1	10	45
	CS ₂ 1½-100	wet	60	20	83.9	10	40
	Check			20	38.9	0	60

As is shown, counts made May 14 and 25 definitely show that carbon bisulphide used at a strength of either 1 to 100 or 1½ to 100 will not control scale. As compared with the check, however, it is evident that a number of the insects were killed but not enough to warrant its use.

On April 9, 1917, the following trees were treated with carbon bisulphide, 1½ to 100.

TABLE XXVI

Date	Treatment	Condi- tion of trees	Length of treat- ment min.	No. trees treated	% scale dead April 20
Apr. 9	CS ₂ 1½-100	wet	60	8	96.6
	CS ₂ 1½-100	dry	60	8	94.6
	Check			4	75.00

The results obtained in 1917 are practically the same as those obtained in 1916 and they also show that carbon bisulphide used at the rate of 1½ to 100 will not control San Jose scale.

TABLE XXVII

Effect of Carbon Bisulphide Upon San Jose Scale on Peach.

Date	Treatment	Condi- tion of trees	Length of treat- ment min.	No. treated	% scale dead 1916 5/25	% trees dead 1916 5/26	1917 4/4
Mar.21	CS ₂ 1-100	dry	60	8	100	62.5	75
	CS ₂ 1-100	wet	60	8	100	62.5	87.5
	CS ₂ 1½-100	wet	60	8	100	37.5	75
	CS ₂ 1½-100	dry	60	8	94.8	30	87.5
	Check			8	100	25	62.5

The results obtained on the peach also show that carbon bisulphide will not entirely control San Jose scale when used at the rate of 1½ to 100. However, these results are much better than those obtained upon the apple which is probably due to the fact that most of the heavily infested peach trees died, which made it impossible to get as good a count. The peaches that lived were not so heavily infested.

TABLE XXVIII

Effect of Carbon Bisulphide
Upon San Jose Scale on Peaches in 1917.

Date	Treatment	Condi- tion of trees	Length of treat- ment min.	No. treated	% scale dead April 20
Apr.9	CS ₂ 1½-100	wet	60	4	100
	CS ₂ 1½-100	dry	60	4	100
	Check				50

No live scale could be found upon the peach trees treated which was probably due to the fact that as a result of the treatment practically all of the young tender growth, which was the most heavily infested part of the trees, had died.

Effect of Carbon Bisulphide Upon the Plants.

It seems that the greatest trouble in using carbon bisulphide for the control of San Jose scale is the danger of killing or injuring the plants which are treated, and in order to determine more definitely the relation between the controlling of the scale and the injury of plants, a large variety of non-infested shrubs and small fruits were treated with carbon bisulphide, as is shown by the following tables. The plants were divided into four sets. Two sets were thoroughly dampened before treatment and two were treated dry. One set in each group was treated at the rate of 1 pound to 100 cubic feet, and one set in each group was treated at the rate of $1\frac{1}{2}$ to 100.

TABLE XXIX

Effect upon Apple. Treated March 21.							
Treatment	Condi- tion of trees	No. treated	Length of treat- ment min.	% dead 5/26/16	% dead 4/4/17	Condi- tion of growth	
CS ₂ 1-100	dry	8	60	0	0	fair	
CS ₂ 1-100	wet	8	60	0	0	fair	
CS ₂ 1½-100	dry	8	60	0	0	fair	
CS 1½-100	wet	8	60	0	0	fair	
Check				0	0	good	

None of the non-infested apple trees seemed to be injured to any great extent by carbon bisulphide at either strength upon either wet or dry trees.

TABLE XXX

Effect Upon Peach - Treated March 21, 1916							
Treatment	Condi- tion of trees	No. treated	Length of treat- ment min.	% dead 5/26/16	% dead 4/4/17	Condi- tion of growth	
CS ₂ 1-100	dry	6	60	0	16.6	fair	
CS ₂ 1-100	wet	6	60	0	0	poor	
CS ₂ 1½-100	dry	6	60	0	0	med.	
CS ₂ 1½-100	wet	6	60	0	0	fair	
Check		6		0	0	good	

Of the 24 peach trees treated on April 4, 1917, only one was dead.

TABLE XXXI

Effect on Pear - Treated March 21, 1916							
CS ₂ 1-100	dry	4	60	0	0	good	
CS ₂ 1-100	wet	4	60	0	0	good	
CS ₂ 1½-100	wet	4	60	0	25	good	
CS ₂ 1½-100	dry	4	60	0	75	good	
Check		4		0	0	good	

At the end of a year 25 per cent of the trees treated with the 1½-100 strength were dead, and 75 per cent of those treated dry at the same strength were dead. None of the other trees were dead.

TABLE XXXII

Effect on Plum - Treated March 21, 1916.

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth
CS ₂ 1-100	dry	4	60	0	25	good
CS ₂ 1-100	wet	4	60	0	0	good
CS ₂ 1½-100	wet	4	60	0	0	good
CS ₂ 1½-100	dry	4	60	0	0	good
Check		4		0	0	good

Only one tree in the entire lot was dead at the end of the year.

TABLE XXXIII

Effect on Cherry - Treated March 21, 1916.

CS ₂ 1-100	dry	4	60	75	75	poor
CS ₂ 1-100	wet	4	60	75	75	med.
CS ₂ 1½-100	wet	4	60	75	100	very poor
CS ₂ 1½-100	dry	4	60	25	75	poor
Check		4		75	100	very poor

The cherries did very poorly as is shown by the table. A very large percentage died, including the check.

TABLE XXXIV

Effect on Poplar - Treated March 21, 1916

CS ₂ 1-100	dry	7	60	0	28.5	fair
CS ₂ 1-100	wet	7	60	28.5	55.5	med.
CS ₂ 1½-100	wet	7	60	28.5	21.5	med.
CS ₂ 1½-100	dry	7	60	0	14.2	med.
Check		7		0	0	good

As compared with the other plants treated, the poplars withstood carbon bisulphide very poorly.

TABLE XXXV

Effect on Japanese Quince - Treated March 21, 1916

Treatment	Condition of trees	No. treated	Length of treatment min.	% dead 5/26/16	% dead 4/4/17	Condition of growth
CS ₂ 1-100	dry	2	60	0	50	fair
CS ₂ 1-100	wet	2	60	0	50	fair
CS ₂ 1½-100	wet	2	60	0	50	fair
CS ₂ 1½-100	dry	2	60	0	0	fair
Check		2		0	0	good

The Japanese quince also suffered very heavily from carbon bisulphide as compared with the other plants.

TABLE XXXVI

Effect on Goldenbell - Treated March 21, 1916.

CS ₂ 1-100	dry	1	60	0	0	good
CS ₂ 1-100	wet	1	60	0	100	good
CS ₂ 1½-100	wet	1	60	0		good
CS ₂ 1½-100	dry	1	60	0	100	good
Check		1		100	100	

Fifty per cent of the goldenbells treated were dead at the end of a year. At the end of a month none were dead.

TABLE XXXVII

Effect on Gooseberry - Treated March 21, 1916							
Treatment	Condi- tion of trees	No. treated	Length of treat- ment min.	% dead 5/26/16	% dead 4/4/17	Condi- tion of growth	
CS ₂ 1-100	dry	4	60	0	100	med.	
CS ₂ 1-100	wet	4	60	25	100	med.	
CS ₂ 1½-100	wet	4	60	0	75	good	
CS ₂ 1½-100	dry	4	60	0	75	good	
Check		4		0	0	good	

The gooseberries treated with carbon bisulphide at both strengths also suffered very heavily.

TABLE XXXVIII

Effect on Currant - Treated March 21, 1916							
CS ₂ 1-100	dry	2	60	50	100	med.	
CS ₂ 1-100	wet	2	60	0	50	fair	
CS ₂ 1½-100	wet	2	60	0	50	good	
CS ₂ 1½-100	dry	2	60	0	100	med.	
Check		2		0	0	good	

Of the treated currants one was dead at the end of the first month; all but two were dead at the end of a year.

TABLE XXXIX

Effect on Blackberry - Treated March 21, 1916.

Treatment	Condi- tion of trees	No. treated	Length of treat- ment min.	% dead 5/26/16	% dead 4/4/17	Condi- tion of growth
CS ₂ 1-100	dry	2	60	50	100	med.
CS ₂ 1-100	wet	2	60	0	100	good
CS ₂ 1½-100	wet	2	60	0	100	med.
CS ₂ 1½-100	dry	2	60	50	100	poor
Check		2		0	100	good

At the end of the first month only two of the eight plants treated were dead; at the end of a year all were dead.

TABLE XL

Effect on Spiraea Vanhouttei - Treated March 21, 1916

CS ₂ 1-100	dry	1	60	0	0	good
CS ₂ 1-100	wet	1	60	100	100	good
CS ₂ 1½-100	wet	1	60	100	100	good
CS ₂ 1½-100	dry	1	60	0	0	med.
Check		1		0	100	poor

Like the remainder of the shrubs and small fruits the Spiraea suffered heavily from the carbon bisulphide. Fifty per cent of the entire lot died.

The following tables show a comparison of carbon bisulphide used at different strengths and also shows the results obtained by treating wet and dry plants.

TABLE XLI

Non-scaley Trees, (Wet), Treated with Carbon Bisulphide 1-100

Kind of Tree	No. of trees	% trees dead	% trees dead	Condition of Growth
5/26/16				
Apple	8	0	0	med.
Peach	6	0	0	poor
Pear	4	0	0	good
Plum	4	0	25	good
Cherry	4	75	75	very poor
Poplar	7	28.5	55.5	med.
Jap. quince	2	0	50	med.
Goldenbell	1	0	100	good
Gooseberry	4	25	100	med.
Currant	2	0	50	med.
Blackberry	2	0	100	good
Spiraea	1	100	100	

TABLE XLII

Non-scaley Trees, (Dry), Treated with Carbon Bisulphide 1-100

Apple	8	0	0	med.
Peach	6	0	16.6	med.
Pear	4	0	0	good
Plum	4	0	25	good
Cherry	4	75	75	poor
Poplar	7	0	28.5	med.
Jap. quince	2	0	50	med.
Goldenbell	1	0	0	good
Gooseberry	4	0	100	med.
Currant	2	50	100	med.
Blackberry	2	50	100	med.
Spiraea	1	0	0	good

TABLE XLIII

Non-scaley Trees (Wet), treated with Carbon Bisulphide $1\frac{1}{2}$ -100

Apple	8	0	0	med.
Peach	6	0	0	med.
Pear	4	0	25	good
Plum	4	0	0	good
Cherry	4	75	100	very poor
Poplar	7	28.5	71.5	med.
Jap. quince	2	0	50	med.
Goldenbell	1	0	0	good
Gooseberry	4	0	75	good
Currant	2	0	50	good
Blackberry	2	0	100	med.
Spiraea	1	100	100	

TABLE XLIV

Non-scaley Trees (Dry), Treated with Carbon Bisulphide $1\frac{1}{2}$ -100

Apple	8	0	0	med.
Peach	6	0	0	med.
Pear	4	0	75	good
Plum	4	0	0	good
Cherry	4	25	75	poor
Poplar	7	0	14.2	med.
Jap. quince	2	0	0	med.
Goldenbell	1	0	100	good
Gooseberry	4	0	75	good
Currant	2	0	100	med.
Blackberry	2	50	100	poor
Spiraea	1	0	0	med.

Results with Check Trees

Apple	8	0	0	good
Peach	6	0	0	good
Pear	4	0	0	good
Plum	4	0	0	good
Cherry	4	75	100	very poor
Poplar	7	0	0	good
Jap. quince	2	0	0	good
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	0	good
Blackberry	2	0	100	good
Spiraea	1	0	100	poor

TABLE XLV

Summary of Foregoing Tables

Treatment	Condi- tion of plants	No. plants treated	Per cent dead	
			5/26/16	4/4/17
CS ₂ 1-100	wet	45	15.6	40.0
CS ₂ 1-100	dry	45	11.1	35.5
CS ₂ 1-150	wet	45	13.3	40.0
CS ₂ 1-150	dry	45	4.4	33.3
Check		45	8.8	11.1

From the above summary it is readily seen that carbon bisulphide caused considerable injury. At the end of the second month the percentage of dead trees was the greatest among those upon which the weaker, or 1-100, strength was used, but at the end of the first year the percentage dead among those plants treated at this strength was still a little greater, but not enough to amount to a great deal. In the first place there is not a great deal of difference in the strengths of carbon bisulphide used at the rate of 1-100 and 1-150. Taking this into consideration and also the fact that the season of 1916 was a very unfavorable one for the growth of young plants, it is not surprising that a smaller number of trees died from the stronger treatment.

It will also be noticed that a larger per cent of the plants treated wet died, both at the end of the second month and at the end of the first year. However,

the difference was not very great. With hydrocyanic acid gas more of the plants treated dry died. It may be that carbon bisulphide has an altogether different physiological effect upon the plant, especially in the presence of moisture. By referring back to Tables XXIX and XXX it will be noticed that a larger percentage of the scale on the trees treated wet were killed which seems to further indicate that carbon bisulphide used in the presence of moisture is more active.

Owing to the fact that carbon bisulphide did not in any case completely control the San Jose scale upon apple trees, and in only three out of four cases upon the peach, and since the percentage of injury to the plants was very great, its use as a fumigating material upon nursery stock should be discouraged.

Lime Sulphur First Used.

On page 18, under "Control in the Orchard," a discussion of the first use of lime sulphur for the control of insects is given.

(24)
Mr. F. A. Sirrine, of New York Agricultural Experiment Station, was probably the first to dip nursery stock for the control of San Jose scale. He dipped some nursery stock in 1894 on Long Island with a whale oil soap preparation. Lime sulphur was probably first used as a dip for nursery stock for the control of the scale by
(33)
Professor C. V. Close of the Delaware Experiment Station in

1903.

Used up to Present Time.

Since 1894 a large number of experiments have been made with lime sulphur as a tree dip for the control of San Jose scale but none have been, on the whole, entirely successful. In some cases the scale was controlled but the most serious objection to using it was the fact that in nearly every case the plants were injured to a greater or less extent. Although lime sulphur is used almost altogether for controlling San Jose scale on old trees, it has never proven to be a practical success for dipping nursery stock.

Methods of Using.

When lime sulphur is used upon nursery stock as a spray for the control of San Jose scale, it is during the dormant season while the trees are still in the nursery row, it is applied at the usual rate, the same as recommended for mature trees - 1 to 7 - and is put on with a spraying machine, either hand or power. Most large nurseries have especially constructed spraying machines which are built so as to be easily gotten between nursery rows.

When lime sulphur or any other material is used for dipping nursery stock a vat is constructed or a trough made which is large enough to hold sufficient liquid to immerse an entire tree.

Chemical Composition of Lime Sulphur.

Lime sulphur is made by boiling in water, slaked

Trough used for dipping the plants.

rock lime containing not less than 95 per cent calcium oxide, and flowers of sulphur. A very complicated chemical reaction takes place when lime and sulphur are boiled together in water. The sulphur (S) combines with the calcium (Ca) in the lime (CaO), in varying amounts, with the result that two compounds are formed - calcium tetrasulphide (CaS_4), containing 76 per cent of sulphur, and calcium pentasulphide (CaS_5) containing 80 per cent of sulphur. Also a small quantity of thiosulphate (CaS_2O_3) is formed. These compounds formed are soluble in water and it is to them that the insecticidal value of the mixture is due. The higher the percentage of pentasulphide, the more effective is the mixture. In making the lime sulphur solution, it is necessary to boil it for an hour in order to form a complete chemical union of the lime and sulphur. Two parts of sulphur combine with one part of lime and in making the solution, twice as much sulphur as lime should be used.

Results of Experiments with Lime Sulphur.

As the lime sulphur wash has become the most standard spray for the control of San Jose scale on infested fruit trees, the writer saw no reason why it should not be used to dip infested nursery stock.

Object.

The object in using lime sulphur was to determine definitely, if possible, its exact efficiency for killing scale on nursery stock, and its injurious effects, if

any, upon the plants. Lime sulphur is the cheapest material used in the control of San Jose scale and as no fumes are produced, it is less dangerous to use than hydrocyanic acid gas or carbon bisulphide.

Procedure.

First a water tight wooden V-shaped trough was made, 9 feet long and 8 inches deep. This trough held with ease 8 gallons of the solution. The number of trees to be dipped were divided into four sets as shown by the following table.

TABLE XLVI

Fruit	Insect-icide	Strength	Condi-tion of trees	Length of treat-ment	No. scaley trees		No. non-scaley trees 1916
					1916 3/23	1917 4/9	
Apple	L.S.	1-9	tops	inst.	10	*	3
	L.S.	1-9	t. & r.	inst.	10	0	3
	L.S.	1-7	tops	inst.	10	6	3
	L.S.	1-7	t. & r.	inst.	10	6	3
	Check				20	4	8
Peach	L.S.	1-9	tops	inst.	4	*	3
	L.S.	1-9	t. & r.	inst.	4	0	3
	L.S.	1-7	tops	inst.	4	9	3
	L.S.	1-7	t. & r.	inst.	4	9	3
	Check				8	6	6
Pear	L.S.	1-9	tops	inst.	0	0	2
	L.S.	1-9	t. & r.	inst.	0	0	2
	L.S.	1-7	tops	inst.	0	0	2
	L.S.	1-7	t. & r.	inst.	0	0	2
	Check				0	0	4
PLUM	L.S.	1-9	tops	inst.	0	*	2
	L.S.	1-9	t. & r.	inst.	0	0	2
	L.S.	1-7	tops	inst.	0	1	2
	L.S.	1-7	t. & r.	inst.	0	1	2
	Check				0	1	4

*Each tree was treated for 5 minutes.

Cherry	L.S.	1-9	tops	instl	0	0	2
	L.S.	1-9	t. & r.	inst.	0	0	2
	L.S.	1-7	tops	inst.	0	0	2
	L.S.	1-7	t. & r.	inst.	0	0	2
	Check				0	0	4
Currant	L.S.	1-9	tops	inst.	0	0	1
	L.S.	1-9	t. & r.	inst.	0	0	1
	L.S.	1-7	tops	inst.	0	0	1
	L.S.	1-7	t. & r.	inst.	0	0	1
	Check				0	0	2
Goose- berry	L.S.	1-9	tops	inst.	0	0	1
	L.S.	1-9	t. & r.	inst.	0	0	1
	L.S.	1-7	tops	inst.	0	0	1
	L.S.	1-7	t. & r.	inst.	0	0	1
	Check				0	0	4
Black- berry	L.S.	1-9	tops	inst.	0	0	2
	L.S.	1-9	t. & r.	inst.	0	0	2
	L.S.	1-7	tops	inst.	0	0	2
	L.S.	1-7	t. & r.	inst.	0	0	2
	Check				0	0	2
Poplar	L.S.	1-9	tops	inst.	0	0	4
	L.S.	1-9	t. & r.	inst.	0	0	3
	L.S.	1-7	tops	inst.	0	0	4
	L.S.	1-7	t. & r.	inst.	0	0	3
	Check				0	0	7
Spiraea	L.S.	1-9	tops	inst.	0	0	1
	L.S.	1-9	t. & r.	inst.	0	0	1
	L.S.	1-7	tops	inst.	0	0	1
	L.S.	1-7	t. & r.	inst.	0	0	1
	Check				0	0	1
Jap. quince	L.S.	1-9	tops	inst.	0	0	1
	L.S.	1-9	t. & r.	inst.	0	0	2
	L.S.	1-7	tops	inst.	0	0	1
	L.S.	1-7	t. & r.	inst.	0	0	2
	Check				0	0	2
Golden- bell	L.S.	1-9	tops	inst.	0	0	1
	L.S.	1-9	t. & r.	inst.	0	0	1
	L.S.	1-7	tops	inst.	0	0	1
	L.S.	1-7	t. & r.	inst.	0	0	1
	Check				0	0	1

In the first set the tops and trunk down to the roots only, were dipped, and those trees dipped in 1916 were immersed and immediately removed, while those dipped in 1917 were left immersed for five minutes. With the second set of trees the tops and roots both were dipped. With the first two sets lime sulphur was used at the rate of 1 gallon to 9

gallons of water. The third and fourth sets were treated exactly as the first two except the lime sulphur was used at the rate of 1 gallon to 7 gallons of water.

After the trees had been dipped they were allowed to drain for a few minutes, then set out.

Effect of Lime Sulphur upon San Jose scale.

As shown by the following table, forty apple trees heavily infested with San Jose scale were dipped in the lime sulphur solution.

TABLE XLVII

<u>Effect of Lime Sulphur on San Jose Scale on Apple Trees</u>							
Date	Insect-icide	Condi-tion of trees	Length of treatment	No. of trees treated	% scale dead 1916 5/14 - 5/25	% trees dead 1916 5/26	% trees dead 1917 4/4
Mar. 21	L.S. 1-9	tops	inst.*	10	100	20	50
	L.S. 1-9	t. & r.	inst.	10	100	30	70
	L.S. 1-7	tops	inst.	10	99.6	10	70
	L.S. 1-7	t. & r.	inst.	10	93.9	30	50
	Check			20	38.4		

These results show that lime sulphur will, to a very large extent, control San Jose scale on nursery stock but that the control may not be complete. Every tree was thoroughly dipped, care being taken that every branch and twig was completely wet to the top, and the writer is convinced that none of the insects escaped immersion. Also a count of the scale was made from every tree and as shown by the results a very small percentage was alive a month after

treatment. So far as the strength of the solution is concerned, the weaker gave the best results; however, there is very little difference in the strength of the two solutions used and the fact that the weaker solution gave the better results is of little significance.

In order to verify the above results, the following trees were treated in 1917 with lime sulphur at a strength of 1-7.

TABLE XLVIII

Date	Insect-icide	Condi-tion of trees	Length of treat-ment	No. trees treated	% scale dead
1917					4/20/17
Apr. 9	L.S.1-7	tops	5 min.	6	100
	L.S.1-7	t. & r.	5 "	6	100
	Check			4	75

TABLE XLIX

Effect of Lime Sulphur upon Scale on Peaches - 1916

Date	Insect-icide	Condi-tion of trees	Length of treat-ment	No. trees treat-ed	% scale dead May 25	% trees dead 1916 5/26	% trees dead 1917 4/4
Mar. 21	L.S.1-9	tops	inst.	4	100	25	25
	L.S.1-9	t. & r.	inst.	4	100	25	25
	L.S.1-7	tops	inst.	4	94.3	12.5	100
	L.S.1-7	t. & r.	inst.	4	100	12.5	100
	Check			8	100	25	62.5

Practically the same results were obtained upon the peach in 1916 as upon the apple.

TABLE L

Effect upon Scale on Peach - 1917

Date	Insect-icide	Condi-tion of trees	Length of treat-ed	No. trees treated	% scale dead 4/20/17
May 4	L.S.1-7	tops	5 min.	9	100
	L.S.1-7	t.& r.	5 min.	9	100
	Check			6	50

As with the apple, no live scale could be found.

TABLE LI

Effect upon Scale on Plum - 1917

Apr. 4	L.S.1-7	tops	5 min.	1	100
	L.S.1-7	t.& r.	5 min.	1	100
	Check			1	

The scale on the treated trees were all dead.

Effect of Lime Sulphur upon the Plants.

Some injury has been reported by different experiment stations, upon nursery stock as a result of dipping in lime sulphur; also there is a general belief among the practical nurserymen that lime sulphur dip will injure nursery stock, especially if the roots are also dipped. For this reason, and also to determine the practicability of using lime sulphur as a dip for nursery stock, the following non-infested plants were dipped. The lime sulphur was used at a strength of 1 gallon lime sulphur to 9 gallons of water, and 1 gallon of lime sulphur to 7 of water.

TABLE LII

Effect upon Apple, Trees Treated 3/21/16

Treatment	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condition of growth
				1916 5/26	1917 4/4	
L.S. 1-9	tops	3	inst.*	0	0	poor
L.S. 1-9	t.& r.	3	inst.	0	0	med.
L.S. 1-7	tops	3	inst.	66.6	66.6	poor
L.S. 1-7	t.& r.	3	inst.	0	0	very poor
Check						good

At the end of the first month and also the first year, all the trees were living with the exception of 66.6 per cent of the trees treated both tops and roots in the 1-7 strength.

TABLE LIII

Effect upon Peach

L.S.	Condition	No.	Length	% dead		Condition
				1916	1917	
L.S. 1-9	tops	3	inst.	0	0	med.
L.S. 1-9	t.& r.	3	inst.	0	66.6	med.
L.S. 1-7	tops	3	inst.	0	0	poor
L.S. 1-7	t.& r.	3	inst.	0	33.3	med.
Check		6		0	0	good

None of the trees died except those dipped both tops and roots.

*instantaneous

TABLE LIV

Effect upon Pear

Treatment	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
				1916 5/26	1917 4/4	
L.S. 1-9	tops	2	inst.	0	0	good
L.S. 1-9	t.& r.	2	inst.	0	50	poor
L.S. 1-7	tops	2	inst.	0	0	good
L.S. 1-7	t.& r.	2	inst.	0	0	med.
Check		4		0	0	good

Only one tree was dead at the end of a year, and it was treated both top and root with 1-9 strength.

TABLE LV

Effect upon Plum

L.S. 1-9	top	2	inst.	0	0	good
L.S. 1-9	t.& r.	2	inst.	50	50	fair
L.S. 1-7	top	2	inst.	0	0	good
L.S. 1-7	t.& r.	2	inst.	0	0	med.
Check		4		0	0	good

Only one tree died and both top and roots of this tree were treated, 1-9.

TABLE LVI

Effect upon Cherry

L.S. 1-9	top	2	inst.	100	100	
L.S. 1-9	t.& r.	2	inst.	100	100	
L.S. 1-7	top	2	inst.	100	100	
L.S. 1-7	t.& r.	2	inst.	50	50	fair
Check		4		75	100	very poor

All of the cherry trees died except one, including the check.

TABLE LVII

Effect upon Poplar						
Treatment	Condition of trees	No. treated	Length of treatment	% dead 1916 5/26	% dead 1917 4/4	Condition of growth
L.S. 1-9	top	4	inst.	0	0	good
L.S. 1-9	t. & r.	4	inst.	0	0	poor
L.S. 1-7	top	3	inst.	75	75	med.
L.S. 1-7	t. & r.	3	inst.	0	0	poor
Check		7	inst.	0	0	good

The poplars withstood the lime sulphur treatment very well; 75 per cent of those treated, tops only, with the 1-7 strength, died. The others all lived.

TABLE LVIII

Effect upon Japanese Quince						
L.S. 1-9	top	1	inst.	0	100	good
L.S. 1-9	t. & r.	1	inst.	0	0	poor
L.S. 1-7	top	2	inst.	0	0	fair
L.S. 1-7	t. & r.	2	inst.	0	0	poor
Check				0	0	good

Of all the Japanese quince treated, only one died. None were dead at the end of the first month.

TABLE LIX

Effect upon Goldenbell

Treatment	Condition of trees	No. treated	Length of treatment	% dead		Condition of growth
				1916 5/26	1917 4/4	
L.S. 1-9	top	1	inst.	0	100	good
L.S. 1-9	t. & r.	1	inst.	100	100	
L.S. 1-7	top	1	inst.	0	0	good
L.S. 1-7	t. & r.	1	inst.	100	100	
Check		1		100	100	

Those dipped both top and roots suffered most.
Checks also died.

TABLE LX

Effect upon Gooseberry

L.S. 1-9	top	1	inst.	0	100	good
L.S. 1-9	t. & r.	1	inst.	0	100	good
L.S. 1-7	top	1	inst.	0	0	good
L.S. 1-7	t. & r.	1	inst.	0	0	poor
Check		4		0	0	good

Those treated with the weaker solution were dead
at the end of a year.

TABLE LXI

Effect upon Currant

L.S. 1-9	top	2	inst.	0	100	fair
L.S. 1-9	t. & r.	1	inst.	0	100	fair
L.S. 1-7	top	1	inst.	0	0	fair
L.S. 1-7	t. & r.	1	inst.	0	0	fair
Check		2		0	0	good

At the end of a year those treated with the weaker solutions were dead.

TABLE LXII

Effect upon Blackberry

Treatment	Condition of trees	No. treated	Length of treatment	% dead		Condition of growth
				1916 5/26	1917 4/4	
L.S. 1-9	top	2	inst.	50	100	poor
L.S. 1-9	t. & r.	2	inst.	0	100	good
L.S. 1-7	top	2	inst.	0	100	fair
L.S. 1-7	t. & r.	2	inst.	0	0	good
Check		2		0	100	good

At the end of the first month only one plant was dead. At the end of a year all were dead, including the check, except one, and this was dipped both top and roots in the 1-7 solution.

TABLE LXIII

Effect upon Spiraea Vanhouttei

L.S. 1-9	top	1	inst.	0	100	med.
L.S. 1-9	t. & r.	1	inst.	0	0	fair
L.S. 1-7	top	1	inst.	100	100	
L.S. 1-7	t. & r.	1	inst.	0	0	fair
Check		1		0	100	poor

One Spiraea dipped top only in the 1-7 solution was dead at the end of the first month. At the end of the year the check and the one dipped in the 1-9 solution, top only, were dead.

The following tables show a comparison of lime sulphur used at different strengths and also shows the results of dipping tops only and both tops and roots.

TABLE LXIV

Non-scaley Trees Dipped in Lime Sulphur 1-9, Tops and Roots

Kind of Tree	No. of trees	% trees dead 5/26/16	% trees dead 4/4/17	Condition of growth
Apple	3	0	0	med.
Peach	3	0	66.6	med.
Pear	2	0	50	poor
Plum	2	50	50	good
Cherry	2	0	0	
Poplar	4	0	0	poor
Japanese quince	1	0	0	poor
Goldenbell	1	100	100	
Gooseberry	1	0	100	good
Currant	1	0	100	med.
Blackberry	2	0	100	good
Spiraea	1	0	0	med.

TABLE LXV

Non-scaley Trees Dipped in Lime Sulphur 1-7, Tops and Roots

Apple	3	0	0	poor
Peach	3	0	33.3	med.
Pear	2	0	0	med.
Plum	2	0	0	med.
Cherry	2	50	50	poor
Poplar	4	0	0	poor
Jap. quince	1	0	0	poor
Goldenbell	1	100	100	
Gooseberry	1	0	0	poor
Currant	1	0	0	med.
Blackberry	2	0	0	good
Spiraea	1	0	0	med.

TABLE LXVI

Non-scaley Trees Dipped in Lime Sulphur 1-9, Tops.

Apple	3	0	0	poor
Peach	3	0	0	med.
Pear	2	0	0	good
Plum	2	0	0	good
Cherry	2	100	100	
Poplar	4	0	0	good
Jap. quince	1	0	100	good
Goldenbell	1	0	100	good
Gooseberry	1	0	100	good
Currant	1	0	100	fair
Blackberry	2	50	100	poor
Spiraea	1	0	100	med.

TABLE LXVII

Non-scaley Trees Dipped in Lime Sulphur 1-7, Tops.

Apple	3	0	0	poor
Peach	3	0	0	poor
Pear	2	0	0	good
Plum	2	0	0	good
Cherry	2	100	100	
Poplar	4	75	75	med.
Jap. quince	1	0	0	fair
Goldenbell	1	0	0	good
Gooseberry	1	0	0	good
Currant	1	0	100	fair
Blackberry	2	0	0	fair
Spiraea	1	100	100	

Results with Check Trees

Apple	8	0	0	good
Peach	6	0	0	good
Pear	4	0	0	good
Plum	4	0	0	good
Cherry	4	75	100	very poor
Poplar	7	0	0	good
Jap. quince	2	0	0	good
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	0	good
Blackberry	2	0	100	good
Spiraea	1	0	100	poor

TABLE LXVIII

Summary of Foregoing Tables				
Treatment	Manner of dipping plant	No. plants treated	Per cent dead	
			5/26/16	4/4/17
L.S. 1-7	top	23	21.3	30.4
L.S. 1-7	t.& r.	23	8.7	13.0
L.S. 1-9	top	23	13.0	39.1
L.S. 1-9	t.& r.	23	17.3	47.8
Check		45	8.8	11.1

By comparing the plants treated with those which were not treated it will be seen that the lime sulphur solution used at both strengths caused considerable injury. There is not a great deal of difference in the strength of the two solutions used and some authorities claim that lime sulphur used at the rate of 1 gallon lime sulphur to 9 gallons of water will give as good results as 1 gallon lime sulphur to 7 gallons of water. At the end of the first two months and also at the end of the first year, a larger percentage of stock treated with the weaker, or 1-9 solution, was dead, which seems to indicate that nursery stock can stand a solution of lime sulphur a little stronger than 1-9 without any additional injury.

Neither did the lime sulphur have any effect upon the roots of the plants which were treated, for, in only one case, the 1-9 solution where both roots and tops were dipped, was the percentage of dead plants greater than when

tops only were dipped. Of these plants treated with the 1-7 solution, the percentage of dead was greater in the set treated tops only. All of the plants treated with both the lime sulphur and miscible oil were dipped instantaneously. If the plants had been allowed to remain in the solution for 5 or 10 minutes or longer there would have probably been a greater difference in the results obtained.

The 1-9 solution gave better results in controlling the scale than the 1-7 solution, so taking everything into consideration it seems that just as good results could be obtained by using a 1-9 solution upon nursery stock for the control of scale, as a 1-7 solution. However, owing to the fact that lime sulphur may not kill all the scale and that considerable injury may result from its use upon young plants it seems advisable according to these experiments, to discourage lime sulphur as a dip.

Miscible Oil First Used.

(13)

In a paper which appeared in Marseilles, France, in 1763, petroleum, turpentine and other oils were recommended for killing plant lice. In this country turpentine mixed with earth and water was used to destroy worms in trees as early as 1835, and in 1865 kerosene was recommended for destroying scale on orange trees and was successfully applied to oleander, sago-palm, acacia and lemon trees. The oil was applied by means of a feather. In June 1866 kerosene was

recommended, in Gardener's Monthly,⁽¹³⁾ for destroying all insect life. Later it was found that kerosene and other oils mixed better with water if a soap was added and the material could be applied with a syringe. It is not definitely known who made the first kerosene emulsion but about 1875 kerosene mixed with soap was first used.

Use up to Present Time.

Since 1875 many different mixtures containing miscible oils have been recommended for the destruction of both chewing and sucking insects, particularly the latter. Petroleum oils and soap form the basis of many patented miscible oil solutions which can be purchased on the market today. The miscible oils kill the insect by contact. The oil has great penetrating ability and probably kills the insect by preventing the assimilation of oxygen in the tissue.

The following are some of the most common and most widely used of the miscible oil insecticides.

Kerosene.....2 gals.

Soap..... $\frac{1}{2}$ lb.

Water.....1 gal.

Dissolve the soap in hot water, remove from fire and while still hot add the kerosene. The mixture is thoroughly agitated for five or ten minutes or until it becomes a creamy mass. Crude oil can be substituted for the kerosene. For a dormant spray one part of the mixture is used to five or seven parts of water.

Distillate Emulsion:

Distillate (28° Baume).....20 gals.

Whale oil soap.....30 lbs.

Water.....12 gals.

Dissolve the whale oil soap in the water, which should be heated to the boiling point, add the distillate and agitate thoroughly while the solution is hot. For dormant use, add 20 gallons of water to each gallon of stock emulsion.

Method of Using.

The miscible oils may be used upon all types of sucking insects and also upon the chewing insects where it is desirable to kill them with a contact spray. The best results are obtained by using a spraying machine when treating trees in the field, either a power or hand pump, and give the trees a thorough spraying. When used for scale insects it must be applied during the dormant season. It may be used as a dormant spray upon nursery stock, but more generally when nursery stock is treated for scale with a miscible oil, a tank is constructed, the tank filled with the oil at the desired strength, and the trees dipped. It is the general belief that the oil is not good for the roots of a plant and the tops only are dipped.

Chemical Composition of Miscible Oil.

The alkali in the soap or other emulsifier reacts upon the oil in such a way as to cause it to break up and become miscible in water. The commercial preparations

are presumably composed of different types of oils treated in different way, and are protected by United States patents.

Results of Experiments with Miscible Oil.

Owing to the fact that miscible oils are used to some extent in controlling San Jose scale upon fruit trees, and that in some states nurserymen are allowed to use it instead of hydrocyanic acid gas upon nursery stock, an effort was made to determine its efficiency for controlling the scale. Some of the nurserymen who use a miscible oil to dip their stock say that it controls the scale just as well, if not better, than hydrocyanic acid gas; that it is not so costly, and that there is less danger of injury to the tree. Also, like lime sulphur, it is non-poisonous.

Procedure.

The larger nurserymen who make a practice of dipping their stock usually construct a large cistern-shaped vat of concrete or use a large tank which they fill with the solution and in which very large trees can be dipped. In this work the same trough was used as with the lime sulphur and in every detail the methods of procedure were the same with the exception of the solution. With the first two sets of trees treated, 1 gallon of oil was used to 15 gallons of water; with the third and fourth sets, 1 gallon of oil to 13 gallons of water was used, as is shown by the following table.

TABLE LXX

Fruit	Insecti- cide	Strength	Condi- tion of tree	Length of treat- ment	No.		No. non-scaley trees 1916
					scaley trees	1917	
Apple	Mis.Oil	1-15	top	inst.	10	*	3
	Mis.Oil	1-15	t.&r.	inst.	10	0	3
	Mis.Oil	1-13	top	inst.	10	5	3
	Mis.Oil	1-13	t.& r.	inst.	10	5	3
	Check				20	4	8
Peach	Mis.Oil	1-15	top	inst.	4	*	3
	Mis.Oil	1-15	t.& r.	inst.	4	0	3
	Mis.Oil	1-13	top	inst.	4	9	3
	Mis.Oil	1-13	t.& r.	inst.	4	9	3
	Check				8	6	6
Pear	Mis.Oil	1-15	top	inst.	0	0	2
	Mis.Oil	1-15	t.& r.	inst.	0	0	2
	Mis.Oil	1-13	top	inst.	0	0	2
	Mis.Oil	1-13	t.& r.	inst.	0	0	2
	Check				0	1	4
Plum	Mis.Oil	1-15	top	inst.	0	0	2
	Mis.Oil	1-15	t.& r.	inst.	0	0	2
	Mis.Oil	1-13	top	inst.	0	0	2
	Mis.Oil	1-13	t.& r.	inst.	0	0	2
	Check				0	0	4
Cherry	Mis.Oil	1-15	top	inst.	0	0	2
	Mis.Oil	1-15	t.& r.	inst.	0	0	2
	Mis.Oil	1-13	top	inst.	0	0	2
	Mis.Oil	1-13	t.& r.	inst.	0	0	2
	Check				0	0	4
Cur- rant	Mis.Oil	1-15	top	inst.	0	0	1
	Mis.Oil	1-15	t.& r.	inst.	0	0	1
	Mis.Oil	1-13	top	inst.	0	0	1
	Mis.Oil	1-13	t.& r.	inst.	0	0	1
	Check				0	0	2
Goose- berry	Mis.Oil	1-15	top	inst.	0	0	1
	Mis.Oil	1-15	t.& r.	inst.	0	0	1
	Mis.Oil	1-13	top	inst.	0	0	1
	Mis.Oil	1-13	t.& r.	inst.	0	0	1
	Check				0	0	4
Black- berry	Mis.Oil	1-15	top	inst.	0	0	2
	Mis.Oil	1-15	t.& r.	inst.	0	0	2
	Mis.Oil	1-13	top	inst.	0	0	2
	Mis.Oil	1-13	t.& r.	inst.	0	0	2
	Check				0	0	2
Poplar	Mis.Oil	1-15	top	inst.	0	0	4
	Mis.Oil	1-15	t.& r.	inst.	0	0	3
	Mis.Oil	1-13	top	inst.	0	0	4
	Mis.Oil	1-13	t.& r.	inst.	0	0	3
	Check				0	0	7

*treated for 5 minutes.

Spiraea	Mis.Oil	1-15	top	inst.	0	0	1
	Mis.Oil	1-15	t.& r.	inst.	0	0	1
	Mis.Oil	1-13	top	inst.	0	0	1
	Mis.Oil	1-13	t.& r.	inst.	0	0	1
	Check				0	0	1
Jap. quince	Mis.Oil	1-15	top	inst.	0	0	1
	Mis.Oil	1-15	t.& r.	inst.	0	0	2
	Mis.Oil	1-13	top	inst.	0	0	1
	Mis.Oil	1-13	t.& r.	inst.	0	0	2
	Check				0	0	2
Golden- bell	Mis.Oil	1-15	top	inst.	0	0	1
	Mis.Oil	1-15	t.& r.	inst.	0	0	1
	Mis.Oil	1-13	top	inst.	0	0	1
	Mis.Oil	1-13	t.& r.	inst.	0	0	1
	Check				0	0	1

Effect of Miscible Oil Upon San Jose Scale on Apple.

The following table shows the results obtained by using miscible oil upon San Jose scale on apple trees, at the strength of 1 gallon to 15 gallons of water, and 1 gallon to 13 gallons of water.

TABLE LXXI

Date	Insecticide	Condi- tion of trees	Length of treat- ment	No. of treat- ed	% scale dead		% trees dead	
					1916 5/14--5/25	1916 5/26	1917 4/4	
Mar.21	Mis.Oil	1-15	top	inst.	10	100	10	50
	Mis.Oil	1-15	t.& r.	inst.	10	100	0	40
	Mis.Oil	1-13	top	inst.	10	100	10	50
	Mis.Oil	1-13	t.& r.	inst.	10	100	20	50
	Check				20	38.9	0	60

Each tree was very carefully examined and no live scale whatever could be found, and the control seemed to be complete.

TABLE LXXII

Effect on Apples Treated in 1917

Date	Insecticide	Condi- tion of trees	Length of treat- ment	No. treated	% scale dead 4/20/17
Apr. 9	Mis.Oil	1-12 top	5 min.	5	100
	Mis.Oil	1-12 t. & r.	5 min.	5	100
	Check			4	75

No live scale could be found when examined.

TABLE LXXIII

Effect Upon San Jose Scale on Peaches 1916

Date	Insecticide	Condi- tion of trees	Length of treat- ment	No. treat- ed	% scale dead 1916 5/14--5/25	% trees dead 1916 5/26	% trees dead 1917 4/4
Mar. 21	Mis.Oil	1-15 top	inst.	4	100	0	0
	Mis.Oil	1-15 t. & r.	inst.	4	100	37.5	37.5
	Mis.Oil	1-12 top	inst.	4	99.3	25	25
	Mis.Oil	1-12 t. & r.	inst.	4	100	12.5	12.5
	Check			8	100	25	62.5

All of the above treatments proved effective with the exception of one, the 1-12, tops only, and the control in this case was 99.3 per cent. However, this is enough to re-infest the tree.

TABLE LXXIV

Effect Upon San Jose Scale on Peaches 1917

Date	Insecticide	Condi- tion of trees	Length of treat- ment	No. treated	% scale dead 4/20/17
Apr. 9	Mis.Oil 1-12	top	5 min.	9	100
	Mis.Oil 1-12	t. & r.	5 min.	9	100
	Check			6	50

No live scale could be found.

Effect of Miscible Oil upon the Plants.

In order to determine the effect of miscible oil on some of the more common nursery plants, the following experiments were performed, the same as with the lime sulphur.

TABLE LXXV

Effect upon Apple

Date	Insecticide	Condi- tion of trees	No. treat- ed	Length of treat- ment	% dead 1916 1917 5/26 4/4	Condi- tion of growth
1916						
Mar. 21	Mis.Oil 1-15	top	3	inst.	0 0	good
	Mis.Oil 1-15	t. & r.	3	inst.	0 66.6	good
	Mis.Oil 1-12	top	3	inst.	0 0	good
	Mis.Oil 1-12	t. & r.	3	inst.	0 0	good
	Check					good

The only dead trees at the end of a year were 66.6 per cent of those treated both top and root with the 1-15 strength.

TABLE LXXVI

Effect upon Peach

Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil	1-15 top	3	inst.	0.	0	good
	Mis.Oil	1-15 t.& r.	3	inst.	33.3	100	poor
	Mis.Oil	1-12 top	3	inst.	0	0	good
	Mis.Oil	1-12 t.& r.	3	inst.	33.3	33.3	med.
	Check		6		0	0	good

Those trees dipped tops only did not suffer; the ones dipped both top and roots suffered heavily, as the table shows.

TABLE LXXVII

Effect upon Pear

Mar.21	Mis.Oil	1-15 top	2	inst.	0	0	fair
	Mis.Oil	1-15 t.& r.	2	inst.	0	0	fair
	Mis.Oil	1-12 top	2	inst.	0	0	good
	Mis.Oil	1-12 t.& r.	2	inst.	0	0	good
	Check		4		0	0	good

None of the pears were injured at all by the miscible oil on either tops or roots.

TABLE LXXVIII

Effect upon Plum

Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil	1-15 top	2	inst.	0	0	good
	Mis.Oil	1-15 t.& r.	2	inst.	0	0	good
	Mis.Oil	1-12 top	2	inst.	0	0	good
	Mis.Oil	1-12 t.& r.	2	inst.	0	0	poor
	Check		4		0	0	good

None of the plum trees were injured.

TABLE LXXIX

Effect upon Cherry

Mar.21	Mis.Oil	1-15 top	2	inst.	50	100	very poor
	Mis.Oil	1-15 t.& r.	2	inst.	50	100	very poor
	Mis.Oil	1-12 top	2	inst.	50	50	good
	Mis.Oil	1-12 t.& r.	2	inst.	100	100	
	Check		4		75	100	very poor

As in all other cases, most of the cherries were dead.

TABLE LXXX

Effect upon Poplar

Mar.21	Mis.Oil	1-15 top	4	inst.	0	25	good
	Mis.Oil	1-15 t.& r.	4	inst.	0	0	good
	Mis.Oil	1-12 top	3	inst.	0	100	good
	Mis.Oil	1-12 t.& r.	3	inst.	0	0	med.
	Check		7		0	0	good

None were dead at the end of the first month.
At the end of a year several of those treated tops only,
were dead.

TABLE LXXXI

Effect upon Japanese Quince							
Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil 1-15 top		1	inst.	0	0	good
	Mis.Oil 1-15 t.& r.		1	inst.	0	0	fair
	Mis.Oil 1-12 top		2	inst.	0	0	good
	Mis.Oil 1-12 t.& r.		2	inst.	50	100	poor
	Check		2		0	0	good

The plants treated 1-12, both top and root, were
dead at the end of a year; the rest were living.

TABLE LXXXII

Effect upon Goldenbell							
Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil 1-15 top		1	inst.	0	0	good
	Mis.Oil 1-15 t.& r.		1	inst.	0	0	fair
	Mis.Oil 1-12 top		1	inst.	0	0	good
	Mis.Oil 1-12 t.& r.		1	inst.	0	0	poor
	Check		1		100	100	

None were injured by the miscible oil. The
check plant died.

TABLE LXXXIII

Effect upon Gooseberry

Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil	1-15 top	1	inst.	0	0	good
	Mis.Oil	1-15 t.& r.	1	inst.	0	0	good
	Mis.Oil	1-12 top	1	inst.	100	100	good
	Mis.Oil	1-12 t.& r.	1	inst.	100	100	
	Check		4				fair

All of the plants treated at the rate of 1-12 were dead at the end of the first month. Those treated with the weaker solution lived.

TABLE LXXXIV

Effect upon Currant

Mar.21	Mis.Oil	1-15 top	1	inst.	100	100	fair
	Mis.Oil	1-15 t.& r.	1	inst.	0	100	med.
	Mis.Oil	1-12 top	1	inst.	100	100	
	Mis.Oil	1-12 t.& r.	1	inst.	0	100	med.
	Check		2		0	0	good

All of the currants treated tops only, died the first month. After a year all were dead.

TABLE LXXXV

Effect upon Blackberry

Date	Insecticide	Condi- tion of trees	No. treated	Length of treat- ment	% dead		Condi- tion of growth
					1916 5/26	1917 4/4	
Mar.21	Mis.Oil	1-15 top	2	inst.	0	100	good
	Mis.Oil	1-15 t.& r.	2	inst.	0	100	good
	Mis.Oil	1-12 top	2	inst.	0	100	good
	Mis.Oil	1-12 t.& r.	2	inst.	50	100	med.
	Check		2		0	100	good

One of the trees treated with the stronger solution was dead at the end of a month. At the end of a year all were dead, checks included.

TABLE LXXXVI

Effect upon Spiraea Vanhouttei

Mar.21	Mis.Oil	1-15 top	1	inst.	0	0	good
	Mis.Oil	1-15 t.& r.	1	inst.	0	0	good
	Mis.Oil	1-12 top	1	inst.	0	0	fair
	Mis.Oil	1-12 t.& r.	1	inst.	0	0	good
	Check		1		0	100	poor

None of the Spiraea plants died except the check.

The following tables show a comparison of the miscible oil used at different strengths, and also show the results obtained by dipping tops only, and both tops and roots.

TABLE LXXXVII

Non-scaley Trees Dipped, Tops & Roots, in Miscible Oil 1-15

Kind of Tree	No. of trees	% trees dead 5/26/16	% trees dead 4/4/17	Condi- tion of growth
Apple	3	0	66.6	good
Peach	3	13.3	100	poor
Pear	2	0	0	med.
Plum	2	0	0	good
Cherry	2	50	100	good
Poplar	4	0	0	good
Japanese quince	1	0	0	good
Goldenbell	1	0	0	good
Gooseberry	1	100	100	
Currant	1	0	100	med.
Blackberry	2	0	100	good
Spiraea	1	0	0	good

TABLE LXXXVIII

Non-scaley Trees Dipped, Tops & Roots, in Miscible Oil 1-12

Apple	3	0	0	med.
Peach	3	33.3	33.3	med.
Pear	2	0	0	good
Plum	2	0	0	good
Cherry	2	100	100	poor
Poplar	3	0	0	med.
Japanese quince	1	50	100	med.
Goldenbell	1	0	0	good
Gooseberry	1	100	100	med.
Current	1	0	100	med.
Blackberry	2	50	100	med.
Spiraea	1	0	0	good

TABLE LXXXIX

Non-scaley Trees Dipped, Tops Only, in Miscible Oil 1-15

Apple	3	0	0	good
Peach	3	0	0	good
Pear	2	0	0	med.
Plum	2	0	0	good
Cherry	2	50	100	very poor
Poplar	4	0	25	good
Japanese quince	1	0	0	good
Goldenbell	1	0	0	good
Gooseberry	1	0	0	good
Currant	1	100	100	med.
Blackberry	2	0	100	good
Spiraea	1	0	0	good

TABLE XC

Non-scaley Trees Dipped, Tops Only, in Miscible Oil 1-12

Apple	3	0	0	good
Peach	3	0	0	good
Pear	2	0	0	good
Plum	2	0	0	good
Cherry	2	50	50	good
Poplar	3	0	100	good
Japanese quince	1	0	0	good
Goldenbell	1	0	0	poor
Gooseberry	1	0	0	good
Currant	1	100	100	
Blackberry	2	0	100	good
Spiraea	1	0	0	med.

Results with Check Trees

Apple	8	0	0	good
Peach	6	0	0	good
Pear	4	0	0	good
Plum	4	0	0	good
Cherry	4	75	100	very poor
Poplar	7	0	0	good
Japanese quince	2	0	0	good
Goldenbell	1	100	100	
Gooseberry	4	0	0	good
Currant	2	0	0	good
Blackberry	2	0	100	good
Spiraea	1	0	100	poor

TABLE XCI

Summary of Foregoing Tables

Treatment	Condition of trees	No. trees treated	Per cent Dead	
			5/26/16	4/4/17
Mis.Oil 1-15	tops	23	8.6	26.0
Mis.Oil 1-15	tops & roots	23	13.0	47.8
Mis.Oil 1-12	tops	23	8.6	30.4
Mis.Oil 1-12	tops & roots	23	26.0	39.1
Check		45	8.8	11.1

The foregoing tables show that miscible oil does not injure nursery stock to any great extent; however, as compared with the check, some injury results from its use. The summary table shows that the plants probably require some time before the injury shows up to any great extent. At the end of the first two months, the per cent of dead plants was not so great where the tops only were treated, as in the case of the checks. At the end of a year, however, there was about three times as many of the plants which were treated tops only, dead, as in the case of the check. Those plants which were dipped both tops and roots showed a very much higher percentage of death than those dipped tops only. So it seems very evident that it is not advisable to dip the roots of plants in miscible oil. In the case of the fruit trees the injury was very slight, but the more tender shrubs and ornamentals were severely injured.

In comparing the two strengths of miscible oil used, the 1 gallon to 12 gallons of water, caused a much greater percentage of injury than the weaker strength of 1 gallon of the oil to 15 gallons of water.

As to the control of San Jose scale, the miscible oil gave excellent results. Both strengths controlled the scale upon the apple. Upon the peach the results were as good with the exception of those trees treated, tops only, with the 1-12 strength and in this case 99.3

per cent of the scale was killed.

Taken as a whole, the miscible oil injured the plants less and controlled the San Jose scale better than any of the other materials used.

SUMMARY

First. Hydrocyanic acid gas did not completely control the San Jose scale. However, the gas used at a strength of 1-1-3 gave better results than the weaker strength of $\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$.

Second. Hydrocyanic acid gas was more effective when used upon dry plants than upon wet. A larger percentage of the scale was killed.

Third. Both strengths of the hydrocyanic acid gas caused more or less injury to the plants. The 1-1-3 strength caused a little more injury than the $\frac{1}{2}$ - $\frac{1}{2}$ -1 $\frac{1}{2}$.

Fourth. The plants treated dry showed the most severe injury.

Fifth. The 1-1-3 formula should always be used in fumigating nursery stock, and the stock should be dry. There may be greater danger of injury to the plants, but the scale will be more completely controlled, and this is the most important factor.

Sixth. Carbon bisulphide did not control the scale and it caused a very high percentage of injury. Its use as a fumigating material for the control of San Jose scale on nursery stock should be discouraged.

Seventh. Lime sulphur used at 1-9 and 1-7 strengths gave fairly good results in controlling the scale.

The 1-9 solution gave perfect results on apples, peaches and plums.

Eighth. The lime sulphur dips injured the plants to some extent. The plants dipped both tops and roots showed no more injury than those dipped tops only.

Ninth. The miscible oil gave the best results, 100 per cent of the scale being controlled in every case but one, and in this case the control exceeded 99 per cent.

Tenth. Miscible oil caused some injury to the plants. Those dipped tops and roots were injured most. When treating nursery stock with miscible oil the roots should not be dipped.

Eleventh. Neither of the materials used completely controlled the San Jose scale.

Twelfth. All scale infested nursery stock should be burned or destroyed in some other way.

Thirteenth. Nursery stock which has been subjected to infestation, but is not infested should be treated before being placed on the market.

Fourteenth. The best results should be expected by treating the stock with hydrocyanic acid gas 1-1-3, or with miscible oil at the strength of 1-12 or 1-15, tops only.

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Color	Grayscale and color
File types	pdf
Notes	Grayscale pages cropped, canvassed, and images brightened. Color pages cropped. Blank pages removed.