THE RURAL SCIENCE SERIES
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THE SPRAYING OF PLANTS

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(*See page 26.*)

THE

SPRAYING OF PLANTS

A SUCCINCT ACCOUNT OF THE HISTORY, PRINCIPLES AND PRACTICE OF THE APPLICATION OF LIQUIDS AND POWDERS TO PLANTS FOR THE PURPOSE OF DESTROYING INSECTS AND FUNGI

BY

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PREFACE.

In looking back over the past ten or twelve years, it is difficult to realize the rapid advance made in combating the insects and fungi which attack our cultivated plants. It is not going too far to say that the discoveries made within this period have worked almost a revolution in certain lines of agriculture. So phenomenal has been the progress in this direction that we are sometimes led to think that we have gone forward too fast, for in our intense desire to make the work thoroughly practical we have in many cases merely skimmed the surface, overlooking some of the most important fundamental questions involved. However this may be, the fact remains that America to-day stands well to the front in the discovery and application of practical methods of dealing with the numerous insect and fungous enemies of cultivated plants. The advance in this department has been so rapid that it has hardly been possible for investigators to keep track of all that has been written on the subject, nor has it, under the circumstances, been an easy matter to pause and consider what is to be the final outcome of work of this kind. This seems to be a fitting time, therefore, to take a broad survey of the subject in order that we may see where we stand. Mr. Lodeman has done this in the present volume, in which is given a clear, concise statement of the existing condition of our knowledge on the spraying of plants and the fundamental principles underlying this operation.

As to the future, it can only be said that the prospect for broadening the work so well begun is exceedingly promising. As yet it cannot be stated that we have a well-defined science of plant pathology, but gradually the investigations and thought in this direction are being crystallized. It is now realized that to truly understand and appreciate pathological phenomena we must be familiar with physiology, the normal life processes of plants. After all, the highest aim of the investigator in this field of research is not to deal only with effects as he finds them, but to study causes, as it is only by this means that the true nature of many of the phenomena involved can be obtained. Following this line, we shall in the future look for a science capable of elucidating the problems which form the very basis of agricultural and horticultural pursuits.

B. T. GALLOWAY.

WASHINGTON, D.C.

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PART II.

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THE SPRAYING OF PLANTS.

Part I.

THE HISTORY AND PRINCIPLES OF SPRAYING.

CHAPTER I.

EARLY HISTORY OF LIQUID APPLICATIONS.

Man's power over the organisms which injure cultivated plants was never so great as it is at the present time. One by one these enemies have been carefully studied, the history of their lives determined, and their habits observed. Only by understanding them thoroughly can proper steps be taken to check their ravages in the most economical and efficient manner; yet it is within comparatively recent years that this first step was taken to obtain the mastery over them. Formerly, when a pest injured a plant, it was no uncommon practice to apply any remedies or materials that came to hand, regardless of their probable efficiency. It was not generally the weakest point of the organism that was assailed. In many cases it was not even the proper organism which was held responsible for the injury. Nevertheless many valuable discoveries came from these varied and desultory treatments, and some of the remedies most highly prized to-day were discovered merely by chance, not very many years ago.

Present knowledge and methods of investigation, largely founded upon this experience, enable us to arrive at conclusions which, from the outset, are founded upon a sound and logical basis. It is fortunate that this is the case. The number of the enemies of cultivated plants is either now more numerous than formerly, or the attacks are much more energetic. It is undoubtedly true that the maladies of cultivated plants are much more widespread. This fact is mostly due to the greater food supply, and to the greater ease with which most of the injurious forms can pass from one part of the country to another, because the cultivated areas lie so close together. If a plant is grown to any considerable extent, it is easy for its enemies to spread over the entire region in which it is cultivated. Physical barriers are almost without value in checking this spreading of disease. The ocean is only a partial exception, since such close means of communication have been established between all parts of the globe that this obstacle is now of little avail. Some diseases have not yet been able to overpass it, but as it has proved of little hindrance in so many cases, it is probable that ultimately the enemies and diseases of plants will be as widespread as are the plants upon which they flourish. Weedy plants, insects, and possibly also fungi, are frequently more destructive in a new country than in their old home. They are freed from the enemies or conditions which formerly kept them in check, and in some cases they are the cause of very serious disturbance, although originally they may not have been markedly destructive.

Farmers and fruit growers cannot fence out the many forms of insects and fungi which live upon their crops and which are as anxious for a harvest as the grower is. It is a fight between the grower and the pest, and it must be admitted that the latter has generally had the best of the battle. The farmer has not been properly equipped. He has often had invisible foes to contend with, — foes which he did not understand, and which he could not assail. It frequently occurred that an entire crop was ruined in a day or two, and the cause remained unseen and unknown; and even if it was visible, almost the only remedy upon which the grower could rely with certainty was mere force, first catching the pest and then destroying it. As this could be done with profit only in rare cases, it was little better than no remedy, and the general result was that the insect or the fungus obtained an ample supply of nourishment, and the grower took what was left. Indeed, this method is still followed by many cultivators, but it is not the safest, nor is it the most profitable one.

The best is generally the most profitable commodity, and the poorest is the least so; and the grower of to-day has it in his power to produce the best. It rests entirely with him whether his apples shall be wormy or not, whether his trees shall retain their foliage or lose it from disease. There are few evils that affect his crops which he cannot control, in many cases almost absolutely. Only a few diseases remain which still refuse to submit to treatment, but the number is rapidly decreasing, and the time will come when these also will disclose some vulnerable point which will allow of their destruction.

Foremost among the operations by means of which cultivated plants are protected from their enemies, is spraying. This consists in throwing upon plants any fluids, or semi-fluids, in the form of a fine rain or mist. It rests upon the general principle of covering the plants, or the parts of plants to be protected, with a thin but uniform layer of some material that is poisonous, caustic, or offensive to the organism which it is desired to destroy. The word "spraying," as understood in this connection, has not been in general use more than ten or fifteen years, for the operation previous to this time was practiced only to a very limited extent. It was then referred to as "syringing," from the fact that hand syringes were generally used as a means of making the applications. This term is still in common use among florists and gardeners, whose daily duty it is to throw water upon their plants either for the purpose of promoting growth, or in order to keep them free from foreign matter, such as insects or dust. It is essentially a term which, in this country, is used in connection with plants grown wholly or partially in a greenhouse or in some similar structure. Spraying, on the other hand, is a term now used by farmers and fruit-growers to designate a similar operation, but the plants treated are grown entirely out of doors, and pure water is rarely used. The operation of both syringing and spraying is, however, the same; namely, the throwing of liquids, more or less finely divided, upon plants or other objects.

It is impossible to tell when plants were first syringed. It is very probable that the value of the operation was understood as soon as the cultivation of plants began to attract serious attention. The immediate causes which led to the practice were undoubtedly the same as those now existing. Foliage almost invariably looks brighter and fresher when wet, and one instinctively feels that if the appearance of a plant is improved by a certain operation, the general health of the plant is improved to an equal degree. The removal of insects or any injurious substances would have a similar effect, and all good gardeners would feel a temptation to improve their plants in this simple way.

Insects and diseases have unquestionably troubled cultivators from the time plants were first grown. Remedies would naturally be sought, and it appears that these older gardeners were controlled by the same feeling which even to-day often manifests itself in connection with the taking of medicine: the worse the drug smells or tastes, the more good it is supposed to do. Early in the seventeenth century Parkinson advised the use of vinegar to prevent canker on trees, and the recommendation was supposed to rest upon a very firm foundation.[1] One old record [2] giving instructions for making liquid applications of an insecticide reads as follows: "Cantharides (*Cantarides*) are flies which attach themselves to the branches near the upper parts of trees, especially on the ash. They may be destroyed by pouring or throwing on the tops of the trees, by means of a small pump, water in which has been boiled some rue." *Ruta graveolens* is probably meant. This herb has a strong, heavy, and very disagreeable odor, and a sharp, bitter taste. If such qualities make a plant a good insecticide, rue should be one of our most valuable remedies. It seems very probable that the idea of selecting materials which are offensive to the senses was uppermost in the minds of those who first had occasion to use them, for most of the earlier substances recommended are of

[1] John Parkinson, "Paradisus," The Ordering of the Orchard, Chap. viii. 550. 1629: "The canker is a shrewd disease when it happeneth to a tree; for it will eate the barke round, and so kill the very heart in a little space. It must be looked into in time before it hath runne too farre; most men doe wholly cut away as much as is fretted with the canker, and then dresse it, or wet it with vinegar or cowes pisse, or cowes dung and urine, &c. untill it be destroyed, and after healed againe with your salve before appointed."

[2] "La Théorie du Jardinage," 166, 1711. See also Deane, "The Newengland Farmer," 177–184.

this character. A great variety of materials must have been tested again and again by various persons independently of each other. Those materials which possessed real or imaginary remedial values, or which from their very nature appeared to possess them, remained in use until something that promised better could be found. Thus it came that at the close of the eighteenth century, and early in the nineteenth, the number of things recommended against various diseases was large, and some of the compounds possessed considerable insecticidal value. The following examples may here be cited:

"In the year 1763, there appeared in the papers of Marseilles a remedy for plant-lice. The applications should be made by means of a small tin syringe having a nose pierced by about one thousand holes. The instrument is filled with water in which lime has been slaked, previously mixing with the clear liquid some bad tobacco, finely powdered; this should be used at the rate of a handful to two liters of the liquid. The trees are syringed with the mixture, and although the foliage remains uninjured the pests are destroyed. But after four or five days the trees should be again syringed, using clear water."[1]

"But many of the plant-lice may be destroyed by passing the leaves upon which they are found between two sponges wet with tobacco water. Ground tobacco powder spread upon the insects will kill them instantly. One may also use with it the water of slaked lime or of strong soap, soot, sage, hyssop, wormwood, and other bitter or strong-smelling herbs. Soot, lime, and soap have the disadvantage of staining the leaves, fruits, and the plants to which they are applied. Tobacco and wormwood leave small particles upon the portions treated. Other materials are often without value. Tansy, hellebore, rue, leek, bitter gourd, and long pepper have the disadvantages mentioned above. Petroleum, turpentine, and other oils are also recommended; but care must be taken in their use, since they also act upon the plants, making them sick or even killing them."[2]

"First wet the trees infested with lice, then rub flowers of sulphur upon the insects and it will cause them all to burst."[3]

[1] J. A. E. Goeze, "Geschichte einiger schädlichen Insecten." Leipzig, 1787, 166.

[2] *Ibid.* 164. [3] *Ibid.* 168.

Forsyth in 1791,[1] gave directions for the preparation of a compound which became generally known as "Forsyth's Composition." The ingredients were apparently standard remedies at this time, and they persisted long after his composition went out of use. It was made as follows:

"Take one bushel fresh cow dung, one-half bushel lime rubbish from old buildings, one-half bushel wood ashes, one-sixteenth bushel pit or river sand. The last three are to be sifted fine before they are mixed. Then work them well together with a spade, and afterward with a wooden beater until the stuff is very smooth, like fine plaster used for the ceilings of rooms."

Soap-suds or urine was used to make the composition of the consistency of plaster or paint.

After being applied it was covered with a sifting of powder made of "dry powder of wood ashes, mixed with the sixth part of the same quantity of the ashes of burnt bones."

This composition was recommended to cure disease, defects, and injuries of plants. It was held to be particularly valuable in promoting the healing of wounds, and was commonly used to fill cavities in trees.

Early in the history of the treatment of plant diseases, paints and washes were in general use. They were applied by means of brushes, or the plants were actually washed with a rag or sponge, so that they were very thoroughly cleaned. This practice is by no means out of date, for it is still one of the regular duties in good greenhouse management to wash many of the plants in order to keep the foliage clean and healthy. Soap or some similar substance is still generally added to the water, as was formerly done. This alkali could always be readily obtained, and as it possesses decided merit as a destroyer of certain insects, it was at a very early day regarded as a valuable remedy.

We have another interesting note in the following extract in which the destruction of the canker-worm is desired:[2]

"There are several experiments I could wish to have tried, for subduing these insects: Such as burning brimstone under the trees in a calm time; — or piling dry ashes, or dry, loose

[1] Oath regarding the correctness of the directions was made at the Land Revenue Office, in Scotland Yard, the eleventh day of May, 1791.

[2] Samuel Deane, D.D. (vice-president of Bowdoin College), "The Newengland Farmer, or Georgical Dictionary," second edition, 1797.

sand round the roots of trees in the spring; — or throwing powdered quicklime, or soot, over the trees when they are wet; — or sprinkling them, about the beginning of June, with sea water, or water in which wormwood, or walnut leaves, have been boiled; — or with an infusion of elder, from which I should entertain some hope of success. The liquid may be safely applied to all the parts of a tree by a large wooden syringe, or squirt.

"I should suppose that the best time for making trial of these methods would be soon after the worms are hatched: for at that stage of their existence they are tender, and the more easily killed. Sometimes a frost happening at this season has destroyed them. This I am told was the case in some places in the year 1794."

Forsyth[1] recommended the following mixture for the destruction of aphis:

Unslaked lime	½ peck.
Water	32 gallons.

Allow this to stand three or four days, stirring two or three times per day. It was applied by means of a syringe. He recommended[2] the same mixture for the destruction of acarus, or red spider, but said that pure water would also answer the purpose. For plants in hothouses the use of pure water alone was advised. Against insects on melons, however, he said[3] that the plants should first be washed with water, and then again washed with a mixture of urine and soap-suds, using a rag. It is also stated[4] that several English nurserymen used train- [whale-] oil against coccus, or scale insects on plants. It was applied with a brush, but the author claims that it was not an efficient remedy. Nevertheless it was extensively used in some parts of England.

During the early years of this century a great many substances were recommended both in this country and in Europe for the destruction of the enemies of cultivated plants. Mention[5] is made of the following articles which were to

[1] William Forsyth, "A Treatise on Culture and Management of Fruit Trees," American edition edited by William Cobbett, 1802, 173.

[2] *Ibid.* 174. [3] *Ibid.* 176. [4] *Ibid.* 179.

[5] J. Thacher, M.D., "American Orchardist," 1822, 104.

be used against the apple-tree borer, an insect that is designated as a "pernicious reptile" by the author. After digging out the borer, fill the cavity about the base of the tree with "flax rubbish, sea-weed, ashes, lime, sea-shells, sea-sand, mortar rubbish, clay, tanner's bark, leather scraps, etc." I can find no record of careful experiments having been made with these articles, and it is not improbable that some of them were recommended without actual trial, as is sometimes done even to this day, simply on the ground that the remedy "ought" to be of value. It is also stated,[1] quoting from the "Massachusetts Agricultural Reports," that Josiah Knapp, of Boston, in 1814, used air-slaked lime with success against the canker-worm. He applied it thickly about the base of the tree. Later experiments have shown that this is of little benefit in checking the ravages of the insect. The use of air-slaked lime is said[2] to have been successful in the destruction of slugs found on the foliage of fruit trees, and this is still one of the best remedies we possess. Tar water also proved to have the power of instantly killing the slugs with which it came in contact. It was prepared by pouring water on tar and allowing it to stand for two or three days. This gave a strong infusion and was said to be very effective.

Several remedies against caterpillars are also mentioned.[3] "It is asserted" that spirits of turpentine, or common fish-oil, has the power of penetrating through the web made by these insects and they are killed when the liquid comes in contact with their bodies. Mr. Yates, of Albany, N.Y., made a mixture which well illustrates the variety of materials used during this period:

Wormwood	1 handful.
Rue	1 "
Virginia tobacco	2 handfuls.
Water	2 pailfuls.

Boil the herbs in the water for half an hour, strain the liquid, and it is then ready to be applied. Yates also said that if sufficient tobacco is used alone, it will answer the same purpose as the above, but not so well.

[1] J. Thacher, M.D., "American Orchardist," 1822, 92.
[2] *Ibid.* 107. [3] *Ibid.* 96.

Reference is also made[1] to some experiments of E. Perley to combat scale insects on trees. He found, after trying many substances, that the most effectual way of removing scale insects from trees was to wash them with lye, or brine. Lime could be used with the lye to advantage. The brine was made by using

Common salt	1 quart.
Water	2 gallons.

This could be applied as soon as the salt was entirely dissolved.

Thacher[2] regarded train-oil as a very powerful insecticide against lice, but discouraged its use on account of its glutinous character, it being on this account harmful to trees.

Clay paint was perhaps one of the first remedies to be applied to plants. Several factors would encourage its use ; among others may be mentioned the ease of its preparation, its cheapness, and its adhesive properties. When properly used it forms a thin, dense coating over the parts to which it is applied, and it has the appearance of granting almost perfect protection to the part covered. The Caledonian Horticultural Society, of Scotland, recommended[3] its use, and, in fact, its application has been very generally advised. It has also formed the basis of many mixtures and only with the appearance of the remedies now in common use has it fallen from favor. Only the purest clay obtainable was selected, and it was generally strained so that the coarser particles might be removed.

A solution which appears to have been in common use for the destruction of bed-bugs was also said[4] to be valuable as a remedy for canker. "Canker" is an indefinite term which was employed to denote almost any disease of the stems or trunks of plants, whose origin was not understood; the injury may have been caused by insects or by fungi, or any of several other causes. Whenever death and decay overtook any part of the stem, it was generally termed canker. The solution which would cure or check the disease was made by taking

Corrosive sublimate	1 drachm.
Spirits (alcohol)	1 gill.
Soft water	4 quarts.

[1] J. Thacher, M.D., "American Orchardist," 1822, 109.
[2] *Ibid.* 108. [3] *Ibid.* second edition, 1825, 79.
[4] "The Practical American Gardener," Baltimore, 1822, 170.

The corrosive sublimate was first dissolved in the spirits, and then this solution was added to the water. It was said to kill the eggs as well as the insects with which it came in contact; and although long in use it still stands as one of the most valuable agents for the destruction of some insects which are not closely connected with horticultural products. It also possesses[1] the power of destroying the "brown turtle [scale] insect, white scaly coccus, pine bug [mealy-bug?], and red spider." A decoction of tobacco was pronounced to be excellent for the removal of aphis, thrips, and wood-lice.

Although fungous diseases are rarely mentioned in these early writings, their suppression was nevertheless attempted. John Robertson, in a paper read Nov. 20, 1821, before the London Horticultural Society,[2] said sulphur was the only specific remedy that could be named for the treatment of mildew on peaches. It should be mixed with soap-suds and then be applied by dashing it violently against the trees by means of a rose syringe. It was necessary to sprinkle all parts of the tree with the mixture to be certain of success. Sulphur is to-day one of our standard remedies against such mildews, and it seems that no other substance will soon supersede it.

William Cobbett mentions[3] some instructions for the treatment of the cotton blight (woolly aphis) which, if well carried out, would certainly dislodge the pest. He directs that where these insects are found, to wash "the place well with something strong, such as tobacco juice. The potato, which some people look upon as so nutritious, very nearly poisons the water in which it is boiled; and an Irish gentleman once told me that that water would cure the cotton blight. Rubbing the part with mercurial ointment will certainly do it."

The idea that "something strong" was necessary to dislodge the enemy was still, apparently, the leading thought, and nearly everything that could be said to possess this desired quality was probably given a chance to prove its merits at one time or another. Thomas Fessenden gives[4] an interesting list of a few of the materials which were supposed to possess the

[1] "The Practical American Gardener," Baltimore, 1822, 397.
[2] *Trans. London Hort. Soc.*, Vols. i.–v. 1824, 178.
[3] Cobbett, "The English Gardener," 1829, first English edition, 289.
[4] Fessenden, "New American Gardener," sixth edition, 1832, 169.

strength necessary to overcome the organism against which they were applied. He writes as follows:

"Insects may be annoyed, and oftentimes their complete destruction effected, by sprinkling over them, by means of a syringe, watering-pot, or garden engine, simple water, soap-suds, tobacco water, decoctions of elder, — especially the dwarf kind, — of walnut leaves, bitter and acrid herbs, pepper, lye of wood ashes, or solutions of pot and pearl ashes, water impregnated with salt, tar, turpentine, etc.; or they may be dusted with sulphur, quicklime, and other acrid substances." Another article, one mentioned by Lindley,[1] is vinegar, and he says that it is of considerable value for destroying insects.

With such a battery of powerful materials directed against them, it is a wonder that so many insects we now have to contend with should still exist. The very number of the materials named is an indication of weakness; for if any of them had really possessed very decided merit, there would have been no necessity for the existence of the rest. Some of them are really valuable, and are in use at the present time, yet it is true that we are still on the lookout for something which is superior to the remedies now at hand.

The value of hot water as an insecticide has long been known. Fessenden quotes[2] Loudon as saying: "Saline substances mixed with water are injurious to most insects with tender skins, as worms and slugs; and hot water, when it can be applied without injuring vegetation, is equally, if not more powerfully, injurious. Water heated to 120 or 130 degrees will not injure plants whose leaves are expanded and in some degree hardened; and water at 200 degrees or upwards may be poured over leafless plants." In a later work,[3] Loudon says: "Mr. Swainson advises for the destruction of the aphis 'the application of warm water, sufficiently hot to destroy aphis without injuring the trees: more will be thus destroyed than either by repeated application of the syringe or by the use of tobacco water. . . . Two or three applications of warm water will destroy nearly all the insects.'" The remedy was also frequently mentioned in horticultural journals.

[1] Lindley, "Guide to the Orchard and Kitchen Garden," 1831, 509.
[2] Fessenden, "New American Gardener," sixth edition, 1832, 169.
[3] "Loudon's Encyclopædia of Gardening," 1878, 795.

Dr. William Kenrick[1] speaks of aloes and cayenne pepper, among other materials, as being effective in the treatment of aphis, but their use never became very general. He also gives[2] a formula for the destruction of a white, mealy insect:

Quicklime	½ peck.
Flowers of sulphur	½ pound.
Lampblack	¼ "

Mix all in as much boiling water as will make a thick paste, and apply warm. The lime and the sulphur are probably the most active portions of the mixture. Although lampblack is here mixed with them, these two substances, when used together in water, already formed one of the most important and valuable remedies in use against the various mildews which attack plants. The same writer gives[3] the following formula, in which sulphur and quicklime are recommended for checking mildew on grapes:

Sulphur	½ pint.
Quicklime	piece size of the fist.
Water (boiling)	2 gallons.

When cool, dilute with cold water, and allow the solid material to settle. Then draw off the clear liquid, and pour it into a barrel. The barrel is then filled with water, and the mixture is ready for use. A modification of this formula eventually came to be a standard preparation for the treatment of mildews; but during this period the substances were used in varying proportions, and generally other ingredients were mixed with them.

John Mearns made a composition, which was suggested to him by Thomas Andrew Knight, at that time president of the London Horticultural Society.[4] In a paper read in 1835, he gave directions for making this preparation:

Strongest farmyard drainage	1 gallon.
Soft soap	1 pound.
Flowers of brimstone	"

[1] William Kenrick, "The New American Orchardist," 1833. Introduction, xxxiii.

[2] *Ibid.* xxxvi.

[3] *Ibid.* 328.

[4] *Trans. London Hort. Soc.* second series, 1842, Vol. ii. 39.

These ingredients were well mixed together and were stirred three or four times a day. This was done for several days, and then some finely sifted quicklime was added, until the whole assumed the consistency of paint. Mearns said the farmyard drainage might be replaced by tobacco juice, and the lime by soot. This mixture was recommended for the destruction of insects.

The use of pungent and acrid herbs long continued to be recommended for the same purpose. T. Bridgeman, among other remedies, speaks [1] of burdock leaves as being effective in preventing injury from the attacks of the "turnip and cabbage fly." He recommends preparing hogsheads full of the infusions of this and other herbs, and then sprinkling the plants with the liquor. For the annoyance or destruction of insects on fruit trees he advises the use of decoctions made of walnut leaves, as well as those of tobacco and elder; the use of pepper, soot, sulphur, and similar substances are also mentioned as having value, their action being perhaps more particularly the annoyance of the pest than its destruction.

White hellebore was also commonly recommended as early as 1842, although it did not prove of value in the hands of all growers. It was used particularly to destroy worms on gooseberry plants, and was applied in the form of a powder or in pure water, or when mixed with soap-suds.[2] It does not appear to have been used to any considerable extent in America until after the introduction of this gooseberry saw-fly, or as it is here known, the imported currant worm, which occurred sometime before 1858, at which time its presence was first noticed. Joseph Harris is said to have been the first to recommend the use of hellebore in America,[3] after he had been using it successfully for four years. P. Barry used it mixed with water, and applied the liquid to his plants by means of a syringe, one-half pound being used in a pail of water.

A rather unusual solution was used by J. Murray [4] against mildew on peach trees. He applied

Sulphur	2 pounds.
Alcohol	1 quart.

[1] Bridgeman, "The Young Gardener's Assistant," seventh edition, 1837, 11.
[2] *Gardeners' Chronicle*, 1842, June 18, 397.
[3] *Country Gentleman*, 1865, June 29, 413.
[4] *Gardeners' Chronicle*, 1841, Aug. 21, 550

The trees were thoroughly painted with this when the buds were swelling. He asserts that he used the mixture for twenty years, so it must have been very effective in his hands. Nitre was also applied for mildew on roses.[1] It was prepared by using

Nitre	1 ounce.
Water	1 gallon.

In December, 1844, its use on chrysanthemums for mildew was also mentioned.

On June 13, 1840, the Massachusetts Horticultural Society offered a premium for the most cheap and effective mode of destroying the rose-bug. David Haggerston, of Watertown, Mass., was awarded a premium of $120 on March 5, 1842, after his remedy had been thoroughly tested by a committee. The material which he employed was whale-oil soap, used at the rate of

Whale-oil soap	2 pounds.
Water	15 gallons.

He said the strength of the soap varied and this would require a change in the above formula in certain cases. He contended that this is an effectual remedy for other troublesome insects; as the thrips or vine fretter, the aphis or plant-louse, the black fly that infests the young shoots of the cherry, the red spider, and other insects. He also asserted that it would destroy mildew on peaches, grapes, and gooseberries, if weak solutions were used. Whale-oil soap is to-day so well known and so generally used against insect enemies that it is scarcely necessary to say that many of the statements of Haggerston are just.[2]

Loudon has recorded [3] several interesting recipes that show how complex were many of the mixtures recommended. Some of them contained so many ingredients that it would seem as if any evil that plants are heir to would be reached by at least one of them. Nicol's recipe was thought to be particularly

[1] *Gardeners' Chronicle*, 1844, Jan. 27, 53.

[2] "Hist. of the Mass. Hort. Soc.," 1829–1878, 256. *Country Gentleman*, 1842, 134.

[3] "Loudon's Encyclopædia of Gardening," 1878, 785.

valuable for the destruction of coccus, or scale insects; it was made as follows:

Soft soap	1 pound.
Flowers of sulphur	1 "
Tobacco	½ "
Nux vomica	1 ounce.
Soft water	4 gallons.

These materials were well mixed with the water and then boiled until the amount of liquor was reduced to three gallons. It was then allowed to cool, and was ready for use. Plants which were not in active growth, and whose foliage was not too tender, were dipped into the mixture. For overhead syringing, the liquid was diluted one-third with water.

Hamilton's recipe is also given:[1]

Sulphur	8 ounces.
Scotch snuff	8 "
Hellebore powder	6 "
Nux vomica	6 "
Soft soap	6 "
Cayenne pepper	1 ounce.
Tobacco liquor	1 quart.
Water (boiling)	1 gallon.

Stir and render as fine as possible, and then strain through a rough cloth. Hamilton did not appear to feel very confident of the action of even this array of death-dealing matter, so he advised in addition that the plants be washed with it, and the insects removed while washing. When so used it would doubtless act as a specific. The recipe is also interesting from the fact that it contains hellebore as one of the ingredients; for at that time the use of this poison was probably somewhat limited. The insecticidal value of decoctions made of the wood of quassia was also known to a limited extent; but the material has been more widely recommended than used.

Hémery, a French nurseryman, made a compound[2] which he said would destroy mildew on peaches if only one application were made. It contained some materials which unquestionably

[1] "Loudon's Encyclopædia of Gardening," 1878, 785, quoted from Speechly, "Treatise on the Pine," 1779, 60.

[2] *Revue Horticole*, 1849, Sept. 15, 360.

possessed "strength," but whether best adapted for the purpose designed may be open to doubt:

(*a*)	Aconite branches and tubercles	1 kilogram.
	Water	4 liters.
(*b*)	Pigeon dung	25 "
	Urine	1 hectoliter.

Mixture (*b*) was allowed to ferment forty-eight hours, and infusion (*a*) was added only just before the mixture was used. The applications should be made in April.

The most important and probably the most effective form in which sulphur was used was the solution known as the "Grison liquid" (*eau Grison*). It was also called the poly- or the hydro-sulphur of Grison; it is still in use, although not so commonly as heretofore. Grison was head gardener of the vegetable houses (*serres du potager*) at Versailles, France, and in 1851 he first made the solution. He used [1]

Flowers of sulphur	500 grams.
Freshly slaked lime	500 "
Water	3 liters.

Boil the above for ten minutes, allow the mixture to settle, and then draw off the clear liquid. Keep this in bottles and before using add one hundred parts of water to one part of the liquid. Apply with a syringe. This solution is excellent for all surface mildews, and three applications are sufficient to protect foliage. Later the quantity of sulphur and of lime was reduced one-half and it is one of the few early fungicidal preparations still in use. An Englishman claims [2] to have used a similar preparation as early as 1845, using one part of sulphur, one part of lime, and one hundred parts of water. Grison, however, appears to have been entirely independent in the manufacture of his preparation, and it soon became much better known than the other.

Lime wash was recommended in America against curculio of plums in 1850. Lawrence Young, of Louisville, Ky., seems to have been one of the first to try this remedy, and it was apparently successful.[3] "It consists simply of covering the young

[1] *Revue Horticole*, 1852, May 1, 168.
[2] Tuck, *Gard. Chron.* 1852, July 27, 419. [3] *Country Gentleman*, 1850, 333.

fruit, as soon as danger is apprehended, with a coating of thin lime wash, considerably more dilute than the mixture employed in white-washing."

The use of quassia chips was adopted in America soon after hellebore became known. In 1855 the material was recommended as a remedy for aphis, being prepared by boiling

Quassia chips	1 pound.
Water	8 gallons.

The liquid was boiled until the decoction had been reduced to six gallons.[1]

An interesting article by W. F. Radclyffe appeared in one of the English journals[2] in 1861. The writer, knowing the value of copper sulphate when used upon smutty seed-wheat, reasoned that the rose mildew, being also a fungous trouble, should likewise yield to treatment by this chemical. He therefore applied a solution of two ounces of blue vitriol dissolved in a "stable bucket" of water to live plants by means of a fine spout, and entirely freed his plants from the disease. The statement was also made that weaker solutions would be tried the following year. A few weeks later a note appeared in the same journal which warned growers against the use of the sulphate of copper, as it would kill roses if it came in contact with their roots. No further mention of the remedy was made, and even the following year brought no account of any experiments made by Radclyffe. What millions might have been saved had this important work been carried only a little further! But the old remedies continued to be used until about 1870; insects and fungi were treated practically the same in Europe and in America, and changes of only minor importance were made.

The Americans profited very largely from the experience of European gardeners, but a few new methods of treatment also arose in this country. It could not be otherwise, for different enemies had to be dealt with, and these required different treatments. But these variations were comparatively slight, and the remedies used in the first half of the century were more or less common as late as 1880. Sulphur in some form was every-

[1] *Michigan Farmer.* Cited in *Country Gentleman*, 1855, April 12, 235.
[2] *Gard. Chron.* 1861, Nov. 2, 967.

where the standard remedy for mildews, and when this failed, growers were at a loss to apply anything more efficient. The best insecticides were the various forms of soap, tobacco, quassia chips, carbolic acid, and hellebore, although the last was a comparatively new remedy. Kerosene was also used in America to a limited extent. With these materials gardeners and fruit growers managed, as a rule, to produce good crops.

But a change was to come. In America it was brought about by insects; these became so abundant and began to do so much damage in districts that before had not suffered seriously, that new remedial measures were demanded. A new insect, the potato beetle, was introduced from the far West, and this threatened to be even more destructive than those which were indigenous to the East.

In Europe the revolution was brought about by fungi, but not by the European types. They came from America, and have shown, in southern Europe particularly, the same push and energy which is everywhere recognized as characteristic of the American. And so it came that while the growers in France were combatting fungi, those in America were contending against insects, and a great difference soon arose in the methods of treatment adopted. It was a veritable revolution; for old remedies were obliged to give way to new ones, and established methods to those but little tried. Indeed, the change marks an epoch in the history of the cultivation of plants.

CHAPTER II.

SPRAYING IN FOREIGN COUNTRIES.

I. In France.

Discursive Trials of Fungicides.

No important changes took place in the materials used by the French for the destruction of fungi and insects until about the year 1882. The use of chemicals in place of the substances which appeal strongly to the senses had increased, for an occasional mention is made regarding the more or less successful trial of some new material of this character. Gironard[1] says that in 1862 the idea occurred to him to use from two to four grams of acetate of potassium in one liter of water for the prevention of mildew on grapes. The results were very marked, and in 1863 the vines were productive directly in proportion to the amounts of the chemical applied. But this substance did not come into general use, and it was not until the value of the compounds of copper became known that any permanent advances were made.

Soon after the appearance in France of the downy mildew (*Peronospora viticola*) the necessity for a more energetic fungicide than sulphur became evident. Sulphur as then used seemed to be entirely without effect in checking the progress of this disease. The mildew was first discovered in France in 1878.[2] Millardet saw it in September of that year upon some American grape seedlings growing in the nursery of the Société d'Agriculture de la Gironde, and Plachon at the same time recognized it

[1] *Bulletin de la Société d'Horticulture d'Eure-et-Loir*, 1868, No. 13, January, 270.

[2] *Jour. d'Ag. Prat.* 1881, Feb. 10, 192.

on the leaves of Jacquez grapes at Coutras and also received it from various departments of Lot-et-Garonne, and of Rhône. The disease spread rapidly and was so destructive that in 1882 the fruit in many vineyards was almost entirely destroyed. The climate of France appears to be peculiarly adapted to the growth of this mildew, which flourishes as well upon the varieties of *Vitis vinifera* as upon our American species. In moist seasons it is fully as energetic as in America, or even more so. The leaves fall from the vines, and the grapes are thus prevented from ripening properly. Even in cases in which the vines do not lose all their foliage, a partial reduction is sufficient to decrease the amount of sugar in the grapes to such an extent that their value for wine is very greatly lessened. Many growers did not at first realize the seriousness of this disease. In some vineyards it even obtained a firm foothold without being noticed, for the portions of the fungus which are on the exterior of the leaves are borne on the under side. When, however, it became established in a certain district, all doubts regarding its seriousness vanished, and the vineyardists found themselves confronted by a disease which not only threatened to destroy their vines, but which gave unmistakable proof of its power to do so.

The remedies in general use for controlling the European surface mildew (*Oidium Tuckeri*) proved to be of little value against this new foe. Spraying with milk of lime was recommended and very thoroughly tried, but it did not give such good results in France as were reported from Italy. The milk of lime was used with good results against the oidium of the grape by Professor Keller even before 1852.[1] In 1881 Professor Garovaglio, director of the cryptogamic laboratory at Pavie, used it with fairly good success against the peronospora, but his statement of this work, although apparently of the greatest importance, received no attention from Italian vineyardists. It was not until 1883, when the work of the agricultural school at Conegliano, Italy, became known, that the remedy was generally adopted. Many growers in northern Italy, especially the Bellussi Brothers, near Conegliano, were particularly successful, and so much confidence was placed in their method of controlling the mildew that the minister of agriculture, in a circular published in 1885 recommended its general adoption. During

[1] Cerlettie Cuboni, *Annali di Agricoltura*, 1886, 20.

this same year Cerletti published[1] an important article in which he announced that the peronospora could be effectually combated by the use of the milk of lime. The mixture was made by slaking 3 kilos of quicklime in 100 liters of water, first converting the lime into a fine powder, by partially slaking it, and then adding the remainder of the water.[2]

Powders were very extensively tried in France. Their use was undoubtedly suggested by the fact that sulphur had been applied in the form of a powder for a great many years. There was at this time no apparatus particularly adapted to the application of liquids, but such was not the case with powders. As early as 1881[3] Professor Millardet, of the Faculty of Sciences of Bordeaux, used the sulphate of iron in powdered form in connection with sulphur and also with plaster. He reported to Mme. Ponsot (who suggested this practice, and with whom he carried on the work) that 4 kilos[4] of sulphate of iron mixed with 20 kilos of plaster had stopped the mildew.

J. Laure,[5] an engineer at Apt (Vaucluse), had for several years made a study of a certain ore of sulphur, called "Soufres des Tapets." This mineral contained various substances besides sulphur, and after having been treated so that it contained more or less of the sulphate of iron it was sold under the name of "Fungivore." It was highly recommended against attacks of anthracnose, and was also very effective in checking the oidium of the vine. From three to six applications were necessary to protect the plant well. It was used to a considerable extent, but this powder, as well as the many others which were sold, did not equal the liquid applications in efficiency. (See page 32 for a more complete discussion of the powders which came into use as fungicides.)

Other fungous diseases than those of the grape were now attracting attention. Paul Oliver said[6] that for several years pears had suffered from the attacks of a fungus which pro-

[1] *Rivista di Viticoltura*, 1885, Aug. 30.

[2] Pinolini, "Le Crittogame," 1888, 30 *et seq.*

[3] *Jour. d'Ag. Prat.* 1883, April 19, 553.

[4] One kilogram is equal to 2.2 pounds. Since the metric system is the one used by the large majority of the experimenters of continental Europe, the system will be retained in this portion of the work. For a complete scheme of the weights and measures of the metric system, as well as their equivalents, see Appendix.

[5] *Jour. d'Ag. Prat.* 1883, April 19, 554.

[6] *Ibid.* 1881, July 7, 20.

duced black, velvety spots upon the foliage, and in 1880 it also deformed the fruit to a considerable extent. The cause of the injury was attributed by Prillieux,[1] the inspector-general of Agricultural Education, to *Fusicladium pyrinum* (*Cladosporium dendriticum*, Walr.), and a description of the fungus was published. Paul Oliver[2] made some experiments which were designed to throw light upon the best method of destroying the spores of the parasite. The materials used were, (1) pure water; (2) water acidulated with one-twentieth its amount of sulphuric acid; (3) a $33\frac{1}{3}$ per cent solution of the sulphate of iron; (4) a $16\frac{2}{3}$ per cent solution of the sulphate of copper. He advised the use of the last in rainy weather, but during dry weather either the second or the third would prove effective. Oliver further states that he succeeded in killing the spores of *F. pyrinum* with an 8 per cent solution[3] of copper sulphate, and that he sprayed his trees with a 10 per cent solution during the winter of 1882–3.

This discovery — that the salts of copper would prevent the germination of the spores of fungi — was by no means new. As early as 1807, Bénédict Prévost gave[4] an account of the method by which he prevented the germination of the spores of a fungous disease commonly known as "Carie," or "Charbon" (smut), of corn. His statement regarding the result of his experiments is as follows: "The amount of sulphate of copper really necessary to give to water the power of preventing the germination of the spores in a low temperature does not amount to $\frac{1}{400000}$ of its weight, and $\frac{1}{1200000}$ retards germination." Thus a discovery of immense practical importance has long remained hidden and unappreciated, and it is not impossible that other information equally valuable is at present neglected in a similar manner.

The first general statement in regard to the value of chemical compounds for the destruction of grape mildew seems to have been made by Millardet.[5] He says: "Recent observa-

[1] *Comptes Rendus de l'Académie des Sciences*, 1877, Nov. 12.

[2] *Jour. d'Ag. Prat.* 1881, July 7, 20.

[3] By an 8 per cent solution is meant a solution which contains 8 parts by weight of the solid dissolved in 100 parts of the liquid.

[4] "Mémoire sur la cause immédiate de la Carie ou Charbon des blés." Montauban, 1807.

[5] *Zeitschrift in Wein-, Obst-, und Gartenbau für Elsasz-Lothringen*, 1883, March 1 and 15.

tions make me hope that perhaps the most satisfactory results may be obtained by the use of certain mineral solutions, such as, for example, the sulphate of iron or of copper." But no definite experiment had been made up to this date to prove his assertion.

Prillieux [1] carried on experiments at Nérac for the destruction of the American grape mildew. He found lime to be of little value. Borate of soda, used at the rate of five grams [2] dissolved in a liter [3] of water, gave good results, but the various toxics and antiseptics used by him were practically useless.

A concentrated solution of the sulphate of iron for the destruction of anthracnose was already regarded as a specific,[4] for it had long been used with success in the treatment of the disease. The practice appears to have originated with Schnorf, of Rossbach-Meilen, Germany, for he writes as follows regarding its early history: [5] "During twenty years, I have successfully used the sulphate of iron for anthracnose of the grape, in accordance with the following plan: During spring, before the vines start, I dissolve 3 kilos of sulphate of iron in 6 liters of boiling water. When the solution has cooled, I pour it into earthen vessels. The workmen take these into the vineyard and wash the vines with rags, which are dipped into the liquid. This is done but once during the year, in early spring, and the results are uniformly excellent. It has occurred that during certain seasons before the treatments were begun, I lost the entire crop if the weather was cold and moist, while I have rarely failed to obtain a good yield since the applications were made, and I feel well repaid for my trouble. I repeat the washing every year, and other vineyardists have followed my example with equal success."

In France it became the common practice to cover the posts and vines with this solution during winter or early spring, a broom or brush being used for the purpose. In some cases the entire post was soaked in the solution for several days.

P. de Lafitte states [6] that Sept. 20, 1884, Ricaud and also

[1] *Jour. d'Ag. Prat.* 1882, Jan. 19, 75.

[2] A gram is equal to 15.432 grains. See Appendix.

[3] A liter is equal to 1.056 quarts.

[4] *Jour. d'Ag. Prat.* 1883, April 19, 553.

[5] *Schweizer Monats-Schrift für Obst- und Weinbau*, 1878, ix. 155. See also *La Vigne Américaine*, 1879, May, No. 5.

[6] *Jour. d'Ag. Prat.* 1885, Oct. 1, 479.

Paulin published in the *Journal de Beaune* a note on the good effects which followed the covering of posts with a concentrated solution of the sulphate of copper. The work had been done in Burgundy. On the 23d of September the above journal also contained an article on the same subject, written by Montoy. Ad. Perrey mentions[1] a case in which the posts that supported the vines were treated with a solution of sulphate of copper, and this caused all the leaves within a circle 20–25 cm. in diameter, the post being at the center, to remain upon the vine. Untreated vines lost all their foliage. Several other observers in various sections of France noted the same fact, and all agreed that the beneficial action extended to practically the same distance as mentioned above.[2] The practice was consequently of value only for vines not more than five or six years old, since larger vines carry so much foliage outside of the protected belt. Nevertheless, many growers soon made a practice of covering the posts, vines, and also the tying material, with a strong solution of copper sulphate; and some believed excellent protection followed the treatment. But the method did not give uniformly good results, and some more effective remedy was still sought.

In 1885 the French vineyardists were still apparently without a good remedy for the mildew. P. Pichard, director of the agricultural station at Vaucluse, proposed[3] a solution of the liver of sulphur; and Foëx, director of the school of Viticulture at Montpellier, asserted[4] that, after making an application of an emulsion of one part phenic acid in 100 parts of soap water, all traces of mildew disappeared. He found it advisable to add glycerine to this preparation, in order to prevent it from drying too fast. V. Cambon advised the use of a 2 per cent solution of bisulphate of soda.

Origin of the Bordeaux Mixture.

Such, in general, was the nature of the experimental work which was done at this time. New chemicals were tried, as well

[1] *Jour. d'Ag. Prat.* 1884, Oct. 16, 540. See also report of Van Tieghem to Academy of Sciences, 1884, Sept. 29.

[2] Bidault, *Jour. de l'Ag.* 1885, Oct. 31, 712.

[3] *Jour. d'Ag. Prat.* 1885, Feb. 5, 217.

[4] *Ibid. loc. cit.*

as many different combinations of old ones. Some of these proved to be fairly efficient, but the ideal remedy had by no means been discovered. It was not until the fall of 1885 that there appeared unmistakable evidence, based upon experiments, that a substance had been found which promised to be a specific against the grape mildew, and perhaps also against many other fungous diseases. This substance was copper. Its history is all the more interesting from the fact that the first use of its most effective combination was not in any way connected with the fungous diseases of the grape, but rather with the human enemies of the vineyardist. Nevertheless, when the mildew appeared, this preparation rose to the occasion, and protected the foliage, as well as it had done the fruit of the vines.

In southwestern France, in the maritime department of Gironde, is situated the city of Bordeaux. It lies near the western border of a large horticultural district of which the grape is by far the most important fruit. These grapes are mostly manufactured into wine, and it is particularly the clarets which have made this district known throughout the world. It is here that the downy mildew of America first made its appearance in Europe, probably in 1878, and here also it first became most serious. The summer of 1882 was particularly favorable to its development; and as no steps had been taken to check its progress, the injury done to vineyards was very great. The foliage of the vines was destroyed, and fell to the ground during the summer. This prevented the proper ripening of the grapes, and the harvest was almost without value.

A few vines, however, escape this general attack. These were situated along the highways, particularly about Margaux, St. Julian, and Pauillac, in the Médoc. It was noticed by many that in the fall of 1882 certain vines retained their foliage in an almost perfect condition. Vineyardists in these localities had suffered considerable losses from the stealing of their grapes by children and travelers along the highways. It had formerly been the custom[1] to sprinkle verdigris upon a few rows of the vines nearest to the road for the purpose of giving the fruit the appearance of having been poisoned. Several years before the appearance of the downy mildew this substance was

[1] Millardet, *Jour. d'Ag. Prat.* 1885, Oct. 8, 514. Prillieux, "Report to the Minister of Agriculture," Oct. 22, 1885.

replaced, from reasons of economy, by a mixture of the milk of lime and some salt of copper, the sulphate being commonly used, on account of its cheapness. This mixture was of the consistency of cream, and was of a light blue color. It was applied to the vines by means of brooms, or whisks of heath. The design was to apply enough of the mixture to each vine to give it the appearance of having been well poisoned, the operation, of course, being delayed until the period of ripening approached.

The vines thus treated were the ones which had retained their foliage through the fall of 1882, while others growing further from the road lost their leaves. The cause of the beneficial action of the mixture was soon ascribed to the copper, for lime used alone had proved unsatisfactory as a remedy for mildew. Prillieux and Millardet were among the first to note the effect of the mixture and to ascribe its action to the proper cause; but Millardet is the one who did the most towards perfecting the mixture and testing its action upon foliage, and upon the mildew. (See frontispiece.) He was materially assisted by U. Gayon, professor of chemistry in the Faculty of Sciences, of Bordeaux. These two may justly be considered the leaders in the study and use of the preparation which was destined to prove superior to all fungicides that have been used to the present day, and which is now so well known, in a modified form, under the name of the Bordeaux mixture.

Although these men were the most energetic in conducting the work, and the first to publish results, they apparently were not the only ones working in this field. Prillieux asserted[1] that the treatments of Jouet and of E. Ferrand were made simultaneously with those of Millardet, and independently of the latter, and that they did not even know of Millardet's investigations. Their work, however, does not appear to have been carried on systematically, nor were results published which go to show that the experiments began so early as did those of Millardet and Gayon. It is consequently to these two men that the honor of having first experimented with the "bouillie bordelaise," as it then began to be called, may be granted, and to Millardet in particular may be given the credit of being the

[1] *Société Nationale d'Agriculture de France*, session of Nov. 4, 1885, 590.

first to plan and publish results which showed plainly the value of the copper compounds in commercial work.[1]

The first systematic applications of copper compounds for the prevention of the downy mildew were made[2] on the 18th of August, 1883, or the year following the observation of the apparent value of lime and copper sulphate when applied together. The work was done on the grounds of the castle of Dauzac in the Médoc, by E. David, steward of the place, but under the direction of Millardet. In these experiments the sulphates of iron and of copper were used. They were applied in pure solutions, and also mixed with lime in varying proportions.

In 1883 Millardet, believing that copper was the most efficient agent in the destruction of the mildew, applied this metal in other forms than the sulphate. He used,[3] in addition, the carbonate, phosphate, and sulphide of copper, and also the corresponding salts of iron. Lime was also applied alone. In 1884 the same work was repeated, and although the mildew was not very abundant, still he and Mr. David came to the conclusion that the mixture of the sulphate of copper and the milk of lime was the most promising of all the materials applied. They decided to give up the use of the iron salts, as well as the simple solution of copper sulphate. It was found that the latter burned the leaves when used stronger than one-half part of the salt in 100 parts of water. This result, however, does not agree with those obtained by Messrs. Ad. Perrey, P. de Lafitte, and Maginen. On the estate of Salle de Pez, at St. Estèphe, an 8 per cent solution of copper sulphate proved[4] to be nearly as efficient as when lime was added.

During these two years the mildew was not very prevalent in the treated vineyards, so that only partially satisfactory results were obtained. These were, however, of sufficient value to warrant the publication[5] of an article by Millardet, in which were given the following directions for preparing and applying the mixture:

"In 100 liters of water dissolve 8 kilos of commercial

[1] *Jour. d'Ag. et d'Hort. de la Gironde*, Oct. 1. Cited in *Jour. d'Ag. Prat.* 1885, Dec. 3, 804.

[2] *Jour. d'Ag. Prat.* 1885, Dec. 3, 804.

[3] *Ibid.* 708.

[4] *Ibid.* Nov. 5, 661, 662.

[5] *Annales de la Société d'Ag. de la Gironde*, 1885, April 1, 73 *et seq.*

sulphate of copper. In another vessel make a milk of lime by slaking 15 kilos of quicklime in 30 liters of water. This is then added to the copper sulphate solution, causing a bluish precipitate. The workman should stir the mixture well, and then pour a part of it into a pail or watering pot. This is carried in the left hand while with the right he sprinkles the foliage by means of a small broom. Care should be taken that none of the mixture shall strike the grapes." Such was the first formula for making the Bordeaux mixture; and the first apparatus used for its application was a broom!

On Dec. 3, 1884, some time previous to this publication, Baron Chatry de la Fosse had called the attention of the Agricultural Society of Gironde to the good effects following the use of the mixture of lime and copper sulphate, but he gave no direction for its preparation nor for its use.

During 1885 the downy mildew developed with much intensity. Many experiments were tried, and the year brought out a number of facts regarding the various treatments. The value of the "bouillie bordelaise" was proved beyond all doubt. Wherever it had been properly used, the results were all that could be wished. Untreated vines lost their leaves, and those to which the mixture had been applied, retained them in an almost perfect condition. These results are all the more remarkable on account of the very crude method of applying the mixture, a small broom being generally used for the purpose. The most marked and promising results of the year were probably obtained by de Ferrand, Johnston, and David.[1]

The original formula of the mixture was modified by various vineyardists in 1885. De Ferrand used [2] successfully about the same quantity of lime as of copper sulphate. David added [3] glue to the mixture at the rate of 6 kilos strong glue dissolved in 800 liters of the mixture. This first trial of the addition of glue was apparently followed by beneficial results.

The first application of the Bordeaux mixture for the prevention of other diseases than those of the vine seems also to have been made this year. Prillieux, in his report to the minister of agriculture, dated Oct. 22, 1885, says [4] that Jouet, at Château-Langoa (Médoc), made an application to tomatoes

[1] *Jour. d'Ag. Prat.* 1885, 699 *et seq.*
[2] *Ibid.* 701.
[3] *Ibid.* 661.
[4] *Ibid.* 662.

which were apparently attacked by the same peronospora that is found upon potatoes. He believed he had cured or stopped the disease. Since this fungus is closely related to the peronospora of the vine, it seemed very probable that the remedy would prove equally valuable for all similar diseases. Prillieux even went so far as to advise, for the first time, the use of the mixture upon potatoes and tomatoes, and events have shown that his advice was well worthy of being followed.

At the beginning of the year 1885 the general opinion appears to have been to wait until the appearance of the mildew upon the vines before making an application; and it was also believed that one treatment was sufficient. But after the work of the year Millardet thought [1] that in case of severe rains it might be advisable to make a second.

At the close of the year Prosper de Lafitte summed [2] up the methods then in use for checking the downy mildew of the grape, as follows:

1. "The treatment of Beaune, which consists in covering the posts and the tying material, rye straw being commonly used for this purpose, with a five-tenths per cent solution of copper sulphate. (Page 24.)

2. "The treatment of which Millardet is the promotor" consists in protecting the vines by means of a mixture of the milk of lime and a solution of copper sulphate. (Page 27.)

3. "Spraying the foliage with a simple solution of copper sulphate. (Page 27.)

4. "Spraying the foliage with the milk of lime, using approximately a 2 per cent mixture." (Page 20.)

To the above might have been added also:

5. The treatment which consists in the application of powders. (Page 32.)

The use of the "bouillie bordelaise" became more general in 1886 and many cases are reported in which its beneficial and almost specific action was proved. The general opinion seemed to be that it was superior to any of the other substances recommended.

In accordance with the advice given by Prillieux in the fall of 1885 Jouet, in the Médoc, made what appears to have been the first application of the mixture to potatoes for the preven-

[1] *Jour. d'Ag. Prat.* 1885, 734. [2] *Ibid.* 880 *et seq.*

tion of the rot, a disease which was then very destructive. The experiment is reported[1] by Prillieux, who says that the area treated covered about three hectares.[2] The application was made as soon as the rot appeared, and no further injury resulted from the disease. Jouet was equally successful with the blight of tomatoes, both diseases being attributed to *Phytophthora infestans*, DeBary. Another tomato grower, at Écully, is likewise reported to have been successful.

Origin of the Ammoniated Copper Fungicides, and Various Combinations.

A new fungicide, one destined to become very well known, was tried in 1885 for the first time. It was proposed[3] by Professor Audoynaud of the agricultural school at Montpellier. He gave the following directions for its preparation:

Copper sulphate	1 kilo.
Ammonia	1 liter.
Water, sufficient to spray	1 hectare.

The copper salt was dissolved in the ammonia and then this solution was added to the water. Such a solution had already been known to pharmacists under the name of "eau céleste," meaning "heavenly water," so called on account of its deep blue color. It was used during the year by several experimenters.

In 1886 a great many men conducted experiments to test the value of the compounds of copper, very few other substances being used. Among the many who did valuable work during the year may be named Millardet and David,[4] Gaillot, and Dr. G. Patrigeon.[5] These experimenters planned the work so thoroughly that their results embodied the most important of those obtained by other workers.

In almost every instance the "bouillie bordelaise," or Bordeaux mixture, gave the most satisfactory results. Millardet

[1] *Société Nat. d'Ag. de France*, session of Aug. 18, 1886, 465.

[2] A hectare is 2.47 acres.

[3] *Progrès Agricole et Viticole*, 1886, March 28. Cited by Viala et Ferrouillat, "Traitment des Maladies de la Vigne," 1888, 30.

[4] *Jour. d'Ag. Prat.* 1886, Nov. 25, 764; Dec. 9, 831.

[5] *Ibid.* Nov. 11, 696.

found that the mixture could also be made with air-slaked lime, but it then had the disadvantage of being more difficult to apply. He came to the conclusion that the addition of glue was of no particular value. Eau céleste proved to be a very adhesive solution, and it also showed very efficient fungicidal properties; but it burned the foliage considerably and on that account was open to objection. Simple solutions of the sulphate of copper, of varying strength, were applied, but although the weakest contained only one-half per cent of the salt, the foliage was in every case burned.

L. Gaillot, of Beaune (Côte d'Or), had difficulty in obtaining apparatus for throwing the Bordeaux mixture when made according to the original formula, and so searched for some simpler preparation.[1] It was at that time a common belief in Burgundy that the first treatments need not be strong, for even treating the posts was of benefit. After many trials, Gaillot was led, in 1886, to make use of formulas which called for only one or two kilos of copper sulphate, and only one kilo of lime, these being applied in one hectoliter of water.

Gaillot appears also to have been the first to make a successful preparation of sulphur and the Bordeaux mixture.[2] He used the following formula:

Copper sulphate	1 kilo.
Water	100 liters.

In another vessel he placed

Quicklime	5 kilos.
Water	5–6 liters.

When this was thoroughly slaked, he added

Flowers of sulphur	1 kilo.

This was thoroughly mixed with the lime paste, and to the mixture he added small quantities of the copper sulphate solution, stirring well. When the number of additions caused the material to be of a semi-fluid consistency, it was poured into the barrel containing the copper sulphate solution. The con-

[1] *Jour. d'Ag. Prat.* 1888, May 24, 732. See also "Compte Rendu du Congrès de Dijon," 1886; *Vigne française*, 1886, Sept. 15, 276, over initials R. J.

[2] "Compte Rendu des Réunions Viticoles," Dijon, 1886, June 4 and 5, 55.

tents of the barrel were well stirred before any of the mixture was removed.

"Bouillies bourguignonnes" is the name which Gaillot proposed, in 1888,[1] for the designation of the Bordeaux mixture which contained only one or two kilos of copper sulphate. The name never came into common use, for the term "bouillie bordelaise" was so well known that it could not be easily supplanted, however just the cause for dropping it may have been. Millardet recommended a similar formula in 1887, as a modification of the original.

Gaillot says that in 1886 he protected his grapes perfectly by the use of the mixture of sulphur and the bouillie bourguignonne. He made the first application in April, using a mixture containing two kilos copper sulphate; about eight days after flowering he applied the weaker mixture having only one kilo of the sulphate. The third treatment was made late in the season, and the vines were injured neither by fungi nor by the materials.

Powders.

During 1886 Millardet experimented extensively with powders. He used them upon the vines in the hope that they would prove as valuable as the liquids then in use. Apparatus for applying powders had already been manufactured and it was very desirable that an efficient preparation might be found. The one that appeared to be the most promising was the Podechard powder.[2] It was made by Louis Podechard, of Gigny, according to the following formula:

Quicklime	100 kilos.
Sulphate of copper	20 "
Flowers of sulphur	10 "
Wood ashes	15 "
Water at 20° C.	50 liters.

The sulphur should be added after the other ingredients have been allowed to stand twenty-four hours. Then mix all together, dry the mass, and force it through a fine sieve.

[1] *Jour. d'Ag. Prat.* 1888, May 24, 733.

[2] *Ibid.* 1887, May 5, 642. See also *Bulletin du comité d'Agriculture de l'Arrondissement de Beaune*, October, 1885, 4–10; *Jour. d'Ag. Prat.* 1885, Dec. 3, 803.

This powder in a certain sense forms a link between the older ones in which the ingredients "ought" to be of value, and the later ones in which every material was known to possess a definite composition and also a more or less definite action as a fungicide.

The David powder was used for the first time in these experiments. It was named in honor of Mr. David, who rendered such material assistance to Millardet. The powder was composed of

Quicklime	30 kilos.
Copper sulphate	8 "

As small a quantity of water as possible was used to slake the lime, and to dissolve the sulphate. The latter solution was added to the milk of lime when it had cooled, and then the mixture was dried in the sun. When perfectly dry it was ground into very fine powder which was of a blue color.

Sulphosteatite was also used in these experiments. This substance was often called "stéatite cuprique," and to many American readers it may be still more familiar under the name of "fostite," a term first used in 1894. This substance was proposed by Baron Chefdebien, of Perpignan.

Millardet used a powder known as "sulfatine," made by Paul Estève, of Montpellier. It was composed mainly of sulphur, lime, sulphate of copper, and plaster, and was first made generally known in *Progrès Agricole et Viticole*, Nov. 14, 1884.

Sulfatine gave the best results of any of the powders as regards fungicidal action. Sulphosteatite proved to be the most adhesive, but it burned the foliage of the vines, and for that reason it required careful distribution. This powder had previously been mentioned as possessing no value against the oidium, and the Bordeaux mixture was spoken of in a similar manner.[1] David's powder was not so active against the mildew as was the Bordeaux mixture, and in addition it cost about four times as much. More material was required to cover a given area, and its use was not advised from a commercial standpoint. Podechard's powder proved to be practically worthless, and other growers who used it came to the same conclusion.

[1] *Jour. d'Ag. Prat.* 1886, Nov. 4, 663.

Perfection of the Fungicides, and further Experiments in their Use.

Dr. Patrigeon tested the various methods of applying the copper sulphate solutions. In 1886 he treated, in different plots, the posts, the tying material, the plants themselves during the winter, and the foliage. He also added 10 per cent of plaster to a 1 per cent solution of copper sulphate and applied this mixture with a broom. This last preparation possessed some merit, as did also the application of the pure sulphate of copper solution. But the Bordeaux mixture gave decidedly the best results. Treating the posts, etc., with the copper solution, in these experiments proved to be practically of no value.

Prillieux also mentions [1] a case in which the Bordeaux mixture again gave the best results. Professor Fasquelle, of Jura, applied a 4 per cent solution of copper sulphate to potatoes, and the foliage was plainly injured. Bordeaux mixture, containing an equal amount of copper, was used at the same time and no injurious effects could be perceived in consequence of the treatment.

The difficulty of applying the Bordeaux mixture when made according to Millardet's formula induced several vineyardists to vary the proportions considerably, and the general impression at the close of the year 1886 seemed to be that there was no necessity for using so much copper or lime to obtain equally good results as followed the use of the original formula. This question is not entirely settled even at the present day, and it is very probable that some diseases require the use of more copper than others, some being successfully treated with very small amounts.

It was early in 1887 that the idea was first advanced of using a stock solution for the making of Bordeaux mixture.[2] A certain amount of copper sulphate is dissolved in a given quantity of water, and any desired amount of the salt can be obtained by taking out the amount of water which holds it in solution. The practice is now also in use, to a limited extent, for measuring the lime.

The necessity of adding lime to the copper sulphate solution was not generally conceded.[3] Vautier made comparative tests

[1] *Jour. d'Ag. Prat.* 1886, Dec. 16, 886.

[2] Ricaud, J., *Jour. d'Ag. Prat.* 1887, Jan. 20, 90.

[3] *Vigne Américaine,* 1886, Sept. 290 *et seq.*

of the Bordeaux mixture, eau céleste, and of the treatment of A. Bouchard. This last treatment consisted in the use of 300 grams sulphate of copper dissolved in one hectoliter of water. His conculsions were that there is no particular difference between the three fungicides as regards efficiency, but the last is to be preferred on account of the ease with which applications can be made, and the cheapness of the treatments. These opinions were not generally accepted, unless it was in Burgundy, where Bouchard's treatment was considered an excellent remedy.

The disadvantage of Audoynaud's eau céleste was that it burned the foliage. On account of the ease with which this solution could be applied, many attempts were made to render it harmless. Michel Perret, of Tullius, said[1] that the use of one part of ammonia to two of copper sulphate would form a perfectly safe solution. He said further[2] that the following formula was adopted in Isère, where it was known under the name of "Bouillie dauphinoise":

Copper sulphate	2 kilos.
Water	20 liters.
Ammonia 22°	1 liter.

Allow this to stand some hours and then draw off the liquid. This contains the sulphate of ammonia, which is supposed to be harmful to foliage.

To the precipitate formed above, add

Sulphur	2 kilos.
Water	100 liters.

The sulphur should first be mixed with the precipitate to form a paste, and the water is then added. He favored this mixture because the mutual action of the copper and the sulphur was such that neither affected the wine manufactured from the grapes. Carnot advised[3] the use of five or six parts of the sulphate of ammonia to one part of copper sulphate crystals. G. de Capol said[4] that it might be well to dissolve

[1] *Jour d'Ag. Prat.* 1887, March 10, 354.

[2] *Ibid.* June 23, 878.

[3] *Soc. Nat. d'Ag.* 1887, March 16. Cited in *Jour. d'Ag. Prat.* 1887, May 19, 714.

[4] *Ibid. loc. cit.*

in ammonia the hydrates of copper deposited by the formula given by Perret. This would give a solution entirely free from acid.

Another of the many new remedies proposed during the year 1887 was brought forward[1] by Emile Masson. He recommended the use of the carbonate of soda and the sulphate of copper, and used these two materials in proportions varying from one kilo of copper sulphate to one or two of soda carbonate, or sal-soda. These were used in one hectoliter[2] of water. He said that the fungicide did not burn foliage and that it spread evenly.

Dr. G. Patrigeon, of Chabris (Indre), France, is probably entitled to the credit of having first conceived and put into practice the remedy proposed by Masson. He describes[3] it as the "treatment of mildew with the hydrocarbonate of copper." The substance was prepared by using

Copper sulphate	4 kilos.
Carbonate of soda	6 "
Water	100 liters.

He said it adhered to foliage fully as well as the Bordeaux mixture, and thought it could be used twice as strong as recommended above.

A second preparation mentioned by Dr. Patrigeon was made by dissolving with ammonia the precipitate formed in the preceding mixture. The proportions of the ingredients varied a little as follows:

Copper sulphate	1 kilogram.
Carbonate of soda	1 "
Ammonia 22°	1 liter.
Water	100 liters.

The first two ingredients are each dissolved in four liters of water in separate vessels. The soda carbonate solution is then carefully poured into the solution of copper sulphate, and when all reaction has stopped the ammonia is added. As soon as the precipitate is dissolved the solution may be diluted with the

[1] *Jour. d'Ag. Prat.* 1887, June 9, 814.

[2] A hectoliter is 26.416 U. S. gallons of 231 cu. in.; or 22.009 Eng. Imp. gallons of 277.26 cu. in.

[3] *Jour. d'Ag. Prat.* 1887, June 23, 879.

water. Practically this same solution is more or less used to-day, but it is known as the "modified eau céleste." Patrigeon at the time of its introduction, referred to it simply under the name of the hydrocarbonate of copper dissolved in ammonia.

The "bouillie berrichonne" is a third preparation introduced by Patrigeon. This was made like the preceding, with the exception that only a portion of the copper precipitate was dissolved by ammonia, instead of all of it. He desired that only one-third be dissolved. This portion would have an immediate action upon fungi, while the remaining undissolved part would act as a reserve supply. Later investigations have shown that such preparations are unnecessary for the successful treatment of fungous diseases.

The anthracnose of grapes was at this time receiving considerable attention. No reports of success in treating the disease during the growing season are reported, but all recommendations are to the effect that applications should be made during the winter. The following treatments appeared to be most promising.[2] The first formula was proposed by Michel Perret:

1.

Copper sulphate	10 kilos.
Iron "	10 "
Water	100 liters.

2. The Schnorf[3] treatment (see page 23) consisted in applying

Iron sulphate	50 kilos.
Water	100 liters.

3. Ordinary Bordeaux mixture:

Copper sulphate	8 kilos.
Lime	15 "
Water	130 liters.

4. The same as 3, but 12 kilos of copper sulphate were used instead of 8. This gave the best results, but numbers 2 and 3 follow closely. The first proved to be much less satisfactory.

[1] *Jour. d'Ag. Prat.* 1887, May 5, 641.

[2] Millardet, "Nouvelles Recherches sur le Développement et le Traitement du Mildew et de l'Anthracnose," 1887, 56.

[3] *Ibid. loc. cit.*

Millardet believed that if one or two winter treatments were made regularly for three years, the anthracnose could be entirely cured; and at the present day this grape disease is well under control in Europe.

Millardet's formula for making the Bordeaux mixture in 1887 was as follows: [1]

Copper sulphate	3 kilos.
Quicklime	1 kilo.
Water	100 liters.

He also proposed several others, but this is the one which promised the best results both as regards its application and its fungicidal value.

In a comparative trial of Bordeaux mixture and sulpho-steatite on potatoes and tomatoes, the powder gave apparently the best results.[2] Its value consisted in the fact that it adhered to the foliage better than the Bordeaux mixture, and that it reached the under as well as the upper side of the leaves. This is especially true for the tomato, and he advised the use of this powder upon these two plants.

The formulas recommended for making the Bordeaux mixture in 1888 all mentioned greatly reduced amounts of copper sulphate and lime. Millardet and Gayon found [3] that by reducing the amount of lime the mixture was rendered more adherent. In their experiments carried on at Dausac in 1887, a careful study was made of the effects produced by the use of different amounts of copper sulphate. The original formula contained 6 kilos of this salt in 1 hectoliter of the mixture. Millardet and David were so well convinced of the value of these more dilute mixtures that the former advised [4] the use of only 1 kilo in a hectoliter of water; but if a severe attack of mildew was feared, the use of 2 kilos was thought to be safer.

Eau céleste was also used in this work, but it proved to be inferior to the Bordeaux mixture. This was found to be true even to a greater extent in the case of other preparations containing ammonia.

[1] *Jour. d'Ag. Prat.* 1887, May 19, 704.

[2] *Ibid.* June 9, 807. See, also, "Peronospora de la Vigne et Sulphostéatite cuprique," Dr. B. Nabias, 1887, Bordeaux.

[3] *Ibid.* 1888, May 3, 623.

[4] *Ibid.* 624.

As regards the number of treatments necessary for the best and most economical protection of the vine, Millardet says[1] that at least two must always be made, "but the earlier appearance of the disease, its greater intensity, and rapid spreading may render three or even four applications necessary." They were made in 1887 as follows: June 10, or some days before flowering, July 14, and August 8. This apparently was not sufficient to protect the vines fully.

The conclusions reached by Dr. Patrigeon in his work of 1887 were that the price of applications of the hydrocarbonate of copper dissolved in ammonia (modified eau céleste) was very low; that the formulas for the preparation of the solution are remarkably simple and practicable; that the material is equally or perhaps even more efficient than any other fungicide in use; and that it is perfectly harmless to foliage. These claims for the merit of the solution were indeed founded upon fact, for it has been hard to decide, in regard to the comparative efficiency, between the Bordeaux mixture and the ammoniacal solution of the carbonate of copper, which is practically the same as the modified eau céleste recommended by Dr. Patrigeon.

The American disease of grapes commonly known as black rot was first discovered in the vineyards of France in August, 1885. Mr. Ricard, the steward of an estate situated at the gates of the small town of Ganges at the borders of l'Hérault, was the first to call attention to the presence of this fungus.[2] He saw that his grapes turned brown, then black, while still remaining upon the vine. He sent some of these diseased grapes to the viticultural laboratory of l'École de Montpellier, where Messrs. Viala and Ravaz recognized the parasite. They went to the affected vineyard, and saw that only about thirty hectares in the plain of Ganges showed diseased grapes. In these vineyards the harvest was reduced about one-half.

Immediate and energetic steps were taken to exterminate the fungus, but in 1886 it again appeared. The season proved to be dry, however, and very little damage was done. The area of distribution was nevertheless considerably extended.

On July 25, 1887, Prillieux received diseased grapes from Azen, in Lot-et-Garonne, and was directed by the minister of agriculture to proceed to the infected district. He found

[1] *Jour. d'Ag. Prat.* 1888, May 17, 694. [2] *Ibid.* June 14, 847.

that black rot existed throughout the entire valley of the Garonne as far as Aiguillon. In some vineyards it was so well established that there appeared to be no doubt that the disease had been present at least a year before its discovery in l'Hérault; it was consequently impossible to determine the first place of infection in France. The disease was new, and at the first not very serious, so that its presence had been overlooked perhaps for more than one year. None of the copper compounds had been tried to check the disease, and this was the most encouraging feature of the situation in the fall of 1887. The outcome showed that this fact might indeed give rise to a hope that this new disease could be controlled. It was in truth suppressed with greater despatch and with less trouble than the downy mildew had been, for on August 2 of the following year there was published [1] a letter from Prillieux in which he says: "When we see two rows of grapes, one entirely devastated, the other preserved by treatment, we must feel encouraged for the future." The following week the same journal published [2] another letter from Prillieux, saying: "These experiments demonstrate with complete certainty, as was suspected, but without having been positively established either in America, where the disease has ravaged vineyards for years, nor in France, that cupric treatment can stop the invasion of black rot as well as of mildew, provided applications are made early enough, and in a proper manner. The success in the experimental treatments at Aiguillon in a year favorable to the disease, as was proved by the complete destruction of the crop on untreated plants, is a guarantee of success in the future. We can now combat the black rot as effectually as the mildew."

No other events of much importance appear to have occurred in France in 1887 or 1888. The use of more dilute Bordeaux mixture was not followed by such uniformly good results as was hoped. Several vineyardists recommended a mixture which should contain not less than 3 kilos copper sulphate in 1 hectoliter of the mixture, and it was thought advisable to make it even stronger for the first application. Many were also in favor of using only 2 kilos. Burning of the foliage had resulted from some applications, and this led to the advice of using at least equal parts by weight of quicklime and copper sulphate.

[1] *Jour. d'Ag. Prat.* 1888, Aug. 2, 151. [2] *Ibid.* Aug. 9, 195.

The Bordeaux mixture still retained its supremacy wherever it was used in comparative trials. Prillieux made one of the most satisfactory tests in this direction in his work on the black rot in 1888.[1] He used, in addition to the Bordeaux mixture, eau céleste, pure solutions of copper sulphate, sulphosteatite, and Carrère powder. The relative value of these materials was in the same order as they are here mentioned. The vines treated with the powders were attacked by the disease apparently as much as those which had received no treatment. The dates of treatment apparently had some effect on the efficiency of all the materials. The first applications seem to have been made too late, for Frèchou said[2] he had obtained excellent results from the use of sulphosteatite and also of the Carrère powder. Lasserre controlled[3] the black rot well by applying only 1 kilo copper sulphate and 1½ liters ammonia in 1 hectoliter of water. His first treatments were made April 28, and he ascribes his success to the timely beginning of the work. He believed that the success of Prillieux might have been even more complete if his applications had been made earlier in the season.

During 1889 a new problem was occupying the minds of the leading French experimenters. It was the general belief that the Bordeaux mixture was too slow in its action, since practically none of the copper contained in it was soluble in pure water. Another reason was advanced for this tardy action of the Bordeaux mixture: Millardet and Gayon said[4] that no copper could be absorbed by foliage until all the excess of lime had been formed into the carbonate. This process was supposed to require from a week to a week and a half. They said[5] that the change took place faster during a fine rain, but even then it appeared that the immediate action of the mixture as soon as applied was, at the best, but very slight. The greater the excess of lime, the longer appeared to be the time required for the copper to enter into solution.

[1] *Jour. d'Ag. Prat.* 1888, Dec. 20, 898.
[2] *Ibid.* Dec. 13, 851.
[3] *Ibid. loc. cit.*
[4] *Ibid.* 1890, Feb. 20, 272.
[5] "Nouvelles Recherches sur le Développement et le Traitement du Mildiou et de l'Anthracnose," Millardet et Gayon, 1887, 8–18.

Millardet and Gayon in 1887 conceived[1] the idea of making the Bordeaux mixture on a new plan. This consisted in leaving about the tenth of one per cent of dissolved copper sulphate in the mixture. As comparatively little was heard of this preparation, it is probable that the difficulty of its preparation was one reason why it was not more extensively used. But others were at work upon the problem and it was eventually solved.

B. Pons, a chemist at Limoux (Aude), worked at it from a chemical standpoint.[2] He took advantage of the fact that when concentrated solutions of sugar and of copper sulphate are mixed with each other, there is eventually formed a precipitate which is a true sulphosaccharate of copper. This precipitate, when dry, is in the form of a very fine, bluish-white powder. Pons modified it in such a manner that the amount of dissolved copper in the Bordeaux mixture could be regulated by the varying amounts of the powder used. His directions for preparing the mixture were as follows:

Dissolve 2 kilos of this powder in 90 liters of cold water. Agitate for five to fifteen minutes. Add to this liquid, while stirring well, 1 kilo of quicklime freshly slaked in 10 liters of water. Stir the mixture for about five minutes and it is then ready for use. At first it entirely resembles the Bordeaux mixture as commonly prepared, but when this precipitate is allowed to settle the liquid above the sediment is of a blue color, whereas in the common Bordeaux it is clear. One-fourth of the copper contained in the mixture is held in solution in this "Bordeaux mixture céleste"; the preparation was so called by Pons.

Pons sent some of this powder, which he called the sulphosaccharate of copper, to Millardet and Gayon in October, 1889, for the purpose of having it tested.[3] They described it as a blue powder, as fine as ashes, but homogeneous in character. When prepared, the mixture was very alkaline, and the precipitate was finer and more abundant than that found in the Bordeaux mixture. On this account the solid matter settled

[1] Millardet et Gayon, "Considérations raisonnées sur les divers Procédés de Traitement du Mildiou par les composés cuivreux," 1887, 14. See, also, E. Mach, "Bericht über die Ergebnisse der im Jahr 1886 ausgeführten Versuche zur Bekämpfung der Peronospora," 1887, 20.

[2] *Jour. d'Ag. Prat.* 1889, Dec. 12, 866. See, also, Barreswil, *Jour. de Pharmacie et de Chemie*, 3me série, vii. 1845, 29.

[3] *Ibid.* 1890, Feb. 20, 269.

very slowly and the use of an agitator was almost unnecessary. When applied to the leaves, the preparation was very similar to the Bordeaux mixture in appearance. It adhered to the foliage equally well, and although a large amount of copper was in solution,—240 grams per hectoliter,—the foliage was in no case burned. These points appear to have been very thoroughly tested the same year, for the leaves often remain on the vines until the end of November.

Michel Perret was another who made use of this mutual action of sugar and copper. He announced in a meeting of the Société Nationale d'Agriculture de France held Nov. 27, 1889 (page 604 of the proceedings), that in cases of rapid invasion of the mildew the action of the Bordeaux mixture was too slow. He maintained that some copper should always be in solution, and said that he had obtained the desired result by means of sugar or molasses. He used the following formula:

Copper sulphate	2 kilos.
Carbonate of soda	3 "
Water	15 liters.

The copper sulphate was dissolved in the water, and the soda crystals were then added. When the precipitation of the copper ceased, there was added to the above

Molasses	200–500 grams.

The mixture was then allowed to stand twelve hours, and then Perret added

Water	1 hectoliter.

The finished mixture is of a deep green color and is very adhesive. His experiments of that year showed that this new mixture preserved the vines better than any other in use at the time. In a letter written later,[1] Perret says that it suffices to use 200 grams of molasses, or one-tenth of the weight of copper sulphate, to render soluble the amount of copper oxide necessary for the rapid action desired. If a larger amount of molasses be added, the effect is simply to increase the amount of dissolved copper.

[1] *Jour. d'Ag. Prat.* 1890, Jan. 30, 183.

It was stated[1] by Patrigeon that the addition of 500 grams of dextrine per hectoliter of those fungicides having a solution of copper carbonate for their principal ingredient, would render them more adhesive. The dextrine should first be dissolved in warm water, and then added to the copper solution.

George Bencker gives an account of the treatments for mildew as carried on in 1890, at the School of Agriculture, at Montpellier, France.[2] The experiments were conducted by Duchien. The list of substances used is interesting from the fact that it shows which materials the French at that time considered as having value. The liquids tested were as follows:

Bordeaux mixture; Bordeaux mixture céleste, containing copper sulphate, lime, sugar, and aluminum calcide; Bordeaux mixture and glue; mixture of carbonate of soda and sulphate of copper; gelatinous hydrocarbonate of copper; verdet; and a mixture of chloride of calcium and alum. The powders: Skawinski's powder; Skawinski's sulphur; cuprosteatite; sulphosteatite; sulphocyanide of copper; sulphated verdet; sulphur with the hydrate of copper; sulphated sulphur; cuprophosphate;[3] and sulphur and cuprophosphate.

Verdet was selected as being the most valuable of the above materials, but later work has not substantiated this conclusion. Verdet is an acetate of copper. There are many such combinations, all being known under the general name of verdet, or verdigris. The form used by Bencker was that technically known as the dibasic acetate of copper. It requires to be soaked in water three or four days before it is used, so that as much as possible will dissolve. It may be applied at the rate of one or two kilos in a hectoliter of water.

De Capol prepared the hydrate of copper as follows:[4] Dissolve 2 kilos of copper sulphate in 20 liters of water. To this add 1 liter ammonia. The oxide of copper is precipitated, and when it has settled to the bottom of the vessel the liquid above is drawn off. This liquid contains sulphate of ammonia in

[1] *Bulletin de la Société des Agriculteurs de France*, 1889, Oct. 15, 795. Also, *Jour. d'Ag. Prat.* 1890, May 15, 703.

[2] *Progrès Agricole*, 1890, Dec. 7, 510; *Annals Hort.* 1890, 82.

[3] This material is easily made by uniting solutions of sodium phosphate and copper sulphate. It is thrown down as a precipitate, the other compounds remaining in solution.

[4] *Jour. d'Ag. Prat.* 1889, March 7, 367.

solution, and should be used for fertilizing purposes. The precipitate is then treated with 10 liters of ammonia and there is obtained a normal solution. Dilute forty times when applying. De Capol believed this to be an excellent preventive against the mildew, and he also said that it would not burn the foliage. The preparation, however, never came into general use.

Messrs. Skawinski were among the first in France to use Schnorf's remedy for anthracnose. But their experience suggested to them a change in the preparation, which led to a general modification of the old formula. They remarked that the action of the iron sulphate was stronger when sulphuric acid was present in considerable quantities with the crystals. They consequently adopted the following:

Iron sulphate	50 kilos.
Sulphuric acid, 53°[1]	1 liter.
Warm water	1 hectoliter.

The best method of making the solution is to pour the acid upon the crystals of iron sulphate, and then slowly to add the water. The amount to be used during the day is made in the morning; if the material is allowed to stand for twenty-four hours or more the salt re-crystallizes, and the applications will not be so efficacious. Skawinski washed the grape wood once during the first days of February. The immediate effect upon the wood is to blacken it, and if this color is not uniformly shown, a second application is made to those portions which were not touched by the first treatment. The above formula has not been uniformly adopted in France, for some growers prefer to increase the amount of acid, and others decrease the amount of iron salt. But as the practice of spraying with such a solution has been well established, and since good results generally follow the treatment, it is safe to say that so long as the plants are uninjured, the use of a definite formula is of minor importance.

In 1890 Dr. G. Patrigeon gave the following directions regarding the treatment of grape mildew.[2] He advised that the first application be made about the middle of May in southern France, and during the first week in June in the more northern

[1] This grade of acid was used because it is less dangerous to handle.

[2] *Jour. d'Ag. Prat.* 1890, May 8, 660.

parts of the country. The second treatment should be made three weeks later, and a third again in three or four weeks. In case of necessity a fourth should be made early in September. He further advised that the material should be applied lavishly, during the first treatment in particular, and that the leaves should be thoroughly covered. He also said that it should be made a point to cover the young grapes, a recommendation which does not appear to have been made before. When the Bordeaux mixture was first coming into use, Millardet said one should be careful not to strike the grapes, and he also made the statement that if only a small amount of the mixture fell upon the leaf it would still afford ample protection. Experience evidently had shown that the work cannot be done too thoroughly.

Patrigeon did not favor the use of powders for the following reasons: they require moist foliage to adhere well; they can be applied only when the air is still; more applications have to be made; and the vines are not so well protected.[1]

He considered as entirely unfit for use upon foliage the simple solution of copper sulphate, and the eau céleste of Audoynaud, because they burned the leaves. The materials which could be advantageously applied were reduced to those mixtures or solutions that contain copper in the form of the hydrate (*hydrate oxide*) or of the hydrocarbonate. There were several of these already in use.

Patrigeon was the first to use and to advise the use of the ferrocyanide of potassium as a test for determining the proper amount of lime required in making the Bordeaux mixture.[2] His directions were to add to the Bordeaux mixture a few drops of a 20 per cent solution of this chemical. So long as dissolved copper exists in the mixture, the addition of the ferrocyanide of potassium causes a reddish brown precipitate to appear. Lime should be added till no change takes place when the reagent is added. Some vineyardists used blue litmus paper for the same purpose.[3]

During these years the diseases which affect grapes received by far the most attention. Jouet and Prillieux were among

1 *Jour. d'Ag. Prat.* 1890, May 8, 660. See also, "Réunion publique des Viticulteurs du Midi," held at Montpellier, March 4, 1890.

2 *Ibid.* May 15, 701.

3 A. Petit, *Le Progrès Agricole*, 1890, June 1, 441.

the first to use the remedies (see page 29) on other plants, and some experimenters soon followed their example. Aimé Girard[1] in 1888 and 1889 made some very conclusive experiments upon the potato. Among the points emphasized by him may be mentioned the fact that curative applications do not assure complete immunity; he also noticed that there was a great difference in the varieties as regards their susceptibility to the disease.

Chatrin applied the Bordeaux mixture to pears in 1890[2] for a disease commonly known as "tavelure." It is caused by a fungus, *Fusicladium pyrinum*, and his applications are said to have been followed by good results. Another fungous disease commonly known as "cloque," probably due to some species of Taphrina or Exoascus, was receiving attention.[3] The trouble is mentioned as affecting peach trees. It causes the leaves to curl in a manner similar to that which is only too frequently seen in America. Lesne advised growers to spray their trees with the Bordeaux mixture, but this recommendation does not appear to have been founded upon successful work.

Aimé Girard[4] conducted some experiments to test upon potato foliage the adhesive powers of various fungicides. His conclusions are as follows:

"1. Copper compounds adhere to foliage with different degrees of persistence.

"2. Under the action of severe rains, copper disappears largely on account of the mechanical action of the water.

"3. Among these compositions the one which washes the most is the Bordeaux mixture of various formulas. The diminution of the proportion of lime augments a little the adhesive power; but the addition of aluminous materials does not produce any sensible amelioration.

"4. The precipitated carbonate of copper (*bouillie cupro-sodique*) on the one hand, and verdet on the other, have the faculty of adhering almost twice as well as the Bordeaux mixture. But above all others Perret's mixture of copper, lime, and sugar [see page 43] resists the action of rains remarkably well. Therefore the last is to be preferred, other things being equal, and its use is advised."

[1] *Jour. d'Ag. Prat.* 1890, June 5, 803.
[2] *Ibid.* Nov. 20, 755.
[3] *Ibid.* 1891, May 21, 736.
[4] *Ibid.* 1892, Feb. 4, 177.

In 1891 Millardet and Gayon also made a comparative test of various fungicides.[1] Their work, however, did not consider mainly the adhesive power of the fungicides, but rather their general efficiency. During 1890 they applied the sulphosaccharate of copper of B. Pons (see page 42). The downy mildew was not sufficiently severe to show the value of the fungicide and no report could be made. In 1891 Pons sent another preparation to Millardet and Gayon, this being known under the convenient term "*bouillie bordelaise céleste à poudre unique.*" It was in the form of a very fine blue powder, and was composed essentially of the powder of Bordeaux mixture céleste, sulphate of copper, the carbonate and the bicarbonate of soda.

The amount of the powder used per hectoliter of water was two kilos, this containing exactly one kilo of copper sulphate. The powder was added to the water, was thoroughly stirred, and then applied. The material is so fine that it settles very slowly, probably not before twenty-four hours; the liquid above it is blue and contains a little more than one-tenth of the total amount of copper in solution in the form of the bicarbonate.

The above preparation was used in comparison with the following: the Bordeaux mixture as commonly made (see page 40), Bordeaux mixture céleste (see page 42), Bourguignonne mixture (see page 32), Berrichone mixture of Dr. Patrigeon (see page 37), Bordeaux mixture and the sulphate of ammonia, and Bordeaux mixture and glue (see page 28). The results of these applications were as follows:

"1. All the mixtures, containing equal amounts of copper, have shown an equal degree of efficiency, and the attack of mildew was severe. The mixture containing the sulphate of ammonia burned the foliage occasionally and is therefore more uncertain in its action than are the others.

"2. The mixtures which contain copper in a state of solution do not appear to be more active than the common Bordeaux mixture and the Bourguignonne mixture, each of which contains none. In no case was there for some time a hard rain after the applications, a circumstance which should diminish the efficiency of these two preparations, and augment comparatively the efficiency of the others.

[1] *Jour. d'Ag. Prat.* 1892, Feb. 18, 231.

"3. The bouillie bordelaise céleste à poudre unique is as effective as the others. This is an important point, for the mixture is easily prepared and it dispenses entirely with lime, which is the main objection to the Bordeaux mixture.

"4. The use of one kilo of copper sulphate in these mixtures is not sufficient for obtaining the best results in treatments similar to those just mentioned. If more of the sulphate is not used, a larger number of applications must be made, or more material used at each application."

A case is mentioned[1] in which applications of sulphosteatite were followed by as good results as could be expected from the use of the Bordeaux mixture. At Norbonne, Cenon, and in other portions of France near Bordeaux, this powder had been regularly used for years in the prevention of mildew, and it proved to be very efficient in preserving the fruit as well as the foliage of the vine, even during seasons when untreated plants lost all their leaves. At the estate of Andoque de Seriege, near Norbonne, the powder was applied throughout the vineyards in connection with sulphur. In this manner both the downy mildew and the oidium were simultaneously treated. Some growers in this region used the Bordeaux mixture early in the season, and sulphosteatite for later applications.

At present but little experimental work is being done with fungicides in France. The Bordeaux mixture has become by far the most popular fungicide, and there are now no indications of a superior article to replace it. Fungous diseases do not appear to be so generally severe in Europe as in America, and this accounts for the fact that grapes and potatoes, which are the plants most seriously attacked, are the only ones generally treated. Applications are made upon other plants as well, but only to a limited extent, and for less serious diseases.

The vineyards of France commonly receive the following applications, the work being considered as a regular duty, coordinate with cultivation or pruning. It is an established fact that the vines must be sprayed, and the work is done essentially as follows. Three or four applications, depending upon the season, are considered sufficient:

1. The vines are sprayed when in blossom, or soon after, with the Bordeaux mixture.

[1] *Jour. d'Ag. Prat.* 1892, Feb. 18, 231.

2. The application is repeated in four or five weeks.

3. The mixture is applied within three to six weeks after the second treatment. If the weather is inclined to be wet, a shorter interval is allowed between the two.

4. A fourth application is not regularly made. In case of a wet season it is made three or four weeks after the third. A fifth treatment is rarely thought necessary.

Insecticides.

The insecticides in use in France during these years are, with few exceptions, still of the same general character as those used in the past. Black soap was very commonly employed. It was recommended,[1] in connection with amylic alcohol, for the destruction of the "puceron lanigère" (woolly aphis). The formula given is:

Black soap	35 grams.
Amylic alcohol	60 "
Water	1 liter.

Dissolve the soap in the water and then add the alcohol. The material was applied by means of a broom or a syringe. The alcohol was sometimes replaced by 10 per cent of phenic acid, this and the soap forming an emulsion.

Other recommendations for the destruction of the same insect have also been made.[2] In addition to the black soap wash are mentioned:

Aloes	4 grams.
Water	1 liter.

Also,

Oxalic acid	15 grams.
Water	1 liter.

And another, a commercial preparation:

Insecticide Fichet	250–300 grams.
Water	10 liters.

[1] *Jour. d'Ag. Prat.* 1887, May 12, 680. [2] *Ibid.* June 30, 923.

The most important additions to the list of insecticides made in France were American remedies. During 1884, Professor C. V. Riley of the Agricultural Department at Washington, visited France, and in an address delivered before the Société Centrale d'Agriculture de l'Hérault, June 30, 1884, he spoke of the emulsions of kerosene with milk or soap, of the arsenites as used in America, and of pyrethrum.[1] The formula for making the first preparation was as follows:

Petroleum	8 liters.
Common soap	175 grams.
Water	4 liters.

Dilute with water as experience may suggest. The directions were slightly modified in later years, but on the whole this remedy was soon widely used in France.

Although the attention of experimenters was more particularly directed towards the fungous diseases of plants, various other insecticides were tested.

For large caterpillars, Leizour advised the use of

Water	25 liters.
Sulphide of potassium	100 grams.
Black soap	250 "

The soap and the sulphide of potassium are separately dissolved in a few liters of water. The two are mixed, and the remaining amount of water is added immediately before the applications are made.

A remedy supposed to be particularly valuable for the destruction for the woolly aphis was made by taking,

Water	100 grams.
Benzine	50 "
Strong glue	10 "

This was to be applied in March and April. A decoction of datura plants, when used with the sulphate of iron, was also recommended, as well as amylic alcohol and soap water.[2]

Another preparation of a more complicated character was recommended for the same insects. Chemicals having proved

[1] *Messager Agricole*, 1884, July 10, 255.
[2] *Jour. d'Ag. Prat.* 1890, June 19, 901.

so valuable in the destruction of fungi, it was probably supposed that some material could be found which would bear the same relation to insects that the copper compounds do to the mildew. The idea was certainly a good one, but since no such substance at that time in general use by the French has remained as a leading remedy, their new introductions appear to have been at least only partially successful. The use of the following formula was advised:

Salicylic acid	2 grams.
Red oxide of mercury	2 "
Pyrolignic acid	1000 "

The above was diluted with 30 parts of water when applied.

The cochylis (*Cochylis roserana*) is an insect which often does much damage in French vineyards, as it feeds upon the leaves and the inner portions of the berries. One preparation which was recommended[1] for its destruction is made as follows:

Carbonate of soda	100 grams.
Rain water	1 hectoliter.

When dissolved add to the solution a mixture of

Carbon bisulphide	1 part.
Oil (Colsa, etc.)	1 "

The last two ingredients form an oleo-sulphide of carbon, 10 liters of which are poured into each hectoliter of the carbonate of soda solution, thus forming an emulsion of carbon bisulphide. Quantin, director of the agricultural laboratory of Loiret, said he had freed his vines of the cochylis by means of the above remedy.

A. Lesne[2] tried experiments with eighty preparations for the destruction of the cochylis. His work showed that a preparation of pyrethrum and soap gave the best results. He had it tested by thirty-seven vineyardists and most of them reported favorably regarding it. The ingredients used were

Black soap	3 kilos.
Warm water	10 liters.
Pyrethrum powder	1–1½ kilos.

[1] *Jour. d'Ag. Prat.* 1891, Aug. 6, 209.

[2] *Ibid.* 1892, May 5, 639.

The pyrethrum is added to the soap solution and the two are well stirred; 90 liters of cold water are then put in, and the mixture is ready for use.

Many other preparations were made, but they were composed principally of the ingredients mentioned above, although the combinations and the proportions varied more or less; petroleum, however, is very often mentioned in them.

The arsenites have not as yet been applied to any considerable extent, and the use of pyrethrum has been limited, yet the time may come when the former will be applied as freely as is now done in America.

II. In Italy.

Italian horticulturists have followed the French so closely that little can be said concerning the discovery of new methods in Italy. Milk of lime gave great promise during the first year of the invasion of the downy mildew, as already mentioned on page 20. But this substance was soon replaced by the copper compounds, and the French methods were adopted almost as early as they were in France. At present, the Bordeaux mixture is also the standard fungicide in Italy, and sprayed vines can everywhere be seen during the summer months.

Italian chemists have, however, taken the lead in the study of the various materials used as fungicides, and the principal results of their work of this nature will be found in the chapter treating of the materials and formulas used in spraying.

III. In Other Continental European Countries.

The European mildew of the grape (*Oidium Tuckeri*) is said [1] to have been introduced from England into Germany about forty years ago, and from there it spread to France, the Tyrol, and Italy, causing much damage. The remedy generally adopted was to apply flowers of sulphur upon the fruit and foliage, and this proved effectual in preventing its ravages.

The downy mildew, however, was introduced into Europe by way of southern France. Although it was rapidly disseminated,

[1] Held, "Weinbau," 1894, 125.

the proper remedies for its control were soon found, and as the disease became more widely distributed, the best remedies discovered in the region first attacked were adopted by the newly infected districts, with practically no modification. It has thus been brought about that the Bordeaux mixture, the ammoniacal solution of copper carbonate, the eau céleste, and solutions of copper sulphate, have become standard remedies in those countries which have been last to suffer from the imported American diseases. These fungicides are generally applied as in France. In Germany, however, care is taken that no applications are made during the blossoming period, and there seem to be good reasons for the practice. Later applications are made often enough to prevent injury from fungi, the numbers varying from two to five, three being more commonly made. Anthracnose of the vine is treated as in France, and appears to be held under control without much difficulty.

Confidence has thus again been restored where not more than ten years ago there prevailed the greatest anxiety regarding the future of the grape industry.

IV. In England.

The English have been slow to adopt new remedies for plant diseases. While French growers were struggling to overcome the downy mildew of the grape and the rot of potatoes, British gardeners were practically helpless in dealing with them. Even after success had rewarded their southern neighbors, the new methods were but slowly adopted in England. The horticultural journals of that country, on the contrary, were quick to see the value of the work that was being done, and the French recommendations were repeatedly published. The first account appears to have been given in *The Gardeners' Chronicle*.[1] This was a translation of a report made by Prillieux, inspector-general of agricultural education, to the minister of agriculture of France, regarding the value of a mixture of copper sulphate and lime against the mildew of the vine. The account contains a brief history of the work done in the Médoc, and also mentions the names of the men who were most prominently connected with it.

[1] *Gard. Chron.* 1885, Nov. 7, 594.

The sulphide of potassium was at one time very highly recommended in England. It was first successfully applied by Edmund Tonks.[1] He used one-half ounce in a pint of water, and it proved to be very effective in controlling the mildew of roses. This soon became one of the best known remedies in England, and may have been influential in delaying the adoption of French practices.

A note published in 1887 [2] says that "the sulphate of copper is being used largely in America and France against mildew on vines. It is even suggested as a remedy for potato mildew, but as this grows in the interior of the plant it is difficult to see that it can effect much good. Amongst several methods of applying the copper solution, the simplest is to dissolve 1 pound of the pure sulphate in 25 gallons of water. Spray the vines with a force-pump with a nozzle of fine aperture. The addition of 1 pint of ammonia to the above solution adds to the effect. By ammonia we presume a solution of the carbonate is intended."

The progress made in France was carefully watched by some of the English journals. The results of the more important experiments were published, and English gardeners were not wanting in information regarding the value of the copper compounds. A few of the more important articles may here be mentioned. *The Gardeners' Chronicle* was especially active in this respect, and in 1888 [3] it gave an account of the method of making the Bordeaux mixture as recommended by Prillieux. Three weeks later [4] it speaks of the experiments of Prillieux regarding the treatment of potatoes for the blight. These experiments were very successful, and if the methods had been adopted in England great losses would have been prevented. During January of the following year [5] there appeared a translation of an article in the *Revue Horticole* regarding the proper manufacture and use of the sulphate of copper and lime mixture. Several such translations were made during 1890, but these were apparently not heeded until 1891,[6] when the Royal Agricultural Society of England conducted some experiments for the prevention of blight upon potatoes. These experiments are probably

[1] *Gard. Chron.* 1885, Feb. 28, 276.
[2] *Ibid.* 1887, Aug. 6, 166.
[3] *Ibid.* 1888, Sept. 1, 244.
[4] *Ibid.* Sept. 22, 332.
[5] *Ibid.* 1889, Jan. 12, 50.
[6] *Ibid.* 1891, Aug. 1, 137.

the first of any importance which were undertaken in England, yet they were not begun until four years after the value of the copper compounds had been known there. Messrs. Sutton and Sons undertook a similar work. These first trials were not so successful as had been hoped, and undoubtedly prevented, to a certain extent, the more general adoption of the remedies.

The French authorities were almost exclusively quoted until 1891. By this time the work in America had assumed such proportions that much information of a very varied character was continually appearing. This was freely abstracted by the English journals, and during 1890 and 1891, doubts regarding the value of the copper compounds as fungicides were partially removed from the minds of English gardeners. But faith came slowly. The Highland and Agricultural Society made experiments which were discouraging in their results,[1] and as a rule the first trials were not followed by such marked benefits as were reported from continental Europe. As the methods of making the application improved, however, the growers became encouraged, and during the last two or three years potatoes have been very generally treated with copper compounds for the blight by the more progressive growers. The successful issue of experiments made in the United States has, no doubt, materially assisted in bringing about this result.

The new insecticides have been adopted by English gardeners even more slowly than were the fungicides. Although the value of kerosene for the destruction of insect life has long[2] been known there, its use is still very limited. This, in all probability, is due to the fact that the remedies already at hand are so effective that little demand is felt for others, — a condition of affairs upon which English gardeners are to be congratulated.

The arsenites also are very rarely applied, not only in England but throughout Europe. Their use is not so imperatively demanded as in America, and as there is a certain amount of danger in having them upon the premises, they have not been looked upon with favor. The use of arsenic for the destruction of insects is by no means a novelty in England. Mr. Gordon, the superintendent of the ornamental department of the

[1] *The Garden*, 1892, Feb. 6, 133, based upon an article appearing in the *Morning Post.*

[2] *Gard. Chron.* 1882, July 15, 85. Also known as Paraffine in England.

garden of the London Horticultural Society, says that "small brown ants are also very troublesome [to orchid growers], but they may be destroyed by placing sugar and arsenic, ground to an impalpable powder, on bits of card near the places they frequent."[1] A fear of poisoned fruit following the use of arsenic has also been expressed, and this, although perfectly groundless, has worked against the introduction of such remedies. But nevertheless, spraying has now become the rule and not the exception in some parts of England.[2] This applies particularly to "the various fruit farms around Evesham and Pershore" and may also be true of other localities. The benefits derived from the practice are being appreciated, and eventually all growers must see the necessity of its adoption.

V. In Australasia.

Plants suffer from disease wherever they may be grown. If they are introduced into a new locality, the old diseases follow them. Such has been the case in Australia and Tasmania. These countries have recently taken a prominent position as producers of fine fruit, but here, as elsewhere, the horticulturist must be constantly on the alert to save his crop from some other claimant. The spray evidently did not meet with much opposition in those far-away lands, but it was welcomed as an agent which would assist in the production of more perfect crops. As early as 1886, F. S. Crawford[3] experimented with ferrous sulphate and later he recommended its use at the rate of one pound to ten gallons. It was only to be applied to dormant wood. The following compounds are also mentioned, all but the first two being quoted from American publications: carbolic acid emulsion, copper sulphate, eau céleste (Audoynaud process), eau céleste (modified formula), Bordeaux mixture, sulphatine, sulphatine (Davenport's modification), and David's powder.

[1] George Gordon in a paper, "Notes on the Proper Treatment of Epiphytal Orchids," *Jour. of the London Hort. Soc.* iv. 19, communicated in Nov. 1848.

[2] *Jour. of the Royal Hort. Soc.* 1895, Jan. 185.

[3] Extract from a paper by F. S. Crawford, read at the Congress of the Central Bureau of Agriculture of South Australia, held in Adelaide, 1890, March 4–7. Cited in *Gard. Chron.* 1890, July 19, 69.

Tasmania has been remarkably vigorous in fighting insect and fungous pests, and the government has passed a law (52 Vict. No. 16) which makes it a finable offense for a grower to neglect cleaning his orchard:

"'The Colony of Tasmania is divided into thirty "fruit districts" to make better provision for the destruction of the codlin-moth. Every person who sells, or offers for sale, any fruit infected with the moth is liable to a penalty of five pounds.

"'Bandages to be placed upon the trunks of the trees not later than December in each year.

"'Farmers shall remove all rough and scaly bark from trees, and burn or otherwise effectually destroy such bark as soon as removed.'

"Similar methods are in use in Australia. There are persons appointed by the Agricultural Bureau in each district (I believe there are eighty odd districts in Australia, and over thirty in Tasmania) to see that the law is not evaded."[1]

[1] *Jour. of the Royal Hort. Soc.* 1895, Jan. 185.

CHAPTER III.

SPRAYING IN AMERICA.

I. In the United States.

Spraying for Leaf-eating Insects and the Codlin-moth.

It was not until about 1860, when a ravenous insect — the currant worm — had been introduced into the Eastern States, and another — the potato beetle — into the Western, that American farmers fully realized the necessity of discovering some materials which would be more energetic in the destruction of insect life than any at that time in common use. Hellebore was only partially successful in treating the currant worm, as the fresh article could not always be obtained, and it was of little value after having been long exposed to the air. The insecticidal value of kerosene had long been known, but the use of the oil was not understood, so that it was only sparingly applied. In the Eastern States, therefore, the progress of the currant worm was not very seriously checked, and the majority of the plants were defoliated year after year.

Since the insecticides then known were of so little value in exterminating a soft-bodied, chewing insect like the currant worm, how much less would be their effect upon such a vigorous and well-protected individual as the potato beetle! This insect, a native of the Rocky Mountains, began to travel eastward when potato culture had extended so far to the west that the plant was grown in the territory occupied by the beetle. It then left the plants upon which it had been feeding, and attacked the potato vines. The march to the east then followed. In 1859 the insect had "reached a point one hundred miles to the west of Omaha City, in Nebraska."[1] In 1868 it extended

[1] Riley, "Potato Pests," 1876, 12.

to central Missouri and southern Illinois. In July, 1870, the insect was found in Ontario, Canada; and in 1872 it arrived in central New York. Two years later, it reached the Atlantic coast, having crossed nearly two-thirds of the continent in the short space of fifteen years.

The insects ate as vigorously as they traveled. Potato fields were stripped of every vestige of foliage; desolation could everywhere be seen; and as this increased, the yield of tubers decreased. At first, it seemed as if nothing could stop the ravages of the pest, and it threatened the entire potato industry of the country. All known remedies failed, and the future must have appeared dark to the Western planters, until some remedy could be found that would destroy the beetles, and save the foliage of the vines.

Fortunately, this remedy was not long in coming; but who first suggested it, and who first used it for the destruction of the potato beetle, will perhaps never be told. Paris green appeared upon the scene sometime between 1860 and 1870. The use of this deadly poison may have originated with several persons; for some poison of this nature was evidently needed to destroy such a voracious feeder. The use of Paris green as a standard insecticide undoubtedly began in the Western States, and there the applications to the vines were considered as of primary importance in securing a crop. The use of the poison was, to a limited extent, checked by the possible dangers connected with its careless handling. It is also very injurious to foliage, when applied pure, especially in large quantities, and this may have exerted a certain influence in preventing its general adoption. But the weight of these objections was soon overcome by the absolute necessity of treating the vines in order to save them.

In 1868 the value of the poison appears to have been fairly well known,[1] one man going so far as to obtain a patent upon a mixture of one part Paris green and two of mineral paint.[2]

[1] *American Entomologist*, 1869, July, 219, citing from the *Galena* (Ills.) *Gazette*. The editors of the *Am. Ent.* also carried on experiments in 1868. See, also, an account of the experiments made by Saunders and Reed, in which were tested Paris green, arsenious acid, copper sulphate, bichromate of potash, powdered hellebore, carbonate of lime, and ashes mixed with air-slaked lime; none of these, except Paris green, were found to be of value. *Canadian Entomologist*, 1871, July, 41.

[2] Riley, *U. S. Ent. Com.* 1880, Bull. 3, 57.

In after years, several other patents were granted upon various mixtures in which this poison held a prominent position.[1] The arsenite was most generally applied, however, by being mixed with flour, plaster, or ashes, the proportions varying from two to ten or twelve parts of the diluent to one of the poison. The proportion of poison was greatly reduced in later years, only one part to twenty-five or thirty being used.

Applications of Paris green, when mixed with water, do not appear to have been commonly made during the first few years following the introduction of the poison. The difficulty of transporting the water appears to have been one of the main objections to this method; and another, perhaps an even more serious one, was the imperfect distribution which resulted from sprinkling the plants with the aid of only very unsatisfactory appliances, watering-cans or brooms being at first used for this purpose. It is only since the introduction of improved machinery that the poison has been generally applied in this manner.

The success attending the use of Paris green in the destruction of the potato-beetle soon suggested its application to plants that suffered from similar insect pests. In 1872 Riley suggested the treatment of cotton plants with Paris green for the destruction of the cotton worm.[2] It was advised to use from one-half to one pound of the poison in forty gallons of water, this being considered as sufficient for a single treatment of an acre. The poison is still extensively used, although the proportions of the water and the arsenite have varied.

Le Baron, in 1872, made a suggestion which was followed by consequences vastly more important than were probably dreamed of by its originator. The spring canker-worm of the apple was doing much damage in the West, and in spite of the many devices invented for its capture or destruction, the pest continued to spread, and serious losses were inflicted. The recommendations made by Le Baron,[3] at that time state entomologist of Illinois, were for the growers to place their main reliance upon measures which prevented the insect from gaining a foothold in the trees. In case such precautions should be

[1] Riley, *U. S. Ent. Com.* 1880, Bull. 3, 57.
[2] *Ibid.* 56.
[3] *Second Ann. Rept. on the Noxious Insects of the State of Illinois*, 1872, 116

neglected, however, he says that "strong washes, such as Paris green water, or suds made from the whale-oil soap, thrown upon the trees with a garden syringe, will also materially check their depredations." This is the first statement which I have been able to find in which the syringing, or spraying, of apple trees with Paris green is recommended. and it was adopted to a limited extent in Illinois in 1873.[1]

This note attracted but little attention on the whole. It was not until four years later that Cook advised the use of Paris green for the destruction of canker-worms, and even at that date its use was supposed to injure the tree at certain times, and the total loss of fruit was not thought improbable.[2] In 1878 many orchardists in Michigan sprayed their trees with a mixture of Paris green and water, and from that time the use of this poison has been considered, in that state, as the best means of destroying the pest.[3] Eastern growers, with scarcely an exception, were slow to imitate the more progressive Western pomologists. As late as 1877, H. T. Brooks still recommended to the members of the Western New York Horticultural Society the use of bandages upon apple trees to prevent insects from ascending the trunks; and two years later a member of the same society "had known them [the cankerworms] destroyed by showering the trees with a solution of Paris green."[4]

Paris green, or some other form of arsenic, was nevertheless destined to play another important part in the destruction of insects that were injurious to apples. The codlin-moth, which in the larval stage causes apples to be "wormy," was flourishing unchecked upon this fruit throughout the Central and Eastern States. Several remedies were suggested, but none appeared to possess much practical value. An effectual remedy was eventually found, not by entomologists, however, but by practical growers. The first statement that attracted attention, and which was followed by close investigation, appears to have been made by Edward P. Haynes, in 1878. He was then living near Hess Road, Niagara County, N.Y. In the spring of 1878 he

[1] *Third Rept. U. S. Ent. Com.* 1880–82, 192.
[2] *Rept. Mich. Pom. Soc.* 1876, 43.
[3] *Ibid.* 1878, 236.
[4] Chapin, *Rept. of West. N. Y. Hort. Soc.* 1879, 74.

applied to J. S. Woodward, of Lockport, N.Y., for advice in regard to the best method of treating the canker-worms which were then ruining his apple trees. Mr. Woodward advised the use of Paris green. I will here quote from a letter which Mr. Woodward was so kind as to send me in May, 1894: "I advised him to spray with Paris green, and went with him to get the necessary apparatus. He took it home and used it, and when I saw him again the following fall, he told me of its having not only rid the orchard of canker-worms, but that the apples on the sprayed part were much less eaten by codlin-moths. I was so much interested that I went to see the orchard and was convinced that the spraying had done what he had said. This fact I reported at the following, January, meeting of our society [West. N. Y. Hort. Soc.] and shall never forget this because of the way in which I was jumped upon as a crank."[1] The record, which may be found in the report of the society, is undoubtedly the first that gives an account of the successful treatment of the codlin-moth by means of Paris green. The same fact was also mentioned in a meeting of the Michigan Pomological Society held in Hillsdale, Feb. 11–13, 1880.[2] At the annual meeting of this society, held at Ann Arbor, Dec. 6–8, 1880, Professor Cook reported having used the remedy suggested by Mr. Woodward with the following result: "I thoroughly sprayed some Siberian crab-apple trees the 25th of May, and again the 20th of June; but I used London purple, 1 tablespoon to 2 gallons of water. The fruit of these trees has been seriously injured whenever they have borne during previous years. This year they were loaded with fruit, but careful examination, made Aug. 19th, discovered not

[1] Rept. of a meeting of the West. N. Y. Hort. Soc., held in Rochester, 1879, Jan. 22, 23, 20. It appears that the same discovery was also made at this time in Iowa. According to *Rural Life* of May 30, 1895, 13. London purple was used in 1878 to destroy canker-worms, and this is said to have saved the crop from the codlin-moth: "Hon. John M. Dixon, of Oskaloosa, was then [1877] trustee of the Iowa Agricultural College. He watched our work and concluded he would try spraying on his big orchard to destroy the canker-worm. In doing this he made a great discovery. The spraying was timely for destroying the codlin-moth. He marketed, in 1878, carloads of apples in Minneapolis entirely free from worms or wormholes. Mr. Dixon and the writer [Professor Budd] told of these results in the horticultural reports and the press, yet so far as we know others have been given the credit for this pioneer work."

[2] *Rept. Mich. Pom. Soc.* 1880, 26.

a single injured apple. Other apple trees, only a few rods distant, which were not treated with the poisonous liquid, are bearing fruit, one-fourth to one-half of which is 'wormy.'"[1] This is probably the first experiment made by an entomologist for the control of the codlin-moth by the use of an arsenical compound. Still, scientists were slow to recommend the use of the poison. The year following, Cook said: "I have been very successful in the use of Paris green, and others have, and for myself I would not hesitate to use it, but some of our best entomologists consider there is great danger in the use of this poison, and I prefer not to be put on record as recommending it for others' use. I used the poison on my own trees, and shall not hesitate to do so again."[2] Woodward at the same time said that the remedy was regularly used in western New York, where "two men will spray one hundred trees in half a day, . . . and I have yet to learn of a single instance where any one has been injured by the use of the poison."

Notices of this work appeared in most of the leading agricultural papers. Yet comparatively little was heard of the use of Paris green for the destruction of the codlin-moth during the next few years. Orchardists seemed to hesitate in applying the poison for this insect, although it was quite freely used for the canker-worm. But very few of the most progressive men adopted the method, with apparently satisfactory results. After the establishment of the experiment stations, in fulfillment of the requirements of the Hatch bill of 1887, a new impetus was given to the adoption of the arsenites. As different experimenters published the results of their work, the value of the practice became more generally known, and gradually an ever-increasing number of growers accepted the assistance of the arsenites in the production of perfect fruit.

For several years after the discovery of the successful treatment of the canker-worm, recommendations regarding the destruction of other foliage-eating insects were more freely made than adopted. In the report of the United States Department of Agriculture for 1878, C. V. Riley recommended the use of Paris green for the destruction of the following insects: Chapin's apple-leaf sewer, the thick-thighed walking stick, the imported elm-leaf beetle, the juniper web-worm, and the apple

[1] *Rept. Mich. Pom. Soc.* 1880, 136. [2] *Ibid.* 1881, 130.

coleophora. The first regular experiment station to publish results of the use of Paris green for controlling the codlin-moth was the New York State station;[1] Goff had used it the preceding year also with apparently good results against the squash vine borer.[2] It was in this and the following decade that Paris green and London purple established themselves firmly as the most valuable agents for the destruction of chewing insects.

London purple was early in the field as a rival of Paris green. It is cheaper than the latter, contains large amounts of arsenic, and can be more easily applied. But its composition is not so uniform, and it is more apt to injure foliage, so that on the whole Paris green has been preferred. London purple was manufactured in England, and I have been fortunate in learning of the manner in which the poison was introduced into this country. Dr. C. E. Bessey, of Lincoln, Neb., was the first to use it for the destruction of the potato beetle, as a substitute for Paris green, and his work and that of Professor Budd of Ames, Iowa, first attracted public attention to the new insecticide. The name "London purple" was suggested by Dr. Bessey in 1878, and he has been so closely connected with the introduction of the poison that a letter received from him under date of Feb. 20, 1895, is here published in full:

"In my file of letters I find that on Sept. 7, 1877, the London firm of Hemingway & Co., of 60 Mark Lane, wrote me their first letter enclosing a small packet of London purple (not so named then) and asking me to make a trial of it, offering to send one or two casks of the material free of cost. My reply was returned soon enough, so that on Dec. 18, 1877, they wrote again as follows: 'In conformity with your favor of the 22d October we have done ourselves the pleasure of forwarding to your address per steamer *Holland* to New York, thence by express of Messrs. Baldwin Bros. of that city, three kegs of the substance for poisoning the Colorado beetle, and shall be much obliged by your sending us as early a report as you can of the results of the trial experiments you may make with it.'

[1] Goff, *Ann. Rept. N. Y. State Agric. Exp. Sta.* 1885, 246.
[2] *Ibid.* 1884, 318.

"The bill of lading shows that the kegs left New York City on Feb. 2, 1878, but it was near the end of the month when they reached me at Ames, Iowa.

"My next letter from Hemingway & Co. bears date of March 19, 1878, asking as to the arrival of the kegs. The next letter from the firm I have temporarily mislaid, but on July 26, 1878, it wrote as follows: 'We have to thank you for your favor of the 4th inst. and are of course pleased to find that our expectations are correct as to the poisonous nature of the "London purple" to the potato beetle. We anxiously await the result of the further experiments promised in yours, and shall in the meantime have prepared some few tons of the material ready to be sent over.'

"On Nov. 28, 1878, it wrote as follows: 'We are exceedingly obliged for your favor of the 9th inst. and the Nos. 3 and 4 of your college gazette [1] (which came by same mail) containing yours and Professor Budd's kind notice of our new poison (London purple). Since last we had this pleasure, we have been in correspondence with Messrs. Ward & Co., to whom we intend sending our first consignment, and which we intend shall leave here immediately.'

"My letter, in which I suggested the name 'London purple,'

[1] "A CHEAP AND VALUABLE POISON FOR THE POTATO BEETLE. — Last winter the College received, for trial, a quantity of a material called by the manufacturers, 'London purple,' and designed to be used for killing the Colorado potato beetle (the potato bugs of common parlance). Upon trial it was found to be valuable, killing the old as well as the young insects with great certainty. The virtue of London purple lies in the arsenic which it contains, just as in the case of Paris green. There are, however, several advantages possessed by the new poison over the old, among which are, first, its extreme fineness, permitting it to be mixed with water; second, its adhesiveness; when once applied it adheres tenaciously to the leaves,—this is due, no doubt, to its finely divided condition; third, its purple color enables one always to detect its presence on leaves, even when it exists in but very small quantities; this will not only guard against accidents, but at the same time be of considerable account in enabling one to always know when it is necessary to make another application; fourth, its cheapness as compared with Paris green; it will be impossible to say just what the cost per pound will be, until a considerable quantity has been brought into our markets; it will, however, in all probability not be more than one-fourth that charged for Paris green. The London manufacturers are now making arrangements for putting into the market a sufficient quantity for use upon the crop of beetles in 1879. They propose to designate some firm in Des Moines to take charge of the matter of introducing it. When it becomes available it will be well for our potato growers to give London purple the attention it deserves."—*The College Quarterly*, Iowa Agric. College, Ames, Iowa, Vol. i. No. iii. Sept. 1878, 49.

was in answer to theirs of March 19, 1878, so it was written sometime early in April."

In another letter, Dr. Bessey has informed me that during a visit which one of the Hemingway firm paid him in Iowa, the statement was made that the three kegs sent to Iowa were the first sent to America; and the first small packet sent in a letter was one of three which were mailed at the same time, the other two packets being addressed to two gentlemen in the United States. One of these was Professor A. J. Cook, then of Lansing, Mich. The name of the other was forgotten, for no reply had been received from him. Professor Cook's answer had been delayed or had proved unsatisfactory, for all the kegs of the first shipment went to Iowa, as above stated.

The United States Department of Agriculture has also been active in bringing London purple to the attention of horticulturists. In the annual report of the Department for 1878, page 144, is given a chemical analysis of the poison, and its use is suggested as a substitute for Paris green. The first direct recommendation that is found in the government reports to this effect was made by Riley on page 248 of the same publication. He advised the destruction of the juniper web-worm by treating the parts infested with either Paris green or London purple. The same was also made to apply to the apple coleophora. Experiments to test the value of London purple were carried on this year by Riley, and the work was so successful that large quantities of the poison were distributed to various cotton growers in Georgia, Alabama, and Texas, where it was to be used in the destruction of the cotton worm, in 1879. The result of these tests was so satisfactory that London purple was even more strongly recommended than Paris green. When applied in a dry state, the proportions which appeared most promising to Dr. Riley were one-half pound of the poison to eighteen of the diluent. When used with water, one-half pound of the powder could be used to advantage in about fifty gallons of water. During the spring of the same year, 1879, A. R. Whitney, of Franklin Grove Ill., "found it to be a perfect antidote to the canker-worms.[1] . . . "

During this year, Trelease conducted some experiments for J. H. Comstock, who at the time was chief of the Division of

[1] Riley, *U. S. Ent. Com.* 1880, Bull. 3, 60, 61.

Entomology, in which London purple was used in comparison with several other substances.[1] In this test Paris green proved the most satisfactory, then arsenious oxide, while London purple stood third on the list. The principal objection to the last two materials was that they scorched the foliage of the cotton plants to which they were applied. The conclusion was also reached that it is more economical to apply the powders when mixed with water than in the powder form, only about one-half as much poison being required by the former method.

The value of London purple as an insecticide was recognized with surprising rapidity. The experiments of Comstock and of Riley were widely copied, and although there were some serious objections to the use of this arsenite, its cheapness and the ease with which it could be applied were greatly in its favor. Cook used it successfully in 1879 against the codlin-moth, and with such recommendations it soon won public favor. The principal objection to its use was the danger of scorching the foliage of the plants, and this probably is the main reason why it did not entirely supersede Paris green. It is also less uniform in its composition, which renders it of uncertain value. Yet it was only about three years after its introduction that the value of London purple was generally considered to be nearly equal to that of Paris green, and it is so considered to-day.

Spraying for the Curculio.

No subject connected with the spraying of plants, with perhaps the exception of the best methods of making the kerosene emulsion, has been the subject of such heated controversy as the spraying of stone fruits with arsenites to protect them from the curculio. The value of the operation seems to have been first noted by G. M. Smith, of Berlin, Wis. In 1870 Riley wrote an article on this practice in which he held it up to ridicule,[2] and the subject was again mentioned by the same writer in an article which states that Smith recommended it "to the Saint Joseph (Michigan) Horticultural Society, and from that time on [the poison] has been occasionally suggested

[1] *Ann. Rept. U. S. Com. of Agric.* 1879, 309.
[2] *Third Rept. State Entomologist of Missouri*, 18.

in the newspapers."[1] The use of the remedy by J. Luther Bowers, of Herndon, Va., in 1880, and by William Creed, of Rochester, N.Y., in 1884, is also mentioned. In this report the statement is made, on page 70, that "Riley, in an address delivered before the Mississippi Valley Horticultural Society, in the early spring of 1885, at New Orleans, in giving his experience as to the feeding habits of the beetle, urged experimentation with the arsenicals in this direction as promising fair results," but I have been unable to find such an expression in the record of the above meeting. In 1885, Forbes, of Illinois, applied Paris green for the control of the codlin-moth, and at the same time noted the severity of injuries caused by the curculio upon the apples. These experiments are reported by Howard,[2] and in one of the conclusions he says: "Treatment with Paris green had saved something more than two-thirds of the apples which would otherwise have been damaged by the codlin-moth, and something more than one-half of those which would have been sacrificed to the curculio."

In 1887 the arsenites appear to have been tested for the first time in the destruction of the plum curculio by an investigator of recognized ability. Cook made some experiments which did not, however, form a very firm basis for the drawing of conclusions. Four plum trees were thoroughly sprayed with Paris green on May 18, the poison being used at the rate of one tablespoonful to six gallons of water. Unfortunately no trees of any of the varieties sprayed appear to have been left for comparison, and the fruit of different trees was injured by the insect to a very unequal extent. The two Wild Goose trees dropped all their fruit. A yellow variety was loaded with fruit of which only 15 per cent was affected while the fourth tree, a purple variety, "had not less than 75 per cent of its fruit badly stung."[3]

During the same year, W. B. Alwood carried on some limited experiments at the Ohio experiment station for the destruction of the plum curculio, using a Paris green spray. His conclusion was: "I am confident the curculios eat enough to make it pos-

[1] *Ann. Rept. U. S. Com. of Agric.* 1888, 69. [2] *Ibid.* 1887, 105.

[3] *Rept. Mich. Bd. Agric.* 1887, 40. See also *Ibid.* 1886, 141, where the same writer expresses little hopes for the success of the arsenites in the destruction of the plum curculio; and Saunders in *Rept. Fruit Growers' Ass'n of Ont.* 1887, 58.

sible to poison some of them, but the benefit to be derived from such is as yet unsettled."[1]

In 1888 Weed made the first report of an experiment planned upon a large scale, in which the method could be apparently well tested.[2] London purple, used at the rate of one-half pound to fifty gallons of water, was applied to seventy-five Early Richmond cherry trees. Three applications were made. As a result, "it was found that 14.5 per cent of the unsprayed fruit gave evidence of curculio attack, while 3.5 per cent of the sprayed fruit was injured. There was consequently a percentage of benefit of 75.8." The same year similar experiments were made upon plums and pears, but, as stated in the record (*Seventh Ann. Rept. Ohio Agric. Exp. Sta.* 134–150), the opportunities for a satisfactory test were not so good as with the cherries, so that although the fruit was saved, less stress was laid upon the result.[3]

Professor Herbert Osborn, of Iowa, also tried to solve the problem during this year. There was a trifling difference between the sprayed and unsprayed plots in favor of the former, but it seems that two species of insects were at work, so that no definite conclusions can be drawn regarding the value of the treatment against the plum curculio alone.[4]

The experiments made by Professor Cook during 1888 were somewhat more extended than those of preceding years, but still rather limited. The trees, cherries and plums, were sprayed three times, June 6, 12, and 20, and the results obtained appeared to warrant the following conclusions: "From these experiments, and those of former years, I conclude that while one application will not save our plums and cherries, and prevent apples from being stung, two or three applications may be of signal advantage.[5]

In 1889, Cook repeated his former experiments. At the close of the work his opinion was decidedly against the application of arsenites. He says: "All the trees were severely attacked and all the plums were lost. . . . The arsenites will

[1] *Ann. Rept. U. S. Com. of Agric.* 1888, 70. This is the first published statement of his work.

[2] *Ohio Agric. Exp. Sta.* Bull. 4, second series, 39.

[3] Weed, *American Naturalist*, 1891, Jan. 70.

[4] *Ann. Rept. U. S. Com. of Agric.* 1888, 72–75.

[5] *Mich. Agric. Exp. Sta.* Bull. 39, 9.

protect against the plum curculio if they can be kept on the tree or fruit. But in case of frequent rains, the jarring method will not only be cheaper but much more effective."[1]

Professor C. P. Gillette experimented this year apparently in the same orchard formerly used by Osborn. Although the curculio did but little injury, still "the indicated saving of fruit that would have been injured in the absence of treatment was 44 per cent."[2] In a report of the work, attention was called to the fact that reliable results cannot be obtained unless solid blocks of trees are treated.

The work done by Weed is by far the most valuable and convincing of the year. A condensed account of his operations during 1889 as well as 1890 is as follows:[3]

"In 1889 the cherry experiment was duplicated, the parts of the orchard being reversed to eliminate any possible effect upon the results that might be due to the situation. In 1888 the west half was sprayed, and the east half left as a check; in 1889 the east half was sprayed, and the west left as a check. London purple was applied three times, in the proportion of one pound to 160 gallons of water. At time of ripening, 1000 cherries were picked from each of twenty-four trees in each half of the orchard — a total of 48,000 cherries — and examined for curculio injuries. The percentage of injury on the untreated trees was 6.17, while on the treated trees it was 1.5. This gives a percentage of benefit of 75.6, — just .2 per cent less than in 1888. Plums sprayed with a combination of London purple and the Bordeaux mixture matured a full crop, while unsprayed trees a few rods distant lost all their fruit. The record of this years' work will be found in the bulletin of the Ohio agricultural experiment station for September, 1889 (Vol. ii. 133–143).

"While these experiments were made as complete and satisfactory as circumstances would permit, and every essential detail was inserted in the records, they were open to three objections, namely: First, that while the remedy might work in a region like central Ohio, where fruit-growing forms only a small proportion of the agricultural interests of the inhabitants,

[1] *Proc. Tenth Meeting Soc. Prom. Agric. Science*, 1889, 28. Cited by Weed in *American Naturalist*, 1891, Jan. 67.

[2] *Iowa Agric. Exp. Sta.*, 1890, May, Bull. 9, 386.

[3] *American Naturalist*, 1891, Jan. 70–72.

and where the curculio, though abundant, is not so overwhelmingly present as in a region almost exclusively devoted to fruit production, it might be impracticable in the latter region; second, that the plum orchard was not sufficiently large to make a test under the conditions of the commercial orchardist; and third, that the cherries upon which some of these experiments were conducted ripened before the season of egg deposition of the curculio was over. The force of these objections was fully appreciated while the experiments were in progress, but the work was done in the belief that results of value could be so obtained, and with the expectation of giving the method a thorough trial, from the standpoint of the commercial orchardist, if the preliminary tests were sufficiently encouraging.

"The present season [1890] a plum orchard of 900 bearing trees in Ottawa County, Ohio, right in the heart of a great fruit-growing region, was selected for the experiment. In the north half of it the method of catching the curculios by jarring on a sort of inverted umbrella mounted on wheels was employed, while the south half was sprayed four times with pure Paris green mixed with water, in the proportion of 4 ounces to 50 gallons.

"The first application was made May 8, just after the blossoms had fallen from the late-blooming varieties. There was a heavy rain the same night, and it rained almost continuously until May 15, when there was a short cessation. The second spraying was done on that day. The third spraying was made May 26, and the fourth and last, June 2.

"On the jarred portion of the orchard a great many curculios were caught, showing that they were present in numbers. A careful examination of both parts of the orchard was made on June 3. Between one and two per cent of the fruit on the sprayed trees had been stung, while about three per cent of plums on the jarred trees were injured. No damage to the the trees was then perceptible.

"Early in July the orchard was again examined. Some of the sprayed trees showed that the foliage had been damaged by the spraying, but the injury was not very serious. Not over three per cent of sprayed fruit was stung at that time, while about four per cent of that on the jarred trees were injured. But on both the fruit was so thick that artificial thinning was necessary to prevent overbearing.

"A large crop of fruit was ripened on both parts of the orchard, and so far as could be judged from one field experiment, it showed that spraying is as effective as jarring."[1]

The above experiments are the most exhaustive yet made, and they seem to indicate that spraying for curculio is practicable on a commercial scale. They are all founded upon the fact that the curculio does eat, a question which has been decided in the affirmative by several entomologists of undoubted authority. But it still remains to be determined how extensively the beetles feed before the eggs are laid, and if the character of the season may not to a certain extent modify the results obtained by the use of the arsenites. In New York the practice is not regarded as being so efficient as spraying against the codlin-moth is, and the older method of jarring the trees is still considered to be the safest. S. D. Willard of Geneva, N.Y., who grows many plums and is in a position to be well informed regarding the practices followed, writes me that "the majority of plum growers in this State are jarring their trees instead of using any of the arsenical preparations to prevent the working of the curculio." He uses the jarring method entirely, in his orchards, and in the spring of 1895 apparently saved his crop by jarring the trees twice a day, when spraying with arsenites utterly failed.

Professor W. J. Green, of the Ohio experiment station, has been so kind as to inform me in regard to the attitude of the plum growers of that State towards the use of arsenical sprays: "I must say that opinions are divided on the subject. The majority of those who have tried the method [spraying with arsenites] on plum trees which were surrounded with other kinds of fruit trees have failed, either wholly or partially. This might be expected. . . . On the other hand, those who have sprayed orchards, leaving no trees, and doing the work thoroughly, have generally been successful in saving the crops. William Miller, Gypsum, Ohio, and T. S. Johnson, Port Clinton, Ohio, will corroborate this, and I can name others near them who have practiced the method several seasons, and expect to continue. In my experience the curculio is more easily controlled with the arsenites than the appleworm, but only in

[1] This experiment is recorded in *Ohio Agric. Exp. Sta.* Bull. 8, Vol. iii. Sept. 1890, 225–228.

orchards where all the trees are sprayed. In practice we use Paris green with Bordeaux mixture to prevent injury to the foliage. We must use the latter to keep the leaves from dropping prematurely. Some jar the trees occasionally in addition to spraying, in order to gather and burn all of the plums which are stung. If it were not for the Bordeaux mixture I think that only few would spray for the curculio, but as it is I think that the majority of orchardists prefer spraying to jarring!"

The question is evidently not yet fully settled, but apparently much seems to depend upon the locality, and the time and thoroughness with which the applications are made.[1]

Other Arsenites than Paris Green and London Purple.

Paris purple, another arsenical poison, has been on the market to a limited extent since 1882 or 1883. Mr. A. Poirrier, president of the St. Denis Dyestuff and Chemical Co. of Paris, France, was the introducer of this material. The New York agents of the firm, Sykes & Street, 85 Water Street, write me that it is the refuse obtained from the manufacture of magenta, or violet, or both. The Paris firm has apparently given up the manufacture of the product, and the stock in this country is now very limited. It is used in the same way as London purple, lime being added to prevent injury to foliage, but larger amounts of it appear to be required to give satisfactory results.

English purple poison, as I am informed by the introducer, Henry S. Ziegler, 400 N. 3d Street, Philadelphia, Pa., has been upon the market only a few years. He states that "the name is original with me, and the composition consists of arsenious acid with an aniline base." It seems, therefore, that the last three poisons mentioned, London purple, Paris purple, and English purple poison, are derived from the same source, although there are undoubtedly certain variations in their texture and composition. (For analyses see page 123.) Considerable quantities of soluble arsenic are present in English purple poison, so it should be used with lime to prevent injury

[1] Much information on this subject may be found in the following places: *Ohio Agric. Exp. Sta.* Vol. iii. second series, 1890, Bull. 8; *Ibid.* Vol. iv. second series, Bull. 2; *Minn. Agric. Exp. Sta.* 1890, Bull. 10, 71; *Texas Agric. Exp. Sta.* 1894, Bull. 32, 494; Bailey, *Annals Hort.* 1889, 63.

to foliage. The insecticidal action of the poison is not so energetic as that of Paris green, but if used more freely the insects will succumb. As yet English purple poison is little used.

White arsenic has long been known as an effectual destroyer of insect life. In 1848 George Gordon [1] said that small brown ants are easily destroyed by mixing with one pound of loaf sugar a small portion of arsenic. Grind very fine and put the mixture on bits of white cards near the places they frequent. It is difficult to say how generally this advice was followed, but that the poison was frequently tried for a similar purpose appears very probable. Its very energetic poisonous qualities when it was taken internally were well known, and these must naturally have occurred to the minds of persons desirous of destroying insect as well as animal life. Nevertheless, white arsenic was rarely recommended as being a suitable poison to apply to the foliage of plants, for its action is so caustic that the leaves are exposed to nearly as great injury from the remedy as from the insect to be overcome. It was used upon potato foliage for the destruction of the beetle, but with unsatisfactory results, Paris green at the same time proving so much superior that the white arsenic was abandoned.[2] But an account of the successful use of the poison against the canker-worm appeared in 1871.[3] John Smith, of Des Moines, Iowa, writing to the *Western Pomologist*, says that in 1868 he used arsenic, hellebore, and strychnine against the canker-worm. He applied them separately to different apple trees, using them as follows:

Arsenic one-half pound dissolved in fifty gallons of water, and applied to ten large trees.

Hellebore two pounds mixed in four gallons of water, and applied as above in fifty gallons of water.

Strychnine one bottle, with an amount of water equal to that used with the other materials, and similarly applied.

In two days the worms on the part treated with the arsenic were all dead, and the application of hellebore was also followed by good results. Strychnine apparently possessed little value for

[1] *Jour. London Hort. Soc.* 1848, Vol. iv. 19.

[2] Saunders and Reed, *Canadian Entomologist*, 1871, July, 41.

[3] Smith, *Western Pomologist*, Vol. ii. 1871, May, 125. See, also, *The Small Fruit Recorder*, 1871, July 1, 103.

this purpose. In spite of this favorable report the poison was not in demand, because of its caustic properties.

After the Paris green and London purple had become well known they were both considered safer insecticides than white arsenic, and the first was acknowledged to be the best of the three. Riley, however, did not entirely accept this opinion, but thought that London purple is not more injurious upon cotton foliage than Paris green is.[1] Cook was the first to make a careful study of this point.[2] He made applications to the foliage of plum, cherry, apple, pear, peach, willow, elm, and maple trees, to determine the comparative degree in which the three arsenites mentioned above are injurious. His first conclusion is as follows: "London purple is more injurious to the foliage than is Paris green; and white arsenic — arsenious acid — is more harmful than is either London purple or Paris green." Later experiments have confirmed this result, and the truth of its general application is accepted.

The milk of lime was first used in connection with the arsenites to overcome their caustic properties, by Gillette, in the fall of 1889.[3] The results were so encouraging that extensive experiments were carried on the following year, and many valuable conclusions were reached in consequence of the careful and extended observations made during that season. It was plainly shown that "lime added to London purple or Paris green in water greatly lessens the injury that these poisons would otherwise do to the foliage."[4] Another interesting result obtained in these experiments was that "lime added to a mixture of white arsenic in water will greatly increase the injury that this poison would otherwise do to foliage. If the arsenic is all in solution, the lime will then lessen the injury, as in the case of London purple and Paris green."

The next step in this series of advancements was taken by Kilgore.[5] During 1890 his investigations were made in lines almost identical with those followed by Gillette, and many of the latter's conclusions were verified. In addition to these,

[1] Riley, *U. S. Ent. Com.* 1880, Bull. 3, 62.
[2] *Mich. Agric. Exp. Sta.* 1889, Aug. Bull. 53.
[3] *Iowa Agric. Exp. Sta.* 1890, Aug. Bull. 10, 410.
[4] *Ibid.* 419, 420.
[5] *N. C. Agric. Exp. Sta.* 1891, July, Bull. 77 b, 7.

he also gave directions for the manufacture of an insecticide, in which white arsenic entered as one of the principal ingredients. It was made "by boiling together for one-half hour in two to five gallons of water

White arsenic	1 pound,
Lime	2 pounds,

and dilute to required volume, say one hundred gallons. . . . It is desirable that the lime should be present in the boiling solution of white arsenic, since it renders the latter insoluble as fast as it goes into solution, thus reducing the volume of water and shortening the time for obtaining the arsenite."

Two other compounds of arsenic have been used for the destruction of insects, the first trial being made upon the Gipsy moth, in Massachusetts.[1] One of these, the arsenate of soda, "has been recommended by various parties as an insecticide," but the results of the experiments show that it injures foliage before an efficient quantity for the destruction of the caterpillars can be applied. The other, however, the arsenate of lead, is promising. It was proposed as an insecticide in 1892, by F. C. Moulton, a chemist in the employ of the Gipsy Moth Commission. It was first tested against tent caterpillars in 1893, with the following results:[2] "The smaller proportions, as $\frac{3}{5}$ pound or less to 150 gallons of water, do not kill the caterpillars [*Clisiocampa Americana*] as quickly as is desirable. . . . The larger proportions seem unnecessary and would, of course, be rather expensive for general field work, but some such proportions as 1, $1\frac{1}{2}$, or 2 pounds to 150 gallons of water would prove entirely satisfactory so far as we can judge from these experiments." When used as strong as 24 pounds in 150 gallons of water, no injury to apple foliage resulted, which is indeed remarkable when the small amount necessary to destroy the insects is considered.

Caustic and Non-poisonous Insecticides.

Having thus traced the introduction of the various compounds of arsenic, and their gradual adoption by agriculturists for the destruction of chewing insects, there still remains the consider-

[1] Fernald, *Mass. Hatch Agric. Exp. Sta.* 1894, April, Bull. 24. [2] *Ibid.* 5.

ation of insecticides which destroy the organism, not by entering its body with the food, but by penetrating the outer coverings directly, and causing the death of the insect only after the material has come in contact with some vital part. There are several materials which possess this power, and some of them have long been in use. Strong alkalies, such as potash or soda, were among the first substances employed for this purpose. The insectidal value of soap is largely due to alkalies which have commonly been applied in this form. The intrinsic value of all soaps has caused them to be used as the foundation for many mixtures. Quassia wood contains an alkaloid which is fatal to insect life, and decoctions of the "chips" have been recommended since the early part of this century. Pyrethrum, kerosene, and resin can also be added to the list, although their value has not been known, in all cases, so long as that of the materials mentioned above.

Pyrethrum first attracted the attention of Europeans early in this century.[1] It had long been sold by the people living south of the Caucasus Mountains in southeastern Asia, the plant being a native of the district. An Armenian named Jumtikoff learned that the powder was obtained from the flower heads of certain species of pyrethrum, and in 1828 his son began to manufacture the powder on a larger scale. It was exported, and at present this industry brings large revenues into the countries in which it is carried on. The species which furnishes the best powder is *Pyrethrum roseum* (properly *Chrysanthemum coccineum*); it is not cultivated in Asia, but the flowers of the wild plants are gathered. The Dalmatian powder is produced from *Pyrethrum* (or *Chrysanthemum*) *cinerariæfolium*, a closely related species. About 1850, pyrethrum powder was introduced into France for the destruction of insects in houses. In 1856 good seeds were obtained from the Caucasus, and these having been planted, a crop of home-grown seed was secured two years later. Plants of *Pyrethrum roseum* were grown in America as an ornamental plant at least as early as 1870; but the Dalmatian form has been grown for the purpose of producing the highly prized powder. The first to engage in

[1] See *U. S. Patent Office Rept. Agric.* 1857, 129; *Ibid.* 1861, 223; and *Ann. Rept. U. S. Com. of Agric.* 1881–82, 76.

this industry was G. N. Milco, a native of Dalmatia, who successfully cultivated *Pyrethrum cinerariæfolium* near Stockton, Cal. The powder which he made has been sold under the name "Buhach." It is in every respect apparently as good as the imported article, and is even superior to the latter in regard to strength. It is probably the best form to use in this country. Plants of both species were grown in Washington, D.C., in 1881, with satisfactory results. In the spring of that year Riley distributed seeds of the two forms to growers in various parts of the country. In this way the plants have become fairly well known, and the use of the powder has rapidly increased. On account of the cost, it has been used principally in dwellings and in greenhouses. It is most frequently applied in the dry form, but during the past few years it has given good results either when mixed with water, or when the essential oil has been applied after being extracted by alcohol; an infusion of the entire flowers is also effective.

It is difficult to say when kerosene oil began to be valued for the destruction of insects. The oil was undoubtedly used before any records of its insecticidal value were published; and one might suppose, from its nature, that it would possess energetic properties of this character. Turpentine mixed with earth and water was successfully used to destroy worms on trees as early as 1835,[1] and it is but a step to pass from this liquid to the use of kerosene. The latter was recommended for the destruction of scale on orange trees in 1865,[2] and was also successfully applied to oleander, sago-palm, acacia, and lemon trees. The oil was poured into a saucer and applied by means of a feather. In June of the following year, the *Gardener's Monthly* recommended this oil for destroying all insect life; but in an issue of the next month, the statement was modified by saying that the vegetable oils were safer.[3] Many others probably had the same experience, for if not applied very carefully, much injury to the foliage may result. It has been the practice, both in Europe and this country, to apply kerosene with a certain amount of water, having one part of oil to twenty-five

[1] *The Cultivator*, 1835, 176, cites M. D. Thosse in *Silliman's Journal.*
[2] *Gardener's Monthly*, 1865, Dec. 364.
[3] *Ibid.* 1866, June, 176, and July, 208.

of water, more or less. This was applied by means of a hand syringe, and a fairly uniform mixture was obtained by dashing the contents of the filled syringe back into the vessel holding the liquids. Rapid work was the price of a good mixture. This practice is still followed to a certain extent in England, but is rapidly giving way to more desirable methods.

Soap, water, and kerosene can be so thoroughly mixed together that a permanent emulsion will be formed. Although the product may be a comparatively new one, the idea which led to its manufacture is not so recent. As has already been said, soap and water formed the basis of many mixtures. Records can be found showing that nearly all insecticides, especially if they possess much value, have at one time or another been used in connection with soapy solutions. It is simply carrying out the idea that if a certain remedy is effective, its value will be increased if another substance also possessing value be added to it. Thus we find that a correspondent of the *Gardener's Monthly* says he had used soap water and crysylic acid together, first mixing them thoroughly; and carbolic acid was applied in the same manner.[1] The insecticidal value of kerosene once being known, it was very natural that the oil and soap should be used together. The first record that I have found of such a mixture appeared in February, 1875.[2] George Cruickshank, of Whitinsville, Mass., here says that he had been fighting the currant worm since 1866, but at first with unsatisfactory results. "In May, 1870, I began using kerosene with whale-oil soap, increasing the kerosene until it would kill the worm and not injure the foliage of the plant. I used 5 pounds of whale-oil soap, and 1 wine quart of kerosene to 25 gallons of soft water to mix. Stir the soap and kerosene together till thoroughly mixed; add two pails of hot water, stir till the soap is dissolved, then add the balance of cold water and it is ready for use. Apply with a syringe with *force*, in bright sunshine. . . . Where the kerosene and soap was used, I had no worms after two years. In 1873 I had a barrel of the liquid all mixed, and ready for use by the usual time the worm makes his appearance, but could find no worms to use it on." In June of the same year a similar note ap-

[1] "T. A." in *Gardener's Monthly*, 1868, Jan. 11.
[2] *Ibid.* 1875, Feb. 45.

peared;[1] Henry Bird, of Newark, N.J., made a mixture in which he used a little kerosene oil with strong soap-suds. He said that "it readily combines and can be applied uniformly with a syringe."

Although it is not definitely stated in the two cases just mentioned that emulsions were secured, still there can scarcely be any doubt that at least a part of the oil was emulsified. Who, then, is the originator of the, or a, kerosene emulsion? The answer is undoubtedly to be found in the unrecorded work of some unknown but intelligent grower of plants.

Cook was probably the first experimenter to recommend the use of a mixture of kerosene oil and soap water. He says:[2] "I found it [kerosene] would mix permanently with soap solution in 1877 and 1878, and that it would kill many insects if it touched them, and best of all would destroy haustellate insects like bugs, plant and scale lice. I first recommended this to the public in 1878.[3] . . . The best substances for such use (killing haustellate [sucking] insects) are a weak solution of carbolic acid, a strong suds either of whale-oil or common soap, and tobacco water. I have found that the addition of a half teacupful of crude petroleum to two gallons of either of the above makes them the more effective. . . . I mix one quart soft soap, or one-quarter of a pound of hard soap, with one or two quarts boiling water; as soon as the soap is all dissolved, I stir in, while all is yet hot, one pint of kerosene oil. This is now violently stirred till it is permanently mixed — that is, till upon standing the oil will not rise to the top, but will remain incorporated with the liquid. . . . When we are ready to use this, stir in enough water to make fifteen pints in all — that is, one-fifteenth of the liquid applied would be kerosene oil." These formulas, using either the hard or the soft soap, have received the name of the originator, and they are still in common use.

Riley published the following in the annual report of the Commissioner of Agriculture for the years 1881–82, 127: "Emulsions with soap-suds and lye had been worked at some

[1] "T. A." in *Gardener's Monthly*, 1868, June, 106. See, also, *Country Gentleman*, 1876, July 6, 422, citing from *The Agriculturist*.

[2] *Mich. Agric. Exp. Sta.* 1890, March, Bull. 58, 5.

[3] See *Rept. Mich. State Board of Agric.* 1878, 434.

years ago by Professor Taylor, the microscopist of the Department, and more recently they have been made by several independent experimenters in Florida, but particularly by Mr. Joseph Voyle,[1] an intelligent correspondent at Gainsville, who uses kerosene, soap, and fir-balsam combined at a high temperature and produces a permanent paste which he calls 'murvite,' readily soluble in water. Recent experiments made at our request by Mr. Clifford Richardson, assistant chemist of the Department, with ordinary soap, whale-oil soap, and both light and heavy oils, also show that 20 parts hard soap, 10 parts water, 40 parts kerosene, and 1 part balsam, produce the most satisfactory results. . . . Mr. Hubbard's experiments would indicate, however, that for insecticide purposes nothing equals the milk emulsions which were first suggested by Professor Barnard [2] during our work on the cotton worm at Selma, Ala., in 1880, and though the use of ordinary emulsifying agents, as various mucilaginous substances and the phosphates, lactophosphates, and hypophosphates of lime, may facilitate the making of kerosene emulsions, we have not yet had them sufficiently tested as insecticides, and for the present can recommend nothing more simple and at the same time more available to the average farmer than the permanent milk emulsion as produced by Mr. Hubbard."

During the season 1881–82, Mr. Hubbard was making experiments for the destruction of the scale insects affecting orange trees. He made the milk emulsion only, and of varying strengths. The following is the formula recommended at the close of the season's work:[3] "Refined kerosene, 2 parts; fresh, or preferably sour, cow's milk, 1 part (percentage of oil $66\frac{2}{3}$). Where cow's milk is not easily obtained, . . . it may be replaced by an equivalent of condensed milk (Eagle brand) diluted with water in the proportion 1 to 2. . . . In applications for scale insects, the kerosene butter should be diluted with water from 12–16 times."

Under date of Sept. 15, 1881, Mr. Hubbard writes to Dr. Riley regarding the condition of the work on orange scale then

[1] See *U. S. Dept. of Agric. Div. of Ent.* Bull. 1, 19.

[2] For further details concerning W. S. Barnard's suggestion of an emulsion of milk and kerosene, see *The Official Gazette U. S. Patent Office*, Vol. 59, No. 12, 1919.

[3] *Ann. Rept. U. S. Com. of Agric.* 1881–82, 113, 114.

in progress at Crescent City, Fla.[1] "Experiments with Neal's mixture gave, upon the whole, rather disappointing results." I have not learned what was the composition of this mixture, but it may have been an emulsion of kerosene in soap water, for Dr. Neal did considerable work in this direction. On Oct. 10, 1882, he wrote from Archer, Fla., to the chief of the Division of Entomology regarding these formulas, only two of which it is necessary to mention.[2] These were also applied for the destruction of the cotton worm:

"1. Four pounds whale-oil soap were dissolved in one gallon of water with heat; to this, kerosene was added gradually till it was found that one gallon kerosene made a good emulsion, capable of being diluted to one per cent without at once disintegrating.

"2. Four pounds resin soap, common bar or yellow soap, were dissolved in one gallon water. One gallon kerosene gradually added, with constant agitation. The greater the per cent of resin in the soap, the better was the emulsion I found it made, which would indicate that such a soap for this purpose would no doubt be a valuable article in the market."

On Nov. 28, 1882, Hubbard wrote in detail concerning the use of kerosene, and also criticised Neal's formulas. He says:[3]

"Experiments made in September with kerosene washes on purple scale show that the eggs are much more difficult to kill than I had supposed. They have been killed by 66 per cent kerosene and soap emulsions diluted 1 to 9. . . . I have carefully gone over Dr. Neal's report and have a few comments to add to my former communication.

"Dr. Neal says 'the greater the percentage of resin in the soap the better the emulsion I found it made.' This may be true of the *emulsion*, but when diluted, the resin, or a large part of it, separates from the liquid and forms a waxy scum on the surface, which clogs the pump and nozzle, and is troublesome unless removed. . . . The strongest emulsion used by Dr. Neal contains 50 per cent of oil and the strongest wash a dilution of 1 to 9. My experiments with milk emulsion of this strength did not in the end prove satisfactory, and I long ago decided to

[1] *U. S. Dept. of Agric. Div. of Ent.* 1883, Bull. 1, 10.
[2] *Ibid.* 32. [3] *Ibid.* 17, 18.

increase the amount of oil in the emulsion. I now use 66 per cent emulsion diluted 1 to 9, and these, although sufficiently strong for long scale, are not sufficiently penetrating to kill the eggs of purple scale. . . . The following are my estimates for a standard wash of whale-oil soap and kerosene, emulsion 66 per cent oil, diluted to 1 to 9 (one gallon emulsion = 10 gallons wash): whale-oil soap, ¼ pound; water, 1 gallon; kerosene, 2 gallons."

In the annual report of the Commissioner of Agriculture for 1884 a formula is published which contains twice as much soap as Hubbard's original one, the other ingredients remaining the same. This has become most commonly known under the name of the Riley-Hubbard formula for the kerosene emulsion, and is used to-day unchanged. It is prepared as follows:

"Kerosene, 2 gallons; common soap, ½ pound; water, 1 gallon.

"Heat the mixture of soap and water and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five to ten minutes. The emulsion, if perfect, forms a cream, which thickens on cooling, and adheres without oiliness to the surface of the glass. Dilute with cold water before using, to the extent which experience will indicate is best."

The scale insects found upon the orange trees in California may be cited as further examples showing that obstacles can be overcome if only sufficient attention is directed towards them. These insects were a serious pest on the Pacific coast, and they are not entirely under control even at the present day, but their great numbers in former years aroused the fruit growers to energetic measures. Many compounds were recommended for the treatment of the pests. The preparations were generally in liquid form, and may be considered as rather elaborate outgrowths of compounds whose value had long been known. The following are good examples of these remedies, whose number was almost endless:[1]

1. Forty-six pounds whale-oil soap, 4 gallons coal oil, 100 gallons water.

2. Twenty-five pounds brown soap, 6 pounds wood potash, 4 gallons coal oil, 100 gallons water.

[1] Ellwood Cooper, "California Fruit Culture," a report of the fifth annual convention of California fruit growers.

3. Ten pounds whale-oil or other soft soap, $2\frac{1}{2}$ or 3 pounds sulphur, 1 gallon coal oil, 17 gallons water.

It will be seen that soap or kerosene, or both, formed the basis of most of these washes. They were not entirely satisfactory, for some reason still unexplained. In 1886, D. W. Coquillett and Albert Koebele, were appointed by the Department of Agriculture to investigate the trouble, for in the East such emulsions were used almost invariably with good results.

In a review of their work, published in 1887, Dr. Riley makes the following statements, which indicate well the character of these investigations:[1]

"Among the different substances thoroughly experimented with were caustic potash, caustic soda, hard and soft soaps, tobacco soap, whale-oil soap, vinegar, Paris green, resin soaps, and compounds, and so on. . . . Mr. Koebele's attention was, however, directed mainly to the preparation of resinous soaps and compounds on account of their greater cheapness. He succeeded in making a number of these mixtures, which, when properly diluted, need not cost more than one-half to one cent per gallon, and which produce very satisfactory results, killing the insects or either penetrating or hardening the egg masses so as to prevent the hatching of the young. One of the most satisfactory methods of making a resin soap is to dissolve 1 pound of caustic soda in $1\frac{1}{2}$ gallons water to produce the lye; then dissolve 2 pounds resin and 1 pound tallow by moderate heat, stirring in gradually during the cooking 1 quart of the lye, and then adding water until you have about 22 pints of a brown and thick soap. This will make 44 gallons of wash, costing less then one-half cent per gallon."

A few further suggestions were made regarding various combinations of the above mixture, and the addition of adhesive substances to the washes was strongly advised. But the most important part of this address was the emphasis laid upon the value of the resin washes, for from this time on they were destined to extensive use in the orange district of California.

[1] Address by Professor C. V. Riley before the California State Board of Horticulture, at its semi-annual session at Riverside, Cal., April 12, 1887, as reported in the *Pacific Rural Press*, April 23, 1887, cited in Bull. 15 *U. S. Dept. of Agric. Div. of Ent.* 16, 17. See also *Ann. Rept. U. S. Com. of Agric.* 1886, 558, giving details of Koebele's work.

During 1887 Koebele tested the value of the addition of arsenic acid to kerosene emulsion. In his report to the Entomologist, dated December, 1887, he says: [1] "In the main I have followed your suggestion while here in April last, in preparing the kerosene emulsion, viz. to emulsify with resin compound, and use the arsenic acid in addition. I am glad that your hopes in this wash are verified. In every instance where your proposed arsenic acid was added, either to emulsified kerosene or resin compound, there has been a complete extermination of the scales." Although such washes were here favorably reported upon, they have not come into general use.

The next year another valuable contribution was made upon this subject, of which the following abstracts are the most important: [2]

"Caustic solutions have the disadvantage of hurting the tree, and are not especially adapted to penetrate into the egg-sac, which, on account of its peculiar texture, repels most liquids.

"Various soap solutions, some containing kerosene and some whale-oil, have proved fair remedies, but cannot in my opinion be equaled by the resin solutions, of which we give three formulas. The first was tried by Mr. A. Koebele, the second by Mr. Alexander Craw, of Los Angeles; the third has been given me by Mr. L. D. Green of Sacramento. From personal experiments with them all I am well satisfied with them.

"Recipe No. 1. Four pounds resin, 3 pounds sal-soda, water to make 36 pints. Dissolve the sal-soda in a few pints of water; when thoroughly dissolved, add the resin. Heat until dissolved, and add water finally. Use two quarts of solution to the gallon of water. Use at a temperature of about 100° F.

"Recipe No. 2. One pound caustic soda, 10 pounds resin, 100 gallons water. Prepare as above.

"As, perhaps, owing to the nature of the caustic, the leaves are sometimes liable to be affected, I should recommend the spraying of the tree with pure water liberally (the water will free the pores of the leaves) two or three days after the applications of the resin solutions.

[1] *Ann. Rept. U. S. Com. of Agric.* 1887, 143–147.

[2] Klee, "A Treatise on the Insect Injuries to Fruit and Fruit Trees of the State of California," 1888, Oct. 12, 28, 29.

"These solutions being cheap, they may be used liberally, and two or three treatments a year would, I think, keep the trees in fair order.

"Recipe No. 3. Sixty pounds resin, 60 pounds tallow, 10 pounds potash, dissolved in 10 gallons water; 10 pounds caustic soda (Green bank, 98 per cent). Dissolve the resin and tallow; when dissolved, add caustic water slowly. After mixture is made, add 10 gallons of water. Use at the rate of 1 gallon of mixture to 10 gallons of water.

"In the case of the black scale, I have found the addition of sulphide of soda at the rate of 1 gallon to 75 of resin solution (the strength of the sulphide being 1 pound of concentrated lye to 2 pounds of sulphide) beneficial, and I should recommend the trial of this for icerya."

D. W. Coquillett, assistant in the Division of Entomology, continued the work begun by Koebele in regard to the destruction of scale insects, and at the end of the year 1889 the following was recommended as "the best solution for use during the latter part of the year": it was made by combining with heat, "resin, 18 pounds; caustic soda (70 per cent strong), 5 pounds; fish-oil, 2½ pints; water to make 100 gallons."[1] A slightly modified formula was published the following year; the fish-oil was omitted, and 5 pounds of caustic soda (77 per cent) were used with 40 pounds of resin, this being sufficient to make 50 gallons of the wash.[2] Formulas almost identical to these are in use at the present time and are highly valued for the destruction of orange-scale insects, but fish-oil is very commonly added to the preparations.

History of the Fungicides.

This country has been less energetic in the introduction of new fungicides, probably because fungi have always been more or less serious here, and growers were accustomed to their presence. A special stimulus appears to be necessary to arouse a people to any new line of thought, and if this is not present, progress is slow. The American mildews, introduced into France, forced the vineyardists in the affected districts to

[1] *Ann. Rept. U. S. Com. of Agric.* 1889, 355. [2] *Ibid.* 1890, 263.

discover some efficient remedy, and they did so. The appearance in the Central States of the potato beetle and the cankerworm exerted a similar influence on American farmers; they also were forced to overcome the pests, and the result was as successful as could have been wished. When each country had entered upon the task allotted to it, the next step would naturally be a mutual exchange of results that might be beneficial to the other, and such exchanges have taken place. Americans have not been slow to test many of the excellent practices recommended by French investigators, but when the methods were once understood they have been adopted in all parts of the land, at least by a few growers, with astonishing rapidity; and so well has the information regarding these remedies been disseminated that no man now has an excuse for not knowing how to treat the large majority of the troubles which affect the plants that he grows.

Little was known in this country regarding the treatment of fungous diseases of plants by liquid applications previous to 1885. Saunders and Goff were the pioneers in the work. The former,[1] in 1884, suggested the use of three fungicides for the treatment of apple scab: Hyposulphite of soda, applied for the first time, in proportion of 1 pound to 10 gallons of water: sulphide of lime, made by boiling 2 pounds of sulphur and 1 pound of quicklime in 2 gallons of water, stirring frequently till of a reddish yellow color; after settling, the clear liquid is poured off: a mixture of sulphur and water, in the proportion of 1 pound to 10 or 15 gallons of water. The same remedies were also recommended by Goff for the apple scab and leaf-blight. During the following year he tested the hyposulphite of soda with the result that "in the syringed portion of the tree, the per cent of uninjured fruits was double that in the unsyringed portion, while the percentage of the third quality, or much injured fruits, was one-half less. It also appears that all of the fruits on the syringed portion were larger in size than those on the unsyringed portion. We also noted that there were many more decayed fruits on the unsyringed portion of the tree."[2] These were the first of innumerable experiments regarding the treatment of the same diseases.

[1] *Canadian Horticulturist*, 1884, vii. No. 6, 127.
[2] *Ann. Rep. N. Y. State Agric. Exp. Sta.* 1885, 260.

Colonel Alexander W. Pearson, of Vineland, N.J., summed up the situation, regarding vineyard diseases, in a comprehensive article which was published in 1886.[1] He says: "Years ago, while experimenting with sundry chemicals designed in their application to prevent or cure 'the rot,' I accidentally noticed a vine, one branch of which was trained beneath the shelter of a projecting cornice, while the other ran over a trellis exposed to the sky. The grapes beneath the cornice were sound; those exposed were rotten." Acting upon this hint, Colonel Pearson made a board covering, twenty inches wide, over a portion of his trellis, and the following year he found that the fruit under the shelter was sound, while that which projected beyond was injured as well as all others which were unprotected.[2] The year following, the boards were replaced by cotton sheeting a yard wide, which was regularly used afterwards. Paper bags were also tried, these being tied about the fruit. They also afforded excellent protection, but their use was rather expensive, so that the main reliance was placed upon the cloth coverings, which in addition protected the foliage from the downy mildew.

In 1882, Colonel Pearson selected a block of Concords from which he "had the symptoms of infection removed as fast as they appeared. All the rotted grapes were picked weekly from the clusters, picked up from beneath the trellis, taken away, and buried. The leaves, wherever spotted with the phoma [black rot], were also gathered." The following year "the vines thus cleaned showed an improvement of at least 50 per cent in their crop. Plowing all débris under, late in the spring, and then leaving the ground undisturbed, also proved beneficial." These processes of disinfection were considered as forming the surest and most practicable means for the prevention of rot on grapes.

Vines that were well nourished were supposed to resist disease better than their weaker neighbors, the downy mildew in particular being influenced by this variation. In other respects this fungus was treated with difficulty: "There is no benefit from any method of disinfection, which I have tried. Sulphur

[1] Scribner, *U. S. Dept. of Agric. Bot. Div.* Bull. ii. "Report on the Fungous Diseases of the Grape Vine," Appendix B. "Remarks on Grape Rot and Grape Mildew," 54–63.

[2] This remedy was not new. See *Ann. Rept. U. S. Com. of Agric.* 1861, 498.

is inefficient, and the burial of the vineyard débris and subsequent non-culture, which are of avail against the phoma, are useless here. When atmospheric conditions favor the development of this pest, it spreads like a prairie fire. I have seen the foliage on ten thousand vines completely blasted by mildew within three days after its appearance. Our only defense against peronospora will be in constitutional, prophylactic treatment."

The above review was made by one of the most intelligent vineyardists in the country. It shows how comparatively helpless grape growers were in controlling fungous diseases, although Colonel Pearson himself had obtained good results. In the trial of chemicals of which he speaks, many articles must have been tested, but apparently none proved of value. In 1880, however, another experimenter appears to have been more fortunate:[1] "A writer in the *California Horticulturist* speaks of the success of the application of sulphate of copper for mildew on rose bushes, using one-half ounce to a pail of water." But this note did not attract any particular attention, in which respect it resembles a similar one which appeared in an English journal in 1861 (see page 17).

During 1884 a substitute for Paris green was mentioned in the *Country Gentleman*.[2] Although its use as an insecticide was advised in later years, a similar preparation was also thoroughly tested in regard to its fungicidal value. It was made by dissolving

Copperas	1 pound.
Water	4 gallons.

When dissolved add to this solution

Slaked lime	1 pound.

The Americans were thus hovering about the truth, but they did not quite discern it. The discovery was made by the French, and much of the preliminary work necessary to the development of this new idea was also done by them.

The first formula for the manufacture of a fungicide that was borrowed from the French was for making the material which was later known as the Bordeaux mixture. It was pub-

[1] *Country Gentleman*, 1880, April 22, 262. [2] *Ibid.* 1884, July 17, 597.

lished by F. Lamson-Scribner, at that time assistant botanist in the Department of Agriculture at Washington, in the annual report of the Commissioner of Agriculture for the year 1885, although it actually appeared earlier in articles published by the Section of Vegetable Pathology which bear a later date. On page 84 of this report may be found the following paragraph:

"Many remedies for the disease of the vine due to the peronospora have been proposed, but so far the most effectual specific known is a solution of lime and sulphate of copper. It is made by dissolving 18 pounds of sulphate of copper in about 22 gallons of water;[1] in another vessel mix 34 pounds of coarse lime with 6 or 7 gallons of water, and to this solution add the solution of copper. A bluish paste will be the result. This compound, when thoroughly mixed, is brushed over the leaves of the vine with a small broom, care being taken not to touch the grapes. This remedy, it is asserted, will not only destroy the mildew, but will prevent its attacks." This preparation was at first known as "the copper mixture of Gironde."

The following statements, no less interesting than the above, may be found on page 81 of the same report: "Many of the diseases of our fruit orchards might be remedied, or at least diminished, by raking together and burning the leaves as soon as they have fallen. . . . The plan of raking up the leaves and burning them has been especially recommended as a means of checking the growth of the apple-scab fungus, and the pear-tree scab. In respect to the latter disease, it is not confined to the leaves and fruit, but extends to the young shoots also. . . . If this disease be taken early, say at the time of the formation of the conidial or summer spores (the only spores so far known), the direct application of some fungicide might prove beneficial. Experiments alone will prove the usefulness of this."

Here, then, are the first indications of a future which could scarcely have been prophesied at the time, even by the boldest imagination; we have a hint of a power whose influence was destined to bring the growing of plants largely out of the realm of chance, so far as fungous diseases are concerned, and with

[1] This amount of water is undoubtedly given as an equivalent of the French hectoliter. But the French measure is equivalent to 26.417 gallons of the standard United States measures. See Appendix.

the help of the knowledge already acquired, to place this art upon a footing even more firm than that enjoyed by those occupations in which the weather and other dispensations of Providence have no direct influence. The passage contains the germ of an educational movement which stands unparalleled in the effect it has had in broadening the horizon of the agriculturist of the United States. It has forced him to see that there is more in his business than following the rule-of-thumb processes so long in vogue. It has emphasized the power of knowledge, and it has demonstrated, and is daily impressing the fact upon all who take the trouble to see, that it requires more brains than brawn to succeed in an occupation at which formerly even the most ignorant could be at least fairly successful. The ignorant are going to the wall, and it is the educated man, the "book farmer," who is pushing them along, and who fills their places when they are gone. The fittest stand the best chance of surviving.

The Warfare against the various Fungous Diseases.

The formula for the manufacture of the Bordeaux mixture was soon widely copied. The following year, 1886, it was published by Hilgard in January,[1] by Riley in February,[2] by Colman in May,[3] and again by Scribner in the government reports.[4]

In Hilgard's report the remark is made that attention was called to the mixture at an earlier date in the *Pacific Rural Press.* No other fungicide is mentioned, but some remarks are made concerning the value and use of the mixture in France. Dr. Riley's article is on "The Mildew of the Grape Vine"; it mentions the Bordeaux mixture, and also the use of kerosene-milk emulsion, sulphur and lime, and carbolic acid.

It was during 1886 that the Section of Vegetable Pathology was established as a part of the United States Department of Agriculture. F. Lamson-Scribner was appointed its chief, and in May there appeared the first publication, Circular No. 1,

[1] *Calif. Agric. Exp. Sta.* 1886, Jan. Bull. 51.
[2] *Rural New-Yorker*, 1886, Feb. 6, 87.
[3] *U. S. Dept. of Agric. Bot. Div. Sec. Veg. Path.* 1886, May, Cir. 1.
[4] *Ibid.* Bull. ii. 16; *Ann. Rept. U. S. Com. of Agric.* 1886, 100.

entitled: "Treatment of the Downy Grape Mildew (*Peronospora viticola*) and the Black Rot (*Phoma uvicola*)." The five remedies mentioned in this circular were all copied from the French journals. The directions were in brief as follows:

"For Peronospora.

1. "Dissolve in 10 gallons of water 5 pounds of the sulphate of copper." This was to be used for soaking the stakes and all tying material, and was also to be sprayed upon the foliage, using for the purpose any fine spraying apparatus, the cyclone nozzle being suggested as the best for the purpose.

2. "Make a mixture of lime and water, as one ordinarily applies whitewash." Apply as above, but repeat after rains.

3. This was the formula for the "copper mixture of Gironde," as given on a preceding page.

4. "The powder of Podechard." This contained 225 pounds of air-slaked lime, 45 pounds of sulphate of copper, 20 pounds of flowers of sulphur, 30 pounds unleached ashes, and 15 gallons of water.

5. "The ordinary milk-kerosene emulsion, with the addition of from 2 to 5 per cent of carbolic acid and the same percentage of glycerine, and then dilute 1 part of the emulsion in 20 to 50 parts of water. Spray on the under surface of the leaves by means of a cyclone nozzle of small aperture."[1]

For black rot, the mixture of lime and sulphate of copper was particularly recommended, and in addition to this a free use of Podechard's powder, upon the ground in the vineyard, was advisable.

Scribner wrote as follows concerning the above circular:

"Three thousand of these circulars were distributed, and I have reason to believe that many made a trial of one or more of the remedies proposed, but I regret to say that few responded to the request that the results of these trials be reported to the Department."[2] A report was received from George M. High, Middle Bass, Ohio, the letter being dated Dec. 28, 1886, in which he speaks of having poor success with formula No. 2,

[1] This formula had previously been published by Riley in *Rural New-Yorker*, 1886, Feb. 6.

[2] *Ann. Rept. U. S. Com. of Agric.* 1886, 100.

but No. 3 was very promising. He also used the following upon sixty Catawba vines: "Dissolve 1 pound of sulphate of copper in 2 gallons of water; in another vessel slake 4 pounds of lime in the same quantity of water; then mix these together thoroughly. The advantage was the preservation of the foliage in a healthy condition in a marked degree over vines untreated."[1]

Bush & Son & Meissner, of Bushberg, Mo., also reported their work, saying: "We have tried all the remedies recommended in your circular and find that designated as No. 3 the best. We are continuing to apply this mixture of lime with dissolved sulphate of copper (not too strong), with confidence in its good results."[2] Another correspondent stated that he used Podechard's powder (No. 4) with marked benefit.

The second publication of the Section of Vegetable Pathology was a "Report on the Fungous Diseases of the Grape Vine."[3] It is a bulletin of one hundred and thirty-six pages, and gives exhaustive descriptions of the fungi causing the downy mildew (*Peronospora viticola*), the powdery mildew (*Uncinula spiralis*), the black rot (*Physalospora Bidwellii*), anthracnose (*Sphaceloma Ampelinum*), grape leaf blight (*Cercospora viticola*), and grape leaf spot (*Phyllosticta Labruscæ*). The botanical structure, the general appearance, conditions of development, and similar points were dwelled upon, so that this may be considered as perhaps the most important publication of the section, when one considers the influence that it exerted not only upon grape growers, but upon horticulturists in general.

The remedies recommended against the downy mildew were mostly those in use by French and Italian vineyardists, viz. the mixture of copper sulphate and lime, and the milk of lime alone. There is also published a letter from Dr. John Strentzel, of Martinez, Cal., dated June 28, 1886, in which the following statements are made concerning the use of iron and copper sulphates:[4] "I have been using for years solutions

[1] *Ann. Rept. U. S. Com. of Agric.* 1886, 101. See also *Country Gentleman*, 1887, April 28, 340.

[2] *Ibid. loc. cit.*

[3] This was Bull. ii. of the Section, Bull. i. having been published on a botanical subject not related to the work of the Section.

[4] Scribner, "Report on the Fungous Diseases of the Grape Vine," *U. S. Dept. of Agric. Sec. Veg. Path.* Bull. ii. 17.

of sulphates of copper and iron to destroy parasitic fungi on vines and pear trees, also to kill red spider on almonds. . . . The mixture I use consists of 2 pounds of sulphate of iron to 1 gallon of water, dissolved, and add 3 pounds of lime and 1 pound of sulphur, the lime being slaked in hot salt brine to a consistency of thick whitewash." The removal of diseased fruit, leaves, and canes is also recommended, in addition to the liquid applications.

The powdery mildew was best treated by the use of a mixture recommended by J. F. Allen.[1] It is composed of sulphur and lime, and is almost identical with Grison's liquid described on page 16.

Against black rot, it was advised to wash "the vines in early spring, before the buds have commenced to swell, with a strong solution of the sulphate of iron," but the main reliance was to be placed in the bagging of the fruit.

Anthracnose was to be controlled by the European practice of "washing the vines in early spring, before the buds have commenced to expand, with a strong solution (50 per cent) of sulphate of iron. . . . When the young shoots have attained a length of five or six inches, they receive a good dusting with the flowers of sulphur, whether the disease has appeared on them or not."

As regards the other two diseases mentioned in the bulletin, no remedies were then known, but it was thought "probable that the general treatment advocated for the downy mildew and anthracnose will have a direct tendency to limit their development."

Three appendices form about two-thirds of this bulletin. Appendix A, written by Erwin F. Smith, gives an account of the extent and severity of fungous disease on grapes, and some of the more common methods of treatment. The material was compiled from the answers received to a circular asking for information on these topics.

Appendix B was written by Colonel A. W. Pearson. It is an article on "Remarks on Grape Rot and Grape Mildew," which has already been quoted in these pages.

Appendix C is entitled "The Prevention of Mildew — Results of Experiments with Various Fungicides in French and

[1] *U. S. Patent Office Rept. Agric.* 1854, 312.

Italian Vineyards in 1885." Sixty-eight pages, or one-half of the bulletin, are devoted to this subject, and it forms a fitting close to the matter which precedes. Its contents, coming, as it were, directly from the European vineyards, which were suffering even more severely than ours, lent a weight to the whole publication which greatly increased its value. The subjects treated in the various abstracts have already been discussed in the preceding chapter of this volume.

The annual report of the mycological Section[1] for 1886 contains much interesting matter. The Section seems to have been placed in good working order from the time of its establishment, and many important descriptions and recommendations are contained in this report, a very complete review of the work carried on in France and Italy being given. An abstract of Millardet's article on the work done during the year mentions many of the substances tried in France, the best of which are "the copper mixture of Gironde; David's powder; Podechard's powder; mixture of sulphate of copper and plaster; cupric steatite (a bluish-white, unctuous powder, composed of steatite and sulphate of copper); and sulphatine (a secret mixture of sulphur, lime, sulphate of copper, and plaster)." Then follows a "table showing results of experiments of Millardet and David with mildew remedies in France in 1886."

A letter from M. G. Foëx, of Montpellier, France, contains an account of a meeting of the International Congress held in Florence, Italy, during October. It says that the copper salts were considered most valuable, and the formulas recommended were those of the Bordeaux mixture (the copper mixture of Gironde, page 27); eau céleste, Audoynaud process (page 30); and sulphated sulphur. In regard to the last substance the letter says that "M. Théophile Skawinski, at Château Laujac, in Gironde, and M. D. Cavazza, director of the school of viticulture at Alba (Piedmont), have used successfully mixtures of pulverized sulphur with 8 to 10 per cent of sulphate of copper finely triturated." According to an official report of the meetings held in Florence, the conclusions in respect to the remedies for the mildew "were: (1) That gaseous remedies applied against the peronospora have not given useful results; (2) that among the remedies in the form of powder thus far tried the most effi-

[1] *Ann. Rept. U. S. Com. of Agric.*, 1886, 95–138.

cacious are those in which sulphate of copper is used; (3) that the mixture of lime and ashes, and of lime and sulphur, have not as yet given results sufficiently satisfactory to enable us to recommend their use; (4) among the liquid remedies, the milk of lime prepared so as to make it convenient for application, has proven quite satisfactory; however, its use from a practical and economical standpoint encounters in many places serious difficulties; (5) that the remedies most successful in the results obtained are the mixed liquids or solutions containing sulphate of copper."

This portion of the report closes with an article on Skawinski's powder as a fungicide, giving its history, composition, and use. On the pages which follow are described several fungi found upon the grape and also some occurring upon other plants. Among the latter may be found an account of the celery leaf-blight which is of interest here on account of a remedy which is mentioned for its prevention: "I would hesitate to recommend the application of solutions containing the salts of copper on this vegetable, for hygienic reasons. A solution of penta-sulphuret of potassium, or liver of sulphur, 1 to 2 ounces to a gallon of water, sprayed upon the plants at the first appearance of the blight, may arrest its progress. This preparation deserves a trial in this case." The use of this substance was probably suggested by the English papers, which at this time contained many accounts of its value for the control of certain fungous diseases.

Remedies for the orange-leaf scab are also suggested, three of the preparations named being, "a solution of bisulphide of potassium, one-half ounce to a gallon of water; the Grison liquid . . . ; to 10 gallons of strong soap-suds add about a pound of glycerine and one-half pint of carbolic acid."

Regarding the treatment of potato rot, only suggestions are made. A trial of Podechard's powder, and of David's powder, are recommended.

The curing of pear blight is looked upon as an almost hopeless task, and unfortunately we are now little nearer the solution of the problem than at that time. The report says that "spraying offers little hope of success. . . . An experiment tried during last season in spraying with a solution of hyposulphite of soda, applied several times during the period of expansion of the buds, gave no evidence of beneficial effects."

Although the Department of Agriculture was taking by far the most active part in advancing the cause of the treatment of fungous diseases, the work was not entirely confined to it. Early in 1886 there is recorded[1] an account of the Italian practice of sprinkling lime upon grape foliage. The remedy consists "simply of a lime wash made of 5 pounds fresh lime slaked with 24 gallons of water. The vines are sprinkled abundantly with this wash from the middle of May to the middle of August, the application being repeated five or six times in all."

Goff continued his experiments in the use of the hyposulphite of soda, applying it, in 1886, upon apples and pears. His work of the preceding year was verified in the case of the apple, but the results from pear trees were less striking, only a slight difference occurring in favor of the sprayed half. The material was also applied to pears for the blight, with entirely negative results.[2]

During the spring of 1886, "B. F. J." wrote an account which, at present, appears like a prophecy; for it has taken scientists several years to learn the fact which at that time was not known to exist. The writer, after speaking of the use of a 1 per cent solution of blue stone, and of a 10 per cent solution with lime enough to make a thin paste, for the control of grape diseases, reasons that the copper sulphate solutions should be applied to potatoes "threatened with mildew or rot. . . . But if, in the event of the appearance of the Colorado beetle, Paris green (arsenite of copper) extended in 50 times its bulk of fine, ground land plaster be applied to potato vines as often as needed to destroy the insects, old and young, it will be worth the while to ascertain if mildew makes its appearance in fields so treated. It is believed by the writer that little or nothing will be seen of mildew or rot under such circumstances, and if, after the bugs have disappeared, the Paris green and plaster are continued, the vines will resist to the end."[3]

Whether the above was founded on experience or not, it does

[1] *Country Gentleman*, 1886, Feb. 4, 88.
[2] *Ann. Rept. N. Y. State Agric. Exp. Sta.* 1886, 174.
[3] *Country Gentleman*, 1886, May 27, 405.

not alter the fact that, even at this time, Paris green was believed to have some value as a fungicide, and this is probably the first statement of a fact which was not generally conceded until definite experiments made by trained men had established its truth.

Such are the most important events of the year 1886. The main feature of the work was the spreading of information, and the recommending of lines of treatment to be followed. Little actual work was done.

The work of 1887 was of the same nature, for the results of scarcely an experiment made in this country were published. Each one appeared to wait for someone else to try the remedies, so that there might be no doubt about the successful issue of later experiments. The United States Department of Agriculture apparently had no plantations in which to work, for, in the annual report of the chief of the Section of Vegetable Pathology, more recommendations appear than do the results of actual field tests. The results of the French experiments are still freely drawn upon, and they form the basis of the recommendations. Most of the work done in this country was under the direction of the Department of Agriculture, which is deserving of praise for thus bearing the brunt of a movement which, with characteristic conservatism, has not been immediately adopted by the bulk of the agricultural population.

Circular No. 3 of the Section of Vegetable Pathology appeared in April, 1887. Its subject was the "Treatment of the Downy Mildew and Black Rot of the Grape." The value of copper sulphate was placed above that of all compounds in which no copper appeared, and formulas were given for the manufacture of the following: the simple solution of sulphate of copper, 1 pound of the salt being dissolved in 25 gallons of water; eau céleste (Audoynaud process); copper mixture of Gironde, or Bordeaux mixture, 16 pounds sulphate of copper, 30 pounds of lime, 28 gallons of water, this being a more dilute mixture than that recommended in 1886; and it is also stated that "some have reduced the ingredients to 2 pounds of sulphate of copper, and 2 pounds of lime to 22 gallons of water, and have obtained good results." Directions are also given for the manufacture of David's powder, and of sulphatine, the directions for the latter being to "mix 2½ pounds of anhydrous sulphate of copper with 15 pounds of triturated sulphur, and 10 pounds of air-slaked lime."

Circular No. 4 appeared in July; it was entitled "Treatment of the Potato and Tomato for the Blight and the Rot." Among the formulas given, only two require notice. That for the Bordeaux mixture produced a still more dilute preparation. The directions were to "dissolve 4 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water." This was a decided improvement on the formula published during the preceding April. Among the dry applications is found a "Blight powder"; this was made by mixing "3 pounds of anhydrous sulphate of copper with 97 pounds flowers of sulphur." It has not come into general use.

The annual report of the Section of Vegetable Pathology for 1887 [1] is full of suggestion and encouragement. The white rot and the bitter rot of grapes are described, they having been identified in this country for the first time. Copper compounds are recommended for their treatment. New formulas are introduced, as the old ones had not given satisfaction in all cases. The manufacture of eau céleste is described as follows:

"In 2 gallons of hot water, dissolve 1 pound sulphate of copper; in another vessel dissolve 2 pounds ordinary carbonate of soda; mix the two solutions, and, when all reaction has ceased, add 1½ pints of liquid ammonia; when desired for use, dilute to 22 gallons." [2] This preparation has become better known under the name "modified eau céleste."

To prevent injury to the young shoots, the following solution is recommended: "Dissolve 1 pound sulphate of copper in a gallon of hot water, to this solution add liquid ammonia, a little at a time, until all the copper is precipitated; the liquid is then turbid and blue in color. Add 2 or 3 gallons of water, and let stand to settle. Then pour off the clear liquid which contains sulphate of ammonia — the compound which causes the burning of the leaves. Then pour upon the precipitate left in the vessel just enough liquid ammonia to dissolve it. . . . When required for use dilute to 22 gallons." [3]

[1] *Ann. Rept. U. S. Com. of Agric.* 1887, 323–397.
[2] Formula of M. Masson, *Progrès Agricole*, 1887, July.
[3] *Progrès Agricole et Viticole*, 1888, April 29.

The last formula of the year for making the Bordeaux mixture is introduced by a statement that "considerable latitude is allowed in quantity of lime and copper sulphate in the Bordeaux mixture, but the amount of the latter ought not to fall below 4 per cent. The most recently recommended formula for the preparation of this compound is 4 pounds of sulphate of copper, 2 pounds lime, 25 gallons water."[1]

The report also contains a description of the strawberry-leaf blight with directions for treatment. Regarding the latter point, the work done in the laboratory showed "that these conidia will not germinate in very dilute solutions of hyposulphite of soda or sulphate of copper. It is a simple matter to apply similar solutions to the plants in the field, where it is only reasonable to suppose they will have a like action on the reproductive bodies in question." The hyposulphite of soda solution was made by dissolving 1 pound of the salt in 10 gallons of water. One form of copper solution, recommended for the first time in America, was thus prepared: "In 1 quart of liquid ammonia dissolve 3 ounces of carbonate of copper, then dilute to 20 gallons." This was here called the ammoniacal carbonate of copper.

Regarding the treatment of apples for the scab, are the following statements: "Experiments already made with the sulphate of copper solutions indicate that they will, when properly applied, at once check the scab. . . . The following course of treatment is suggested:

"1. In early spring, before the buds have commenced to expand, spray the trees thoroughly with a solution of sulphate of iron, using 4 pounds of iron sulphate to 4 gallons of water.

"2. As soon as the fruit has set, apply the Bordeaux mixture or one of the modified preparations of eau céleste.

"3. If the weather should be such as to favor the development of the scab fungus, a third application should be made two or three weeks after the second, using the same materials."

The chloride of iron or some other fungicide is suggested for preventing the rust of beets. The anthracnose of the raspberry and the blackberry is supposed to be amenable to treatment as well as that of the grape, and the same practice of washing the

[1] Viala and Ferrouillat, "Manuel pratique pour le Traitement des Maladies de la Vigne," second edition, 1888, 27.

dormant canes with the sulphate of iron solution is recommended. When the plants are in leaf, the Bordeaux mixture should be substituted for the solution. In treating beans for the anthracnose, solutions of the liver of sulphur are most prized, as less danger is connected with their use. Treatments of the following plants for fungous diseases are also recommended, the copper compounds being particularly advised: catalpa, for leaf spot; rose, for black spot; rose rust, for which the chloride of iron is preferred, it having been reported as of value in the treatment of a coffee disease; and gooseberry, for mildew. The Grison liquid is also mentioned.

The work of controlling plant diseases, other than that planned by the United States Department of Agriculture, was conspicuous by its absence. The agricultural journals occasionally copied parts of the government reports, or made recommendations, but scarcely a record of individual efforts can be found. The various State stations already established were also inert, with a single exception. Goff was continuing the work he had begun in 1885, and this year, 1887, treated apple trees with the hyposulphite of soda, and with the Audoynaud's eau céleste. The former proved as satisfactory as in preceding years. The latter, however, was too strong for the foliage, one application causing decidedly injurious effects. The fruits on portions that were sprayed three times dropped from the trees before maturity.[1] These experiments may have formed the basis of the remarks in the report of the Section of Vegetable Pathology regarding the injury caused by eau céleste, for I can find no other account of the use of this fungicide during the year upon apples. Arthur also reports marked success in the use of the sulphide of potassium in the treatment of gooseberry mildew, the solution being used at the rate of one-half ounce of the chemical to one gallon of water.[2]

After the establishment of the government experiment stations, most of which were organized in 1888, the bulk of the work done to advance the methods of controlling plant diseases was carried on by the stations and by the Department of Agriculture at Washington, the work of the Section of Vegetable Pathology being especially thorough. The published reports

[1] *Ann. Rep. N. Y. State Agric. Exp. Sta.* 1887, 99–101. [2] *Ibid.* 348.

of these experiments have taken the lead in the endeavors to overcome fungi affecting cultivated plants, and they are a record in which may be found the gradually lengthening list of plant diseases which have succumbed. It is impossible to give the details of the enormous amount of the work done each year, so only the more important contributions will be noted.

A bulletin of particular value to grape growers was issued by the Agricultural Department in 1888. It records the results of many experiments made in 1887 in the use of the several formulas published in Circular No. 3 of the Section of Vegetable Pathology. The downy mildew and the black rot are the two diseases controlled. The Bordeaux mixture proved to be the most satisfactory remedy.[1]

The report of the Section of Vegetable Pathology for 1888,[2] Professor B. T. Galloway having been appointed chief of the Section in November, contains a long list of diseases which were studied and treated. Mention is made of various diseases of the grape; the downy mildew of potatoes; tomato black-rot, and a form of blight; brown rot and powdery mildew of cherries; leaf blight and cracking of the pear; rose-leaf spot; plum pockets; apple rusts; leaf spot of maples; a sycamore disease; cottonwood-leaf rust; peach yellows; and notes on celery-leaf blight. This list well represents the energy which was displayed in America in combating all fungous diseases as soon as the proper methods were supplied. The study of fungi was vigorously carried on by many investigators, and a firm basis for experimental work was thus established.

Early in 1889 the same department published a bulletin in which several plant diseases and the methods of their treatment are mentioned.[3] Applications of the sulphide of potassium solution, or of modified eau céleste, were advised for the treatment of the apple scab, and the same remedies, or other fungicides then known, were named in connection with apple rust and bitter rot. The black rot of grapes was successfully treated in 1888 by Colonel A. W. Pearson, Vineland, N.J., who made experiments under the direction of the commissioner of agri-

[1] Scribner, *U. S. Dept. Agric. Bot. Div.* Bull. 5.
[2] *Ann. Rept. U. S. Com. Agric.* 1888, 325–404.
[3] Galloway, *U. S. Dept. Agric. Bot. Div.* Bull. 8, 45–67.

culture. The Bordeaux mixture proved to be most satisfactory, and the following formula for its manufacture is given:

"Dissolve 6 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water." The two liquids were then slowly mixed and the preparation was ready for use. This formula is the one which at first was most widely recommended.

The methods of treating the rust of melons consisted in the use of a carefully prepared eau céleste, only enough ammonia being added to precipitate the copper. The liquid was then poured off, and ammonia added to the copper sediment remaining in the bottom of the vessel until all the copper was again dissolved. One pound of the sulphate of copper so treated was sufficient for twenty-two gallons of water. Hyposulphite of soda and also the sulphide of potassium were suggested for the prevention of bean anthracnose.

Bulletin 11 of the Section of Vegetable Pathology gives an account of some of the work done in the treatment of plant diseases during the year 1889. In addition to the various diseases which had already received attention, the following are named: leaf blight of the pear and of the quince; rusts of the peach, plum, quince, and blackberry; leaf blight of the strawberry and of the blackberry; and the rot and the blight of tomatoes. In the annual report of the Section[1] additional mention is made of the treatment of several apple diseases, including the important experiments of Taft, Goff, and Hatch on the apple-scab fungus. The account of the treatment of nursery stock for the powdery mildew is also interesting. Pear stock was treated for the leaf blight, and these experiments may be considered as being the first directed towards the protection of nursery stock. The nurseries of Franklin Davis & Co., situated twenty miles north of Washington, were used in these experiments. The following year the first applications on cherry stocks were made, the disease treated being that commonly known as leaf blight. In later years the treatment of nursery stock became one of the leading features of the work of the Section.

It was during 1889 that the government experiment stations began to report the results of work in the treatment of plant

[1] *Ann. Rept. U. S. Com. Agric.* 1889, 397–432.

diseases. In October, Neale published[1] an account of work done in Delaware vineyards. The Bordeaux mixture was used with an estimated saving of $65.25 per acre. Stained fruit was cleaned by placing it in wire baskets which were dipped in diluted vinegar. The fruit was allowed to remain here a few moments, and then dried on wire frames.

An important article written by Weed appeared the following month.[2] He conceived the idea of applying insecticides and fungicides together, and the statement is made that "a considerable number of experiments with this end in view have been carried on during the season with very satisfactory results." One of these experiments was designed to control the brown rot of stone fruits. A plum orchard was treated for this disease as follows: "We sprayed the trees early in April (April 16), before the leaves came out, with a simple solution of copper sulphate; and twice during May (15th and 25th), the first with London purple alone, the second with a combination of London purple and the Bordeaux mixture, which treatment was repeated June 1. No further applications were made, except to one tree, which was sprayed with the Bordeaux mixture July 16." Fairly satisfactory results were obtained from the applications.

The Bordeaux mixture was also applied to apple trees for the prevention of the scab, but the results were decidedly against the use of this fungicide for the treatment of the disease, a result which, it is scarcely necessary to say, has not been verified in late years. The black rot of the grape, and the quince-leaf spot, were more successfully controlled by the same remedy.

Maynard tried a combination of Paris green and a solution of copper sulphate upon potatoes. The growth of foliage was checked, but the blight was not so serious upon the treated as upon the untreated portions.[3]

At the time that Gillette was experimenting with mixtures of the arsenites and lime (see page 76), he also used the Bordeaux mixture in place of pure lime, with such success that

[1] *Del. Agric. Exp. Sta.* 1889, Bull. 6.

[2] *Ohio Agric. Exp. Sta.* second series, Vol. ii. 1889, Bull. 7, 186. See also *Agricultural Science*, Vol. iii. 1889, 263.

[3] *Mass. Hatch Agric. Exp. Sta.* 1890, Jan. Bull. 7, 12.

the use of the combination rapidly gained favor. One of the conclusions reached was that "London purple (Paris green and white arsenic have not yet been tried) can be used at least eight or ten times as strong without injury to foliage if applied in common Bordeaux mixture instead of water." Later experiments have shown that Paris green can be applied in the same manner with greater safety than when pure water is used.

Although the smuts of grain are not best treated by spraying, still these diseases are sufficiently connected with the subject in hand to allow the mention of some work done by Kellerman and Swingle.[1] In 1889 the work was mainly verifying the methods proposed by Professor Jensen, of Copenhagen, Denmark, for the treatment of the various grain smuts. The following year fifty-one methods for treating the stinking smut of wheat were tried. "Of all the treatments tested, the Jensen, or hot-water method, is probably the best for general use, although in our experiments it did not prevent all the smut" (see Part II. under OATS).

Halsted published a report in 1889 which proved to be the beginning of an important series.[2] This first publication contained notes on diseases of the potato, grape, cranberry, cucumber, sweet potato, and lilac, those of the cranberry having already been mentioned in Bulletin 64 of the station. The reader is referred to later reports by the same investigator for the descriptions and methods of treatment of a great many diseases of plants cultivated out of doors, and also of those grown under glass. The reports are especially rich in the accounts of diseases affecting greenhouse plants, and those commonly grown by florists.

During 1890, Maynard continued his work on the combinations of insecticides and fungicides.[3] He used the ammoniacal carbonate of copper together with Paris green. The foliage was in all cases seriously injured, and the fungicide appeared to lose its value when used in this manner. Later experiments have generally agreed with this result, and such a combination has not been used in common practice. Kerosene had

[1] *Kansas Agric. Exp. Sta.* 1889, Oct. Bull. 8, and 1890, Aug. Bull. 12.
[2] *Ann. Rept. N. J. Agric. Exp. Sta.* 1889, 221–239.
[3] *Mass. Hatch Agric. Exp. Sta.* 1891, Jan. Bull. 11, 18.

been tried for the destruction of the black knot of plums, but injury was liable to be done to the small growths, for the oil spread to other places than those on which it had been applied. The recommendation is therefore made that the oil be mixed with some pigment to form a thin paste, and this is then to be spread over the newly forming knots. Very satisfactory results had followed the use of the remedy, the knots being destroyed without injury to the sound tissues. The applications were made with a brush.

The Agricultural Department at Washington was conducting work in the treatment of diseases of the grape, apple, pear, quince, raspberry, hollyhock, and cotton. Comparative tests of fungicides were also made, and a new one known as mixture No. 5 was considered as having special merit. "It consists of equal parts of ammoniated sulphate of copper [see page 117] and carbonate of ammonia thoroughly mixed and put up in air-tight tin cans."[1] It was used at the rate of 12 ounces in 22 gallons of water, but this proved injurious to the foliage of cherry, peach, blackberry, and young grape shoots.

Chester, of the Delaware station, made some important experiments in the treatment of grape diseases.[2] The fungicides tested were the "ammoniated carbonate of copper," or the ammoniacal solution of copper carbonate; the carbonate of copper and the carbonate of ammonia mixture, a compound first used by this station, and prepared by mixing together 3 ounces of carbonate of copper and 1 pound of pulverized carbonate of ammonia, and then dissolving in 2 quarts of hot water, after which the solution can be diluted to 50 gallons; the precipitated carbonate of copper; the Bordeaux mixture; modified eau céleste; and mixture No. 5, of the United States Department of Agriculture. While all the conclusions drawn from the work have not been fully substantiated in after years, the publication did much to demonstrate the practicability and financial success of proper applications of fungicides. The Bordeaux mixture was recommended as being perhaps the best to use early in the season, but when danger of staining the fruit arose, the use of the carbonate of copper and carbonate of ammonia solution, or of the modified eau céleste, was recom-

[1] Galloway, *Ann. Rept. U. S. Com. Agric.* 1890, 402. See also p. 160.
[2] *Del. Agric. Exp. Sta.* 1890, Bull. 10.

mended. The precipitated carbonate of copper was thought to be valuable as a fungicide, but it has since fallen from favor.

Professor L. R. Jones, of Vermont, began work upon potato diseases in 1890, and since that time valuable reports have been published by him regarding the various diseases of this crop. In the annual report of the station for that year may be found a condensed account of the work upon potatoes as well as upon the diseases of other plants.[1]

In Galloway's report for the year[2] 1890 is the statement: "In treating the disease [leaf blight of pear, cherry, and strawberry] the present season, the best results were obtained from the use of the ammoniacal copper carbonate and the Bordeaux mixture. As far as the efficacy of the two fungicides is concerned, there is little choice. The ease with which the ammoniacal solution is prepared and applied, however, makes it more desirable in the end." These two fungicides were at the time generally considered to be the best.

In 1891, Galloway published an account of the use of Bordeaux mixture made of different strengths, and the results obtained showed that for grape diseases it was not necessary to use as much copper sulphate and lime as the formula given in Circular 4 of the Section of Vegetable Pathology called for. "There was little difference between the plats treated early with full-strength and those treated in the same way with the half-strength mixture."[3] The "half-strength" was made by using one-half the amount of materials called for by what has later been termed the "standard" formula mentioned in Circular 4, the amount of water used remaining the same. The half-strength or "normal" formula was soon very generally adopted.

Goff in 1891 established the fact that Paris green possesses marked fungicidal value, especially during dry seasons.[4] Later experiments made by Lodeman have shown that the poison is

[1] *Ann. Rept. Vt. Agric. Exp. Sta.* 1890, 129–144. See also Bull. 24 of the same station for more detailed descriptions.

[2] *Ann. Rept. U. S. Com. Agric.* 1890, 393–408.

[3] *Ann. Rept. U. S. Com. Agric.* 1891, 367.

[4] *Ibid.* 364; and *Ann. Rept. Wis. Agric. Exp. Sta.* 1891–92, 264.

of value in wet seasons as well;[1] and it is at present considered as possessing more value to the apple grower than any other single compound which he has at his command for checking fungous and insect enemies.

It is singular that while our most reliable insecticide, Paris green, is found to possess value as a fungicide, the Bordeaux mixture, which is probably our best fungicide, should possess a marked insecticidal value. In some notes which appeared in the *Journal of Mycology* (Vol. vii. 27), Hatch, of Ithaca, Wis., says that in treating potatoes it was noticed that plants sprayed with the Bordeaux mixture suffered less from insects than those used as checks, and "it would thus appear that where the mixture is used for rot and blight it may also be efficient as an insecticide." Professor Jones, of Vermont, gave still more positive information of the same nature at the Brooklyn meeting of the Society for the Promotion of Agricultural Science,[2] although his remarks applied particularly to injuries from the flea beetle. Beets were protected in a similar manner. Galloway writes me as follows regarding the experience of the government experimenters: "We also had a striking case a few years ago in treating a large vineyard. The leaves on the plants of our check plats were all badly eaten by the grape-vine fidia, while those adjacent, sprayed with Bordeaux mixture, were not touched at all."[3]

In 1891 Chester made a comparative test of some fungicides which at that time seemed to be of value, but which were not in general use.[4] Applications were made to pear trees, the following formulas being used for preparing the fungicides:

C.	Copper carbonate	1 pound.
	Water	25 gallons.
G.	Copper sulphate	8 ounces.
	Soda hyposulphite	14 "
	Water	25 gallons.

[1] *Cornell Agric. Exp. Sta.* Bull. 48, 272.

[2] *Agricultural Science*, Vol. viii. 364–367.

[3] See *Ann. Rept. Ky. Agric. Exp. Sta.* 1890, 40 (distributed early in 1895), for experiments made by Garman on tobacco worms, grasshoppers, and potato beetles, in 1889, these being the first of this nature; also *Cornell Agric. Exp. Sta.* Bull. 86, 58, for the prevention of insect injuries to apples; *Ann. Rept. Vt. Agric. Exp. Sta.* 1894, 12, 81, 95 *et seq.*

[4] *Del. Agric. Exp. Sta.* 1892, Bull. 15, 5.

H. Johnson's mixture:[1]		
	Copper sulphate	8 ounces.
	Ammonium carbonate	1 pound.
	Water	25 gallons.
I.	Copper carbonate	8 ounces.
	Ammonium carbonate	1 pound.
	Water	25 gallons.
A.	Copper carbonate	3 ounces.
	Ammonia 26°	1 quart.
	Water	25 gallons.
B.	Copper carbonate	3 ounces.
	Ammonium carbonate	1 pound.
	Hot water	2 quarts.
	Water to dilute to	25 gallons.
D.	Copper sulphate	6 pounds.
	Quicklime	4 "
	Water	25 gallons.
E.	Copper sulphate	1 pound.
	Sal-soda	1¼ pounds.
	Ammonia	1 pint.
	Water	25 gallons.

After two years' trial of the above, the formulas D, E, and I were shown to be the most effective. D, or the Bordeaux mixture, exerted no injurious action on the foliage nor on the fruit; E, or the modified eau céleste, had but slight action on the foliage; while preparation I had little or no action on foliage or fruit. This really implies that the Bordeaux mixture was as effective as any fungicide used, and that it proved to be the safest as well. The only objection raised to it was the difficulty of making the applications. The other preparations were either of less fungicidal value, or they injured foliage.

Since 1892 exhaustive experiments have been conducted by the United States Department of Agriculture for the prevention of rusts affecting wheat and other cereals. In that year, eleven preparations were applied, two being in the form of powder; the remainder were liquid, and were sprayed upon the plants or

[1] This fungicide was so called from the fact that Dr. S. W. Johnson first proposed its use in the *Ann. Rept. of the Conn. Agric. Exp. Sta.* 1890, 113. It never came into general use.

were applied to the soil. The materials used were the Bordeaux mixture, the ammoniacal solution of copper carbonate, ferrous ferrocyanide mixture, copper borate mixture, ferric chloride solution, ferrous sulphate solution, cupric ferrocyanide mixture, cupric hydroxide mixture, potassium sulphide solution, flowers of sulphur, and sulphosteatite. Although these were applied in various ways, the results were in no case favorable for encouraging the use of fungicides in controlling such diseases,[1] and later experiments have, on the whole, verified the results then obtained. The same report also contains a list of twenty-five different mixtures which were applied to pear nursery stock at Geneva, N.Y., the number including various compounds of copper, iron, and zinc. The copper compounds proved to be the most efficient in preventing leaf blight, and no compound was found which has proved to be preferable to the Bordeaux mixture.

One of the most important advances of the year 1894 was made by Bailey.[1] In treating a quince orchard with the Bordeaux mixture it was found that the rust (*Rœstelia aurantiaca*) "was certainly less prevalent in the sprayed portion of Colonel Bowen's orchard [Medina, N.Y.] than in the unsprayed part."

Many valuable experiments have been made, and many important results obtained, which cannot be named in this brief account of the ever-widening use of insecticides and fungicides; yet one other disease is of sufficient importance to require special mention. The black knot of plums and cherries is continually threatening the profitable cultivation of these fruits, and in some localities the disease has forced growers to abandon their culture on account of the death of the trees.

Maynard has recorded[3] an experiment in which certain plum trees were sprayed with copper sulphate solution early in the season, and later with the Bordeaux mixture, the last treatment being made July 29. The conclusion drawn from the experiment was that "the number of warts was *very decidedly* less where treated with the copper mixture than where untreated,

[1] Galloway, *Ann. Rept. U. S. Com. Agric.* 1892, 216 *et seq.* Fairchild, *Jour. of Mycology*, Vol. vii. No. 3, 240.

[2] *Cornell Agric. Exp. Sta.* 1894, Bull. 80, 627.

[3] *Mass. Hatch Agric. Exp. Sta.* 1891, Bull. 11, 19.

. . . and we believe that the plum wart may be held in check by the use of this remedy." This note attracted but little attention, and four years later, when the Cornell station published a bulletin[1] on the same subject, scarcely a person appears to have adopted the remedy. The Cornell experiments were carried on during two seasons, and they showed conclusively that the disease can be treated successfully and profitably by the use of the Bordeaux mixture.

II. In Canada.

Canada was active in taking advantage of the knowledge gained in the United States and in Europe. The experiments of Saunders in destroying the potato beetle were made soon after the discovery of the value of Paris green (see page 60). Through the kindness of Professor Craig, of Ottawa, I have been able to collect the following data regarding the early use of insecticides and fungicides in the provinces. He writes that "as far as I know G. W. Cline, of Winona, Ontario, and J. K. McMichael, of Waterford, Ontario, were the pioneers among the practical orchardists in the work of applying insecticides." In reply to a letter, the last-named gentleman kindly writes as follows: "I commenced spraying about the spring of 1883 with a small force-pump, using a number of ingredients, as an experiment to destroy fungi on pear trees.[2] In the spring of 1887, I bought a large double-acting force-pump, and sprayed my apple and pear trees with a solution of hyposulphite of soda, which I first used in 1885 to destroy fungi, and obtained fairly good results. For canker-worm and other insects I used Paris green. For a few years I sprayed with the carbonate of copper to destroy fungi on the leaves and fruit of apples and pears, but recently the sulphate of copper has been applied for the same purpose." Since neither Mr. McMichael nor Professor Craig know of any grower in Ontario who sprayed any earlier than is stated in the above letter, we may conclude that the former was the first, or at least one of the first, to make such application in that province.

[1] Lodeman, *Cornell Agric. Exp. Sta.* 1894, Bull. 81.

[2] See *Ann. Rept. Fruit Growers' Ass'n of Ont.* 1889, 36. Mention is here made of the application of hyposulphite of soda in 1887.

I am also indebted to Mr. R. W. Starr, of Wolfville, Nova Scotia, who has taken the pains to write so complete an outline of this branch of horticultural work in the Eastern section of Canada, that the letter is given below in full:

"I can scarcely give dates as to when spraying was first adopted in this province, as the practice has grown up from small beginnings with the fine rose watering-pot and garden-syringe, using solutions of whale-oil soap, tobacco, or hellebore to destroy the currant and gooseberry worm, and thrips on the rose bushes. These methods were in use by the late Hon. C. R. Prescott as early as in the forties at least, and I can remember some experiments of his with tobacco and the soap solution to drive the curculio from his plums, but this was afterwards abandoned for the malet and sheet.

"In 1875, Mr. A. S. Harris, of Port Williams, who had been fighting canker-worms for two years with poor success, got a small brass hand-pump with single and double orifice nozzle from New York. With this he sprayed his trees, using Paris green, 1 teaspoonful to 10 quarts of water. This was so successful that the next year every one who was troubled with the canker-worm provided himself with a pump and arsenites. Since then the use of the spray has been continuous where needed, large, powerful pumps fitted to casks or tanks and placed upon wagons being used for the purpose. The first of these was gotten up by myself in 1880. I used a common brass cylinder lift and force pump fitted with suction and delivery hose. With this I tried nearly every kind of nozzle made; some are good and some are worthless. The Vermorel as it is now made is, I think, the best for all purposes.

"During the past four years spraying has assumed a much more important place in our fruit industry than formerly. By using the Bordeaux mixture and other fungicides with Paris green, and spraying early and frequently, we find that we can keep in check the black scab on the apple and pear, and the black knot and rot of the plum, as well as destroy the insect pests that seem to have been increasing proportionately as fast as the fruit trees."

Some of the first Canadian publications regarding the use of fungicides appeared in 1888.[1] Then appeared formulas for

[1] *Ann. Rept. Fruit Growers' Ass'n*, 1888, 105, 152.

making the eau céleste and the original Bordeaux mixture as first prepared in this country. The latter was given by Dr. Riley, while the former was copied from one of the United States government reports.

In the annual report of the Canadian Experimental Farms for 1890, there is an account of experiments made by Professor Craig for the control of the apple-scab fungus. The copper compounds were here used, and he writes me that "the first work done in Canada on this line was in 1890, under my direction, at Abbotsford, Province of Quebec. . . . It is safe to say that the Experimental Farm system has led the work in the practical application of fungicides in Canada. This year [1894] quite a large proportion of our most progressive fruit growers are using Bordeaux mixture in the Hamilton and Grimsby districts of Ontario, the Island of Montreal, the eastern townships of Quebec, and the Annapolis valley of Nova Scotia. In British Columbia, where insects are more injurious thus far than fungous diseases, spraying for the destruction of those foes is more generally practiced than for the prevention of fungous diseases."

The following year a bulletin [1] appeared in which were published methods for treating the apple-scab fungus, the downy mildew of the grape, gooseberry mildew, and there were also given directions for making the carbonate of copper, the copper sulphate solution, the ammoniacal carbonate of copper, and the sulphide of potassium solution. This bulletin was soon followed by another [2] report from the same author, in which were mentioned combinations of the ammoniacal copper carbonate with Paris green, and the copper carbonate in suspension and Paris green.

Early in 1891 Fletcher published a bulletin [3] in which were mentioned a great many injurious insects, and information was given regarding the preparation and use of various insecticides. The annual report of the stations for 1891 also contains matter of a similar nature, and thus Canada took her place in the list of those countries engaged in the task of overcoming the innumerable parasites of cultivated plants.

[1] Craig, *Canada Cent. Exp. Farm*, 1891, Bull. 10.
[2] *Ann. Rept. Exp. Farms*, 1891, 144–148.
[3] *Canada Cent. Exp. Farm*, 1891, Bull. 2.

CHAPTER IV.

THE MATERIALS AND FORMULAS USED IN SPRAYING.

No attempt has been made to render the following list of materials and formulas complete. Such a record would require many more pages than can here be devoted to the subject, and in the end the result would be of little value, since the majority of the substances named would be such as have been found to possess no real worth and have in consequence been discarded. But many of the materials formerly recommended did possess merit, and the principal reason for their abandonment has been that other and more effective substances have been brought forward, with the natural result that the first was displaced by the newcomer. Such formulas are frequently interesting as showing the steps which have been taken in the development of preparations now recognized as the best, and they may also assist in doing away with the idea that a fungicide or insecticide must be made in accordance with a certain definite formula in order to be effective. Nearly all the following directions will bear considerable modification, and while it is highly desirable that the rules be followed as closely as possible, since they have been formulated after much experience, minor changes may be made with comparative safety, and good results will still follow. The cost of the more important substances is given; the first figure refers to the wholesale price, while the second one generally refers to the price when the article is bought at retail.

ACETO-ARSENITE OF COPPER. See *Paris Green*, page 121.

ALCOHOL. — A 30 per cent solution of alcohol when applied in the form of a spray is useful in destroying aphis in greenhouses and in dwellings where the use of other methods is not advisable. See also PYRETHRUM.

ALUM AND PYRETHRUM.—

Alum........................	2 ounces.
Pyrethrum	3 large tablespoonfuls.
Water.......................	10 gallons.

First dissolve the alum, after which the powder may be added. This mixture has been recommended as possessing special value in destroying cabbage worms. The applications are made by means of a watering-can or sprayer when the caterpillars are first seen.

AMMONIA; AQUA AMMONIA; HARTSHORN; VOLATILE ALKALI; NH_3, THE GAS; NH_4HO, DISSOLVED IN WATER.— Although ammonia alone possesses no practical value as an insecticide or as a fungicide, it is so frequently used in the preparation of the latter that it has interest in this connection. Ammonia is the term popularly used to denote a solution of the gas in water. It is a clear, colorless liquid, lighter than water, and possessing an overpowering, pungent odor. It has a strong alkaline reaction, and is a solvent of probably all the copper compounds used in spraying. It is for this reason that the article is of such importance in the preparation of certain fungicides. Commercial ammonia varies greatly in strength, but there are two methods of indicating its degree of concentration. The older method is the one inaugurated by Beaumé. He used an instrument called a hydrometer, which showed the specific gravity of liquids in accordance to an arbitrary scale invented by himself. The following five items have been selected from his table for testing liquids lighter than water.

In the first column are degrees taken from his scale; the second shows the specific gravity (G.) of the liquid as compared with water; the third shows the per cent of the weight of ammonia gas (% Wt.) as found in the liquids which register the indicated degrees upon the scale. The figures in the second and third columns form the standards of measurement now used by most chemists:

Beaumé,	16°	indicates	.960	G.	or	9.8	% Wt.
"	20°	"	.936	"	"	16.6	"
"	22°	"	.924	"	"	20.4	"
"	24°	"	.913	"	"	24.	"
"	26°	"	.901	"	"	28.6	"

The 26° Beaumé ammonia is the strong ammonia of commerce, and in the end it is the cheapest form to buy. The liquid loses its strength very rapidly unless it is kept in tightly closed vessels, bottles having glass stoppers being among the best. It must be handled with extreme care, for the fumes are so overpowering that serious consequences may result unless the operator has at all times fresh air to breathe. Strong ammonia is readily diluted with water to any desired extent. Cost of 22° Beaumé seven to twenty cents per pound.

Ammoniated Copper Sulphate. — According to the "United States Pharmacopœia" of 1870, this substance may be prepared as follows: "Take of sulphate of copper half a Troy ounce; carbonate of ammonium 360 grains. Rub them together in a glass mortar until effervescence ceases. Then wrap the ammoniated copper in bibulous paper, dry it with a gentle heat, and keep it in a well stoppered bottle." The sixteenth edition of the "United States Dispensary," 1877, contains the chemical reactions which take place, and very complete information. When the preparation is exposed to the air it is said to part with the ammonia, resulting in the formation of carbonate of copper and ammonium sulphate. It has been used by the United States Department of Agriculture in a preparation known as mixture No. 5.

Analyses of various substances are here inserted together for sake of convenience of comparison (page 118). The table is taken from the Massachusetts State Agricultural Experiment Station, report for 1893, page 378.

Arsenic; Arsenious Acid; Arsenious Anhydride; White Arsenic; White Oxide of Arsenic; Arsenic Trioxide; As_2O_3. — The element arsenic stands midway between the metals and the non-metals. When pure it is a solid, having a metallic lustre and a steel-gray color. It is but little used, the compound commonly sold as arsenic being arsenic trioxide. This is a white crystalline powder, which is gritty like sand. It is soluble in cold water to the extent of 1 part in 100; boiling water, however, dissolves 1 part in about 10 of water.

A solution of white arsenic has a caustic action upon foliage if a sufficient amount of the poison is present. Danberry records[1] an experiment in which one hundred square feet of young barley was watered with a solution of arsenious acid,

[1] *Jour. Chem. Soc. of London*, 1862, Vol. xiv. 225.

Analyses of Insecticides.

	Moisture.	Arsenious Oxide.	Copper Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Insoluble Matter.
Paris green.	1.30	62.55	32.84	3.10	..	..	..	..	..	..	..	..	0.21
Paris green.	1.41	61.40	33.20	3.90	..	..	..	..	..	..	..	..	0.09
Paris green.	1.40	61.15	33.10	3.71	..	..	..	..	..	..	..	..	0.64
Paris green.	1.15	53.91	31.27	8.10	..	..	..	..	..	..	..	..	0.04
Paris green.	1.34	61.25	33.35	3.93	..	..	..	..	..	..	..	..	0.13
Paris green.	1.31	61.21	33.45	3.94	..	..	..	..	..	..	..	..	0.09
Paris green.	1.15	59.92	30.40	..	..	..	..	..	..	..	..	..	0.10
Paris green.	1.27	54.80	30.85	6.50	..	..	..	..	..	..	..	..	0.12
"Sulphatine"	1.40	..	2.61	..	..	..	48.28	4.73	..	18.60	..	..	1.63
"Death to Rose Bugs"	2.95	..	1.05	..	..	..	34.53	4.35	..	17.76	..	..	0.49
"Professor De Graff's Carpet-Bug Destroyer"	95.81	..	..	..	..	0.78	..	0.48	0.27	..	0.26	0.90	..
"Oriental Fertilizer and Bug Destroyer"	87.14	2.38	..	..	..	..	..	0.64	3.00	..	3.50	..	..
"Non-poisonous Potato-Bug Destroyer"	..	..	..	..	..	..	..	..	..	68.20	..	1.38	1.50
Tobacco liquor.	37.71	..	..	..	2.12	..	..	..	..	3.07	6.55	0.23	..
Tobacco liquor.	40.89	..	..	..	0.53	..	..	..	..	1.47	16.34	0.01	..
Tobacco liquor.	..	..	..	..	4.55	..	..	..	..	..	..	..	..
Tobacco liquor.	..	..	..	..	4.82	..	..	..	..	..	..	..	..
"Nicotinia"	10.00	..	..	..	..	..	..	..	..	4.45	9.15	..	2.12
Hellebore.	..	..	..	..	..	..	..	..	..	..	..	..	2.34
Hellebore.	..	..	..	..	..	..	..	..	..	..	..	..	38.12
"Peroxide of Silicate"	1.65	0.57	0.33	..	..	..	..	49.66	..	41.18	..	..	2.31

made by dissolving 2 ounces in 10 gallons of water. After six days the crop looked blighted, but the plants eventually recovered. Most plants are seriously injured when not more than one-fourth the above amount is used, and the solution for this reason requires dilution to such an extent that its value as an insecticide is largely destroyed.

Arsenious acid may also be the cause of the death of a plant if applied in solution at the roots. Jäger[1] cites many cases in which different plants were seriously injured or killed in this manner, the action of the poison being to cause the entire plant to wilt and finally to die. In one experiment, some young oat plants were watered with a solution containing 1 part of arsenic in 480 of water. The application was repeated a week later, and two weeks from the beginning of the work most of the plants were wilted to the ground, but some still remained fresh and continued to grow.[2] Cuttings also absorb arsenic with the same result as when the poison enters through the roots, for a chemical examination showed arsenic to be present in the tissues.

In view of the above, arsenious acid or white arsenic cannot be recommended as an insecticide. When combined with other substances, however, it can be used with safety. Kilgore published the following formula for combining arsenic and lime:[3] "A very cheap insecticide, having the same insecticidal properties as London purple, can be easily made by boiling together for one-half hour in 2 to 5 gallons of water

White arsenic (commercial) .... 1 pound,
Lime [unslaked] .... 2 pounds,

and dilute to required volume, say 100 gallons. . . . It is desirable that the lime should be present in the boiling solution of white arsenic since it renders the latter insoluble as fast as it goes into solution, thus reducing the volume of water, and shortening the time for obtaining the arsenite. When the white arsenic is dissolved alone, a larger volume of water and more time are required. When lime is added the precipitation

[1] Dr. Georg v. Jäger, "Ueber die Wirkungen des Arseniks auf Pflanzen." Stuttgart, 1864.
[2] *Ibid.* 8, 9.
[3] *N. C. Agric. Exp. Sta.* 1891, July, Bull. 77 b, 7.

goes on slowly, requiring more than twenty-four hours to reach completion." This precipitate is the arsenite of lime, which is the active principle of London purple.

In 1875 McMurtrie, then the chemist at the Agricultural Department in Washington, conducted some experiments from which he drew the following conclusion: "Plants have not the power to absorb and assimilate from the soil compounds of arsenic, and that though arsenical compounds exert an injurious influence upon vegetation, yet this is without effect until the quantity present reaches for Paris green about 900 pounds per acre; for arsenite of potassa about 400 pounds per acre; for arseniate of potassa about 150 pounds per acre." [1]

ARSENATE OF LEAD; GYPSINE; $Pb_3(AsO_4)_2$. — Arsenate of lead may be made by placing "11 ounces of acetate of lead and 4 ounces of arsenate of soda into a hogshead containing 150 gallons of water. These substances quickly dissolve and form arsenate of lead, a fine white powder which remains in suspension in water." [2] If it is desired to make any variations in the above, the poison can be prepared by using 29.93 per cent by weight of arsenate of soda, and 70.07 of acetate of lead. These may be dissolved separately, and when united the arsenate of lead will be precipitated. This compound is much lighter than Paris green and can be used with greater freedom, as it does not injure foliage. The conclusions of Fernald in regard to the amounts to use are that "some such proportions as 1, $1\frac{1}{2}$, or 2 pounds to 150 gallons of water would prove entirely satisfactory," [3] and potato beetles were killed when but $\frac{3}{4}$ of a pound was used. At the Cornell Station this poison proved unsatisfactory in the destruction of canker-worms [4] and of tent-caterpillars in 1895.

ARSENATE OF SODA; Na_2HAsO_4. — This material has also been tried by Fernald, but it injured foliage and was not so effectual in destroying insects as the other forms commonly recommended. Its use for this purpose cannot be advised. [5]

ARSENITE OF COPPER; SCHEELE'S GREEN; $CuHAsO_3$, or

[1] *Ann. Rept. U. S. Com. of Agric.* 1875, 147.
[2] Fernald, *Mass. Hatch Agric. Exp. Sta.* 1894, April, Bull. 24, 6.
[3] *Ibid.* 5.
[4] *Cornell Agric. Exp. Sta.* 1895, Bull. 101.
[5] *Mass. Hatch Agric. Exp. Sta.* 1894, April, Bull. 24, 8, 9.

$Cu_3(AsO_3)_2$. — "This compound is to be had by adding an aqueous solution of arsenic trioxide to an ammonia-copper sulphate solution; this latter solution is prepared by adding ammonia to a solution of copper sulphate until the precipitate which is at first formed dissolves."[1] During 1895, the writer tested this arsenite, and the results showed that its value in destroying the codlin-moth is far inferior to that of Paris green, while its fungicidal action is probably greater than that of any other compound of arsenic and copper. The United States Department of Agriculture conducted a similar work during the year, but a full account has not yet been published.

Paris Green; Schweinfurth's Green; Emerald Green; Mitis Green; French Green; Aceto-arsenite of Copper; $(CuOAs_2O_3)_3 - Cu(C_2H_3O_2)_2$. — Paris green may be prepared by making a boiling solution of white arsenic in one vessel, and a similar one of acetate of copper (verdigris) in another. These two boiling solutions are then combined, and Paris green is precipitated. It appears as a more or less fine powder, having a beautiful clear green color. It is practically insoluble in water, but dissolves readily in ammonia. It is for this reason that ammonia forms such an excellent test for determining the purity of the powder; all sediment which the ammonia will not dissolve may be considered as foreign matter.

Ehrmann has given the composition of pure Paris green to be as follows:[2]

Copper oxide	31.29
Arsenious acid	58.65
Acetic acid	10.06

Most samples, even of the purest grades, show some variations from the above.

Since very nearly all the arsenic found in Paris green is practically insoluble in water, it is true that this poison is the safest insecticide now in general use. It will, nevertheless, injure foliage, sometimes to a serious extent, if several applications are made. The foliage of the stone fruits is particularly susceptible to this action, although even the apple will suffer. The

[1] Shepard, "Elements of Chemistry," 1885, 245.
[2] Cited by Ross, *Ala. Agric. Exp. Sta.* 1894, August, Bull. 58, 5.

danger may be avoided by adding lime to the liquid in which the poison is held, using equal parts of lime and arsenite, as is also done with London purple. Paris green is heavier than the latter, and must be more frequently stirred when in water.

Paris green possesses some value as a fungicide. This is probably due to the presence of the copper. Although the fungicidal value of the poison is, perhaps, only one-half as great as that of the Bordeaux mixture, its protecting influence is fairly strong, as has been shown by several investigators. It is without doubt the most valuable single remedy that can be used in an orchard, since it checks most insect injuries, and reduces, to a marked degree, the losses occasioned by fungous diseases, although it cannot be considered as a very energetic fungicide.

Since Paris green contains less soluble arsenic, it can be used with greater freedom than London purple, as there is less danger of injuring the foliage. When the poison first came into use, more of it was applied than was necessary for the destruction of the insects. The amount has been reduced so that, at present, the following may be accepted as a safe and effective mixture for plants when only one or two applications are to be made. The fine-grained powder is to be preferred, as it does not settle so rapidly, and is more evenly distributed :

Paris green	1 pound.
Water	150–300 gallons.

The more concentrated mixtures should be used only upon plants which are not easily injured, as the eggplant and the potato; in other cases, when the insects are destroyed with difficulty, lime should be added, using an amount equal in bulk to that of the poison. It is always safer to make this addition, even when the mixture is more dilute; the amount of lime used is so small that no clogging of the machinery will result, and there is no danger of injuring the plants.

The action of lime in overcoming the caustic properties of the compounds of arsenic has suggested the use of the Bordeaux mixture in combination with these poisons, but especially with London purple and with Paris green. These mixtures have now been in use for several years, and they have, almost without exception, given excellent results. The value neither of the insecticide nor of the fungicide appears to be weakened, and the presence of the lime in the Bordeaux mixture entirely prevents any injury to foliage. The arsenites are mixed with the fungicide in the same proportions as if clear water were the diluent. Other combinations than the above are not so satisfactory.[1]

When used dry, both London purple and Paris green may be applied pure, provided a uniform and economical application can be made. It is, however, customary to mix the poisons with flour, leached ashes, plaster, air-slaked lime, soot, and similar substances, using 1 part of the insecticide to from 5 to 50 of the diluent, the required amount of the latter being less when the two are thoroughly mixed and carefully applied. But since the introduction of improved machinery, the liquid applications are generally preferred. The price of Paris green varies from eighteen to thirty cents per pound.

ARSENITE OF LIME; $Ca_3(AsO_3)_2$ (Normal). — An arsenite of lime is formed when arsenious acid and lime are boiled together, as already described under ARSENIC. About three-fourths of London purple is made up of this material, according to analyses made at the Cornell experiment station.[2] The arsenite of lime is insoluble in water, and is not injurious to foliage. As an insecticide it is probably not surpassed by any compound of arsenic; it is advisable to mix some coloring matter with the poison to lessen the danger of mistaking it for some other article.

English Purple Poison. — An analysis of this preparation shows the total amount of arsenic trioxide to be 36.75 per cent of the material. Of this amount, 14.58 per cent is soluble in water. This insecticide has as yet been tested only to a limited extent, but my own experience with it has been that the following proportions may be used with success against the potato beetle, an insect which is destroyed with greater difficulty than many other pests:

English purple poison	1 ounce.
Lime	1 "
Water	4 gallons.

[1] See *Cornell Agric. Exp. Sta.* 1891, Dec. Bull. 35, for accounts of experiments in combining various fungicides and insecticides.

[2] *Cornell Agric. Exp. Sta.* 1890, July, Bull. 18, 36.

Considerable difficulty has been experienced in mixing the poison with water. Much of it floats upon the surface in the form of bubbles, and it is almost impossible to wet all the poison. When once thoroughly wet, it remains in suspension fairly well. The color of the mixture is darker than that of London purple.

London Purple. — The chemical composition of London purple is variable. Two analyses published by Bailey[1] are as follows: "1. Arsenic, 43.65 per cent; rose aniline, 12.46; lime, 21.82; insoluble residue, 14.57; iron oxide, 1.16; and water, 2.27. 2. Arsenic, 55.35 per cent; lime, 26.23; sulphuric acid, .22; carbonic acid, .27; moisture, 5.29." Some samples show that fully one-half of the arsenic is in a soluble condition, and this easily explains the scorching of the foliage to which London purple has been applied. In the manufacture of certain dyes this substance appears as a waste product, which accounts for the above variations. The finely divided condition of the powder is one strong point in its favor. It remains suspended in water a long time, and the liquids with which it is mixed require comparatively little agitation. The value of London purple does not rest in its coloring matter, for this can be removed and the arsenite still be as effective as before. In order to check the caustic action of the poison, it is well to add an amount of lime fully equaling in weight that of the drug; the dissolved arsenic will then be converted into an insoluble arsenite of lime.

The following formula indicates the manner of its use:

London purple	1 pound.
Lime	1 "
Water	200–300 gallons.

When less water is used, the amounts of the other ingredients should be reduced in proportion. In making applications, the liquid should be stirred sufficiently to prevent the solid particles from settling to the bottom.

If London purple is used without lime, foliage is commonly scorched when 1 pound in 200 gallons of water is used, but more dilute mixtures will prove more satisfactory. This arsenite should cost from six to fifteen cents per pound.

[1] *Horticulturist's Rule-Book*, third edition, 2.

Paris Purple. — This substance closely resembles English purple poison, being of a very deep maroon color. Chemical analysis shows 34.1 per cent of arsenic trioxide, 40.7 per cent of this amount being soluble in water. It may be used in the same manner as recommended for English purple poison, and it is also defective from the fact that it does not mix readily with water.

BENZINE. — Benzine has been used in the place of the bisulphide of carbon for the destruction of insects infesting seeds. It is not so energetic as the latter, so that larger quantities of the liquid must be used.

BISULPHIDE OF CARBON. See CARBON BISULPHIDE.

BLIGHT POWDER. See SULPHATED SULPHUR.

BLUE STONE. See COPPER SULPHATE.

BLUE VITRIOL. See COPPER SULPHATE.

BORAX. — Borax, whether used as a powder or in a strong solution, is of value in driving roaches and similar vermin from the places they frequent.

BORDEAUX MIXTURE; COPPER MIXTURE OF GIRONDE; COPPER SULPHATE AND LIME MIXTURE; MILLARDET MIXTURE. — The early history of this fungicide has already been thoroughly discussed, as well as the first formulas adopted for its manufacture. The chemical composition of the mixture is by no means clear, for although at first thought it would seem that the reactions which take place when the copper sulphate solution and the milk of lime are brought in contact with each other must be quite simple, still such is not the case. The new compounds formed vary with the proportion of the ingredients, and all who have observed the behavior of the mixture must have noticed that it varies in color with the different amounts of lime added, sometimes being intensely blue, again, much paler blue; and frequently a greenish tinge will be noticed, this being most marked when a small amount of lime is present. Since the chemistry of the mixture has not yet been accurately determined, it will be of little avail to discuss the various theories regarding its composition, and only those concerning which there is the most certainty may here be briefly mentioned.

When the mixture was first studied, it was supposed that the union of the two ingredients caused the formation of copper hydrate, water, and the sulphate of lime, in accordance with the following reaction :

$$CuSO_4, 5H_2O \quad + \quad CaOH_2O \; = Cu(OH)_2 + \; CaSO_4 + {}_5H_2O.$$

copper sulphate crystals + water-slaked lime = copper hydrate + lime sulphate + water.

It was soon found, however, that these changes would not account for the various phenomena noticed during its manufacture. Careful observation has shown that when lime is added to a certain point, the mixture assumes a greenish tinge, due to the formation of precipitates, probably basic sulphates of copper, in which this color predominates. It is a popular idea that the addition of lime is necessary in order to neutralize any free sulphuric acid which may be present. If such were the case, the precipitate would be largely a sulphate of lime, with no hydroxide of copper. When lime is added to a solution of copper sulphate, the latter compound is entirely broken up and new ones formed. The presence of the basic sulphate of copper is thus explained. When sufficient lime is added so that the copper sulphate is entirely neutralized, most of the copper is probably precipitated in the form of a hydrate. But at least one other compound is sometimes formed in the Bordeaux mixture. This appears most commonly when an excess of lime has been added to a concentrated form of the mixture. It may be a double basic sulphate of copper and lime, but so little work has been done regarding its formation and action that no definite statements can be made.

Whatever may be the composition of the Bordeaux mixture, it is certain that all but a trace of the copper is in the form of a precipitate or sediment which is practically insoluble in water. This settles to the bottom, leaving a clear solution above. This solution is of no value as a fungicide, for the sediment contains all the compounds useful for this purpose, and therefore the mixture should be kept thoroughly stirred that the sediment may be uniformly applied.

But the reactions which take place in the Bordeaux mixture do not cease when the material is applied to the plant. It is well known that carbonic acid will cause considerable quantities of copper to enter into solution again if the acid comes in contact with the copper sediment of the mixture. The chemical changes which take place have not been fully determined, but Professor J. T. Willard has suggested the following:[1]

$$\underset{\text{basic copper sulphate}}{2\,(Cu(OH)_2,\ CuSO_4)} + \underset{\text{carbonic acid gas}}{CO_2} =$$

$$\underset{\text{copper sulphate}}{2\,CuSO_4} + \underset{\text{copper hydrate}}{Cu(OH)_2} + \underset{\text{copper carbonate}}{CuCO_3} + \underset{\text{water.}}{H_2O.}$$

This theory appears to be very plausible and several facts tend to support it. When dew or rain-water gathers upon a leaf, the liquid always contains a certain amount of carbonic acid gas in solution, obtaining it both from the air and from the leaf itself. If the foliage has been sprayed with the Bordeaux mixture, the carbonic acid comes in contact with the copper sediment, and a certain amount of the copper is dissolved. This much has been proved. That the dissolved copper may be in the form of the sulphate is also very probable, since it is well known that a solution of copper sulphate is injurious to foliage, and well-prepared Bordeaux mixture has also caused a similar injury. This alone is not very convincing, but when it is considered that the injury following the use of the fungicide does not take place immediately as a rule, but only after the sediment has been exposed to the air for some time, the position is strengthened. If, however, the weather is of such a nature that the foliage is constantly wet by light showers, not enough rain falling to wash off the leaves but only to wet them, and if this were continued for some time, much injury might be expected to result from the use of even such a safe preparation as the Bordeaux mixture. During the early part of the year 1894 such conditions did exist, and much complaint was heard regarding the injury done to both apples and pears by the use of this remedy. It seems very probable that the carbonic acid should unite with some of the copper, and also with some of the lime, although no mention is made of this in the above reaction, and that pure copper sulphate should result. As the amount of this compound gradually increases, the injury to the foliage and the fruit naturally follows.

[1] Cited by Fairchild, *U. S. Dept. of Agric. Div. Veg. Path.* Bull. 6, 14.

The formation of the carbonate of lime may take place as soon as, or even before, the appearance of the copper sulphate, since the acid would probably act more energetically upon the hydrate of lime than upon the copper compounds; therefore the appearance of the copper sulphate would depend to a certain extent upon the absence of the hydrate of lime. This well explains the tardiness with which the Bordeaux mixture injures foliage.[1]

Several corollaries follow from the above, and these have considerable practical bearing on the method of making the mixture.

If a larger amount of lime is used than is required to satisfy the immediate chemical changes which take place, the more slowly will the fungicidal action of the Bordeaux mixture appear. In wet seasons this is an advantage, since the mixture will retain its efficiency longer, and less injury will be done. The disadvantages of using much lime are very easily realized by all who have applied the mixture. The machinery is apt to be clogged, and the liquid becomes more difficult to handle and to apply uniformly. The particles of lime probably also offer more resisting surface to rain in heavy showers, and more of the material will be washed from the trees. The use of as small an amount of lime as possible would therefore appear to be desirable, but such is the case only to a limited extent.

The use of the ferrocyanide of potassium test, or Patrigeon's method, has already been mentioned on page 46. This test shows exactly how much lime is necessary to satisfy all immediate chemical changes, and it serves, therefore, as an index of the minimum amount required. The Bordeaux mixture so prepared is of an intense blue, and, as more commonly made, the amount of sediment is comparatively small. When applied to plants it is easily handled, and is in this respect the most satisfactory preparation. Its fungicidal action probably begins as soon as the application is made, and the copper is more energetic than when it is in the presence of considerable quantities of

[1] For more detailed accounts of the chemistry of Bordeaux mixture consult the work of Chester and of Sostegni. An abstract of Sostegni's article is in *Cornell Agric. Exp. Sta.* 1892, Bull. 48. Fairchild has written an exhaustive article on this fungicide, which was published as Bull. 6 of the Division of Vegetable Pathology, U. S. Department of Agriculture, and entitled "Bordeaux Mixture as a Fungicide."

lime. The adhesive properties are perhaps greater than those of any of the other mixtures of this nature, and there are thus several features which recommend the method for general use. But the season of 1894 showed that the preparation is not a very safe one to use except in dry seasons, or in regions where the rainfall and dew are but slight. In the presence of much water, the mixture will injure both foliage and fruit, whatever may be the compound doing the mischief, and for this reason when so prepared it cannot be unqualifiedly recommended. In some seasons it may be used with impunity, while in others it may cause a loss which will more than overbalance any advantage derived. The ferrocyanide of potassium test is of great value in determining how much lime is actually required, and in this manner it may serve as a check when the ingredients are not weighed, and then this neutral condition may be taken as a starting-point for the addition of more lime.

In making the Bordeaux mixture by the aid of the ferrocyanide of potassium test, certain points must be borne in mind in dissolving the copper sulphate. (See, also, COPPER SULPHATE.) A definite proportion should exist between the amount of the salt used and the water in which it is dissolved. This is necessary so that the amount of the copper compound in a given amount of water may be known. The more common method is to dissolve either 1 or 2 pounds of copper sulphate in 1 gallon of water. Any desired amount can then easily be obtained by first stirring the stock solution thoroughly, and then taking out the quantity which holds the desired amount. The milk of lime is then added to the diluted solution until a few drops of the dissolved ferrocyanide of potassium (which see) give no brown discoloration when added to the mixture. A better way of using the test, however, is to add some of the mixture to a few drops of the solution, the latter being held in a butter dish or other article of white porcelain. This will show the presence of the red precipitate when it cannot be detected by the old method of adding the test solution to the mixture. It is probable that much of the injury which followed the use of the Bordeaux mixture in 1894 was caused by an insufficient amount of lime having been used, this being due to the fact that the ferrocyanide of potassium test did not show plainly the true condition of the preparation. A person experienced in making the mixture can tell by its color when sufficient lime has been added, but he cannot always tell how much to add in excess of the amount demanded by the test. For this reason it is safer to use a definite formula, provided the materials are fairly pure, since then there is less chance of a mistake; this applies especially to beginners.

Another test sometimes employed is to insert into the mixture a polished iron surface. If an insufficient amount of lime is present, so that some copper still remains in solution, the iron will become coated with this metal. The test is said to be very delicate.

It is probably true that, as a rule, each extreme should be avoided. The formulas at present in use in America may be divided into two classes,—those in which the ingredients are weighed, and those in which the ferrocyanide of potassium test is used. Among the former we have the following:

The "Standard," or 3.6 *per cent Bordeaux Mixture.*

Copper sulphate	6 pounds.
Quicklime	4 "
Water	22 gallons.

This formula was at first extensively used, but it was found that a more dilute mixture would answer the purpose equally well, so it has been abandoned for the mixture which may now be termed

The "Normal," or 1.6 *per cent Bordeaux Mixture.*

Copper sulphate	6 pounds.
Quicklime	4 "
Water	45 gallons.

This formula, or one in which the amount of water varies from 40 to 50 gallons, may now be considered the most popular in America. Sixty gallons of water should be used when spraying peaches. If air-slaked lime is used in place of the fresh article, the amount should be doubled, and even then its use cannot be recommended, since too little is yet known regarding the composition and action of the mixture prepared in this manner. By a 3.6 per cent Bordeaux mixture is meant one in which the weight of the copper sulphate is equal to 3.6 per cent of the weight of the water, considering 1 gallon to weigh 8.345 pounds. For the same reason the normal mixture may be termed a 1.6 per cent Bordeaux, as the 6 pounds form such a percentage of the weight of the water. This method of designating the various mixtures is the one generally adopted in Europe, and it is convenient here for purposes of comparison.

Occasionally the recommendation is made to add 1 quart of molasses to the above mixture in order to increase its adhesive properties. As a matter of fact, the addition is rarely made, and is scarcely necessary, since the mixture, even when used alone, is one of the most adhesive of fungicides. The addition of from 1 to 2 pounds of soap has been made for the same purpose, and also to make the mixture spread more evenly. The value of the mixture is slightly increased by such additions; nevertheless, they are scarcely necessary.

In Italy the milk of lime is not used in making the Bordeaux mixture, but in its place lime water, which is a saturated solution, is added to the copper sulphate solution. This makes a very dilute mixture, as the following formula of Cavazza shows.

Cavazza's Bordeaux mixture (Italian):

Copper sulphate	720 grams.
Lime water	100 liters.

This is a neutral mixture which contains about .072 per cent of copper sulphate. It is very highly recommended in Italy, and Professor Cavazza writes me that he has used the mixture so prepared, since 1886, for controlling fungous diseases of the grape as well as those of the peach, and in general it is there used in preference to other formulas. The French, however, use a mixture having from 1 to 2 per cent of copper sulphate, the milk of lime being preferred to a saturated solution.

When the Bordeaux mixture is made according to a certain formula, a few points must be observed which it is unnecessary to notice when the ferrocyanide of potassium test is used. The directions given above call for 1 to 2 pounds of copper sulphate to each gallon of water, the smaller amount being preferable. This solution should be diluted one-half before the lime is added. If too little water is present when the two ingredients are brought together, the mixture thickens up like sour milk, and it must be thoroughly stirred to change it to a more liquid form. Such concentrated mixtures are not, on the whole, the best to make, as in my experience the sediment is more coarse than when a larger amount of water allows of a more free intermingling of the two ingredients. Two gallons of water to every pound of copper sulphate is a safe proportion, and the use of still more water might be of benefit. All immediate chemical action has largely ceased a few minutes after the lime and the copper sulphate have been brought together, and the mixture may then be diluted as desired, and immediately applied.

The most convenient method of making the mixture is to have a stock solution of definite strength, so that any desired amount of the sulphate may be taken. This should be diluted as already described, and then the milk of lime should be added. This ingredient may also be prepared in large quantities before using; it will keep indefinitely if kept covered with water.

The sediment in the Bordeaux mixture remains in suspension much better during the first twenty-four hours after the two ingredients are brought together; in fact, it settles so slowly that an agitator is scarcely necessary during this period. But after a day or two, probably on account of some physical change in the mixture, the sediment rapidly settles, rendering the use of an agitator essential for a uniform application. To what extent this change affects the fungicidal value of the mixture is not known, but if care is exercised in keeping the old mixture well stirred, it is probable that good results will follow. Such, at least, has been the writer's experience with Bordeaux mixture which was allowed to stand several weeks before it was applied to the apple trees which were being treated.

If the Bordeaux mixture has been imperfectly made, or if it is not applied with proper machinery, it will be found better to strain either the lime before it is added to the copper sulphate solution, or else the mixture before it is applied, the former being perhaps the better plan. The mixture should be kept constantly stirred when the application is made.

The dried sediment has been used in place of the liquid form, but the results were not equally satisfactory. It was found that about four times as much material was necessary when the powder was applied, and, besides, its efficiency was apparently less marked. (See, also, DAVID'S POWDER.)

Bordeaux mixture is said to possess a certain value as an insecticide, but this action is not sufficiently great that its use for this purpose can be recommended. Flea beetles appear to be most easily overcome or driven away by this preparation, and it is possible that it can be used to advantage for this purpose when the pest causes much damage.[1] Uniformly good results have not always followed its use for this purpose, however.

BORDEAUX MIXTURE AND MOLASSES. — Perret mentions the following formula as possessing especial merit:[2]

Copper sulphate	4½ pounds.
Quicklime	4½ "
Molasses	4½ "
Water	30 gallons.

Dissolve the lime in 24 gallons of water. To this add the molasses, which has been diluted with 3 gallons of water; stir this well and pour in the copper sulphate, also dissolved in 3 gallons of water. The precipitate settles slowly, leaving a greenish colored liquid above. This color is a proof of the success of the operation. The mixture, even when diluted to 40 or 50 gallons, may be recommended for trial, although in this country it will scarcely prove superior to the preparation commonly employed. Sugar has also been used in place of the molasses.

BORDEAUX MIXTURE, DRIED. See DAVID'S POWDER.

BUHACH. See PYRETHRUM.

CARBOLIC ACID; PHENIC ACID; PHENOL; C_6H_6O. — Carbolic acid is a powerful poison to the lower forms of life, and is very extensively used as an antiseptic. Its value as an insecticide or as a fungicide is, however, comparatively slight, and it cannot be recommended for such use. It has been very thoroughly tested however, and the following has been frequently recommended for the destruction of root insects:

Carbolic acid	1 part.
Water	50–100 parts.

[1] For further details regarding this subject the reader is referred to Jones, *Vt. Agric. Exp. Sta.* 1894, Bull. 44, 95; Halsted, *N.J. Agric. Exp. Sta.* 1895, Bull. 107, 13; Lodeman, *Cornell Agric. Exp. Sta.* 1895, Bull. 86, 58. *Ann. Rept. Vt. Agric. Exp. Sta.* 1894, 12, 95 *et seq.*

[2] *Jour. d'Ag. Prat.* 1892, April, 508.

CARBOLIC ACID AND GLYCERINE:

Carbolic acid	½ pint.
Glycerine	1 pound.
Soap-suds	10 gallons.

An emulsion should be made of these ingredients. Apply against sucking insects.

CARBOLIC ACID AND SOAP. — An emulsion of carbolic acid and a soap solution may be made very readily according to the following formula, and the product possesses considerable insecticidal value, largely on account of the presence of the soap:

Carbolic acid	1 pint.
Soft soap (hard soap ¼ pound)	1 quart.
Hot water	2 gallons.

The soap is first dissolved in the water, after which the acid is added; an emulsion is then produced by thorough agitation. It destroys insects by coming in contact with them, and may be applied as a wash or in the form of a spray. It should be used upon dormant wood only.

CARBOLIC ACID EMULSION. — The stock solution is prepared as in the preceding, but should be diluted with thirty parts of water before being applied to foliage.

CARBOLIZED PLASTER. — Carbolic acid is occasionally mixed with some dry powder as plaster, air-slaked lime, road dust, etc., and the two are then applied together. It possesses little value, but the recommendation is to use:

Carbolic acid	1 pint.
Plaster or other powder	50 pounds.

It is most useful when applied to plums which suffer from the curculio. If it is used with lime, it is effective in destroying slugs upon all plants.

CARBONATE OF COPPER. See COPPER CARBONATE.

CARBON BISULPHIDE; DISULPHIDE OF CARBON; FUMA; CS_2. — This is a clear, colorless liquid, highly volatile and inflammable. The commercial article has a powerful and disagreeable odor. The fumes are poisonous to animal life, and in this lies the value of the liquid. Its insecticidal properties seem to have been first utilized by Louis Dayère, formerly professor of agriculture at the Institute of Versailles. He used the liquid in Algiers for preventing insects from injuring stored wheat, and it is now commonly used in this country for similar purposes.[1] The vapor is heavy and it is better, when possible, to apply the liquid above the parts to be treated, so that the entire space may be more quickly filled. The amount of liquid to use will vary with the tightness of the receptacle, and the character of the product to be protected. For growing plants it is not advisable to evaporate more than 20 or 25 minims in a vessel containing from 2 to 3 cubic feet of space, this being an equivalent of 1 pint of the liquid to about 1000 cubic feet of space, or to 1 ton of grain. If so used, the receptacle should be as nearly airtight as possible. When grain or other seeds are treated, the amount can be advantageously increased, and much larger quantities than the above can be used without fear of injury. All vermin that live underground can also be successfully exterminated. Ants' nests may be destroyed by making a hole in the center of the nests, and then pouring in 2 or 3 teaspoonfuls of the liquid, after which the hole should be tightly closed with earth. Woodchucks and gophers can easily be killed by means of this poison; about a gill of the fluid is poured upon rags or cotton, and these are then forced into the animal's burrow. The opening should then be closed, and the woodchuck will cause no more trouble if all the holes are similarly treated.

Subterranean applications for the destruction of insects have also been successfully made. The phylloxera of the grape has been so destroyed, and the cabbage root-maggot may be overcome in this manner more advantageously than in any other. A machine known as the McGowen bisulphide of carbon injector[2] was invented in 1894 for the purpose of making such applications, so the liquid may now be used quickly and effectively in treating underground insects.

Carbon Bisulphide and Kerosene. — The mixture is prepared by using 1 part of carbon bisulphide, and from 5 to 20 parts of kerosene. The two should be thoroughly stirred before being applied. The action is similar to that of the bisulphide of carbon, but the mixture is practically out of use.

[1] *Akhbár*, 1857, Oct. 16. Cited in *Gard. Chron.* 1858, Aug. 28, 653.

[2] *Cornell Agric. Exp. Sta.* 1894, Bull. 78.

CHLORIDE OF COPPER. See COPPER CHLORIDE.

CHLORIDE OF IRON. See IRON CHLORIDE.

CLAY. See WASHES.

COAL TAR. — If a few quarts of coal tar are added to a barrel of water, the liquid soon becomes so impregnated with the odor that it may be used as a repellent of insects. A strong solution of gas tar may be used for a similar purpose, but these applications possess comparatively little value.

COMBINATIONS OF INSECTICIDES AND FUNGICIDES. — The most successful of these combinations is that of the Bordeaux mixture and compounds of arsenic. The lime in the mixture prevents the arsenic from injuring foliage, while it does not appear to lessen the efficiency of the poison. Each preparation is applied at the same rate as if used alone.

A combination of the ammoniacal carbonate of copper and an arsenite has been used with success by some, but such a preparation is frequently very injurious to foliage, and it should be applied with caution. The ammonia acts as a solvent of the arsenic, and this solution does the damage. The addition of lime would tend to reduce the severity of the injury.

The Bordeaux mixture has been used as an agent for emulsifying kerosene, with apparently satisfactory results.[1] The preparation should be more thoroughly tested before it can be recommended. Kerosene emulsion and Bordeaux mixture have been combined, but not with satisfactory results. See also CORNELL MIXTURE.

When pure kerosene is emulsified with the Bordeaux mixture, the combination allows the addition of Paris green, making a mixture adapted to destroy nearly all the insect and fungous enemies of plant life. When a mixture of kerosene emulsion and the Bordeaux mixture is made, the arsenite cannot be added successfully; for even when the emulsion and the arsenite are united, the resulting mixture is still unsatisfactory.

Resin washes and kerosene emulsion, applied together, have not yet been sufficiently studied and tested to determine the value of such mixtures.

A simple solution of resin, made as described on page 169, is

[1] See Galloway, *Insect Life*, vii. 126, for an account of this and other combinations.

said to increase the adhesive power of the Bordeaux mixture when the two are applied together.

The resin preparations and arsenical compounds have been successfully united and applied, but such combinations are at present little used.

Copper Acetate; Verdet; Verdigris. — There are several compounds of copper and acetic acid, but the one which has been used in spraying is known as the dibasic acetate of copper. It possesses only fairly good fungicidal properties, but it has been highly recommended for its adhesion to foliage. It may be applied at the rate of 2 to 4 ounces in about 25 gallons of water.

Copper Arsenite. See Sheele's Green, page 120.

Copper Carbonate; Carbonate of Copper; $CuCO_3$. — Chester's method of preparing this chemical is as follows: "Dissolve in a barrel 25 pounds of copper sulphate in hot water. In another barrel dissolve 30 pounds of sal-soda. Allow both solutions to cool, then slowly pour the solution of sal-soda into the copper sulphate solution, stirring the same. Fill the barrel with water and allow the precipitate of copper carbonate to settle. Upon the following day siphon off the clear supernatant liquid, which contains most of the injurious sodium sulphate in solution. Fill the barrel again with water, and stir the precipitate vigorously into suspension; again allow the precipitate to settle, and again on the following day siphon off the clear liquid. The operation washes the carbonate free of most of the sodium sulphate which contaminates it. Make a filter of stout muslin, by tacking the same to a square wooden frame which will just fit over the open top of the second barrel, letting the muslin hang down loosely so as to form a sack; through this filter the precipitate, so as to drain off the excess of water, and as the filter fills remove the precipitate, and allow it to dry in the air, when it is ready for use. The operation is not troublesome, and can be carried on in connection with other work."[1] The following reactions are at present supposed to take place when the two solutions are united:[2] $12\ (CuSO_4, 5\ H_2O) + 12\ (Na_2CO_3, 10\ H_2O) = 6\ [CuCO_3, Cu(OH)_2, H_2O] + 12\ Na_2\ SO_4 + 6\ CO_2 + 168\ H_2O$.

[1] *Ann. Rept. U. S. Com. Agric.* 1890, 403.
[2] *Del. Agric. Exp. Sta. 4th Ann. Rept.* 1891, 67.

By using the above amounts of material, there will be formed a trifle over 12 pounds of the carbonate of copper, the selling price of which is about forty cents a pound. When thus made at home, the cost is only about fifteen cents, which is a great saving, especially as the material is nearly chemically pure.

Copper carbonate is a fine, bluish-green powder, insoluble in water. It dissolves readily in ammonia, forming the ammoniacal solution of copper carbonate, which see. The powder has often been used as a fungicide when suspended in water, but the results obtained have almost invariably been unsatisfactory. When applied in this manner, however, the following formula will prove most satisfactory:

Copper carbonate........................	1 pound.
Water................................	40 gallons.

The liquid should be agitated frequently to prevent the copper compound from settling to the bottom. The cost of copper carbonate varies from thirty-five to sixty cents per pound.

Copper Carbonate, Ammoniacal Solution; Cupram. — Penny[1] has made a very careful study of the best method of preparing this solution, and the results of his work are here given in full:

"The practical directions then are these: To 1 volume of 26° Beaumé ammonia (the strong ammonia of commerce) add from 7 to 8 volumes of water. Then add copper carbonate, best in successive quantities, until a large portion remains undissolved. The mixture should be vigorously agitated during the solution and finally allowed to subside, and the clear liquid poured off from the undissolved salt. A second portion should then be made by treating the residue of the former lot with more ammonia diluted as before, then with the addition of fresh copper carbonate, in every case with vigorous stirring or agitation. This method of making in successive lots will result in a richer solution of copper, at least, unless an unwarranted length of time be taken. This solution may be made in any suitable wooden or stoneware vessel.

"A still better way is to place in a large jar an inverted

[1] The chemistry of this solution has been thoroughly treated by C. L. Penny, of the Del. Agric. Exp. Sta. an account of which may be found in Bull. 22. I have also quoted freely from other bulletins of the same station on these subjects.

crock, or other suitable shelf, and on this the copper carbonate, so that it shall be at the surface of the ammonia when it is poured in. After adding the ammonia, diluted as above, the whole should be allowed to stand covered some time, as over night, and then the undissolved copper salt may be in great part easily lifted out of the solution. Instead of the shelf a suitable receptacle may be used, as a fine wire sieve. The jar will need nothing but a loose cover, as the loss of ammonia will be slight at that degree of dilution.

"The clear solution thus obtained, containing from 3 to 4 per cent of ammonia gas, must be diluted as described above, in no case less than 13 or 15 fold, better, for the safety of the plant, 20 fold or more.

"Those directions which recommend *so much* ammonia (whatever it may be) to be used as may be necessary to dissolve the copper salt and then to dilute to a given number of gallons, are not only not economical, but absolutely dangerous, inasmuch as it is an uncertainty just how much ammonia may be used in the first instance, and hence uncertain what strength it may have after dilution, when applied to the trees. It should be borne in mind always that if strong ammonia is used it must be diluted from first to last at least 100 fold, and better considerably more.

"The solubility of copper carbonate in ammonium carbonate has been studied but not yet sufficiently for report."

After the copper carbonate has been dissolved in ammonia water, it should be used by taking as much of the fluid as contains 1 ounce of dissolved copper carbonate, and this is then diluted with 9 gallons of water. These proportions should be retained when either larger or smaller quantities of the fungicide are desired.

The ammoniacal solution of copper carbonate possesses some decided advantages. It is a clear solution entirely free from sediment, and can therefore be applied as readily as water. Another favorable point is that it may be used quite freely upon maturing fruit, and also upon flowering plants, without leaving any conspicuous stain. When certain plants require spraying with a fungicide shortly before the crop is harvested, this preparation is an excellent one to use. In efficiency it also ranks high, being clearly surpassed in this respect only by the

Bordeaux mixture. It is also cheap, and on the whole is one of our most valuable remedies.

Several definite formulas have been recommended for the manufacture of this fungicide, the two following being the best known:

Copper carbonate	3 ounces.
Ammonia (22° Beaume)	1 quart.

Agitate until the copper is completely dissolved. It will keep indefinitely, but should be diluted with 25 gallons of water.

Copper carbonate	5 ounces.
Ammonia (26° Beaume)	3 pints.
Water	45 gallons.

The ammonia should be diluted as already described, after which the copper will dissolve more readily. Sixty gallons of water should be used when spraying peaches.

Combinations of the ammoniacal carbonate of copper and the arsenites are said to have been used with success, but my own experiments have resulted differently. The combination injured foliage to such an extent that it was abandoned after repeated trials. When Paris green was added, the mixture was particularly caustic, since the ammonia undoubtedly caused some of the arsenic to enter into solution. London purple did not make so caustic a mixture, but nevertheless considerable injury resulted, and these combinations may be considered unsafe. The addition of milk of lime, however, obviates the trouble, and renders the preparation a safe one. Lime to the amount of two to three times the bulk of the poison should be added.

There are several other mixtures which, in composition, are essentially the same as the solution of copper carbonate in ammonia. They are the modified eau céleste, copper and ammonium carbonate mixture, and Johnson's mixture. Regarding these, Chester says, "For all practical purposes, the above fungicides of this group are one and the same, the essential copper salt being, in each case, what for brevity we may call an *ammonium copper carbonate*, but which is in reality a mixture of ammonium copper carbonate ($CuCO_3$, $2NH_3$) and ammonium cupric hydroxide [$3Cu(OH)_2$, $4NH_3$, $3H_2O$]." [1]

[1] *Del. Agric. Exp. Sta. 4th Ann. Rept.* 1891, 68.

COPPER CARBONATE AND AMMONIUM CARBONATE MIXTURE. — This mixture was proposed by Chester in 1890. He thought it possible that ammonia might not be the best solvent of copper carbonate and the following formula uses ammonium carbonate in place of ammonium water. The resulting fungicide is nearly identical with copper carbonate dissolved in ammonia, and the remarks regarding that fungicide also apply, in the main, to this preparation :

Copper carbonate	3 ounces.
Ammonium carbonate..................	1 pound.
Water	40–45 gallons.

"By this combination all the copper is completely dissolved. To test the question, I prepared the above fungicide with the exception that I took 5 ounces of the copper carbonate in order to have an excess. An analysis showed that the 1 pound of ammonium carbonate had dissolved 3.11 ounces of the original copper carbonate."[1]

Ammonium carbonate can be bought for fifteen to thirty cents per pound.

COPPERAS. See IRON SULPHATE.

COPPER CHLORIDE; $CuCl_2$. — The chloride of copper has received little attention as a fungicide, although it is a promising compound. It contains 46.93 per cent of actual copper. When used alone it is very caustic to foliage, a solution of $1\frac{1}{2}$ ounces in 25 gallons of water being too strong. Two or three times its bulk of lime should be added, when 5 ounces to 25 gallons of water will prove a satisfactory proportion. The undissolved crystals must be kept in tightly closed glass vessels, as they absorb water rapidly, and are soon reduced to a liquid condition. The chemical is at present too expensive for general use.

COPPER SODA MIXTURE. See COPPER CARBONATE.

COPPER SODIUM HYPOSULPHITE;[2] $Na_2S_2O_3, Cu_2S_2O_3$. — This material may be prepared as follows: "Dissolve 8 ounces of sulphate of copper in hot water, then dilute with cold water, to about 10 gallons. In another vessel dissolve 1 pound of hyposulphite of

[1] Chester, *Del. Agric. Exp. Sta. 4th Ann. Rept.* 1891, 71.

[2] For a more complete discussion of this fungicide, see *Del. Agric. Exp. Sta. 4th Ann. Rept.* 1891, 73.

soda in cold water; add the two together; dilute in 25 gallons." The preparation possesses no special fungicidal value.

Copper Sulphate; Sulphate of Copper; Blue Vitriol; Blue Stone; $CuSO_4$; $CuSO_4 + 5H_2O$.—This chemical is formed by uniting metallic copper and sulphuric acid, the product being formed in several different ways. The substance is deposited from solutions in the form of large, blue, transparent crystals containing 25.46 per cent of actual copper, and it is in this form that the salt is commonly sold. Granulated copper sulphate is formed by breaking up the larger crystals; otherwise, it is identical with the other form. On account of the fineness of the particles, the mass loses its deep blue color, and for this reason the granulated form offers greater temptations for adulteration. A pure solution of copper sulphate forms a reddish-brown discoloration with a solution of the ferrocyanide of potassium, and this may be used as a test for the purity of the copper compound.

Copper sulphate is readily soluble in cold water, and still more so in hot water. A solution may be quickly made by hanging the material in a coarse sack near the surface of the water. This is done so that the dissolved portion may settle to the bottom as fast as it enters into solution, for in this manner the crystals are continually surrounded by clear liquid. If the crystals are placed in the bottom of the vessel, they are soon surrounded by a saturated solution which prevents them from being dissolved until the contents of the vessel are stirred so that the more clear liquid may come in contact with the crystals.

Copper sulphate should always be dissolved in wooden or earthen vessels. If an iron vessel is used, the copper will be deposited upon the iron, forming a copper-plated portion wherever the two come in contact.

A simple solution of copper sulphate should be sparingly applied to foliage, for when the liquid is sufficiently concentrated to have a decided fungicidal action it causes so much injury to most foliage that its use cannot be considered safe. This compound is more caustic than some other forms of copper, but Professor Taft recommends the use of a simple solution of copper sulphate instead of ammonia solution of copper compounds. He has sucessfully applied solutions containing 1 part of blue vitriol in 1000 parts of water to plants whose foliage is not so tender as that of peaches or beans. It is valued also because it does not stain the parts treated.[1] On dormant wood it can be used freely. It is then made of

Copper sulphate	1 pound.
Water	15–25 gallons.

The more dilute solution is for such tender wood as peaches. Grain is often soaked in a solution of copper sulphate to destroy spores of smut. The preparation is then made of

Copper sulphate	1 pound.
Water	1–2 gallons.

The use of a one-half per cent solution has been recommended for a similar purpose, the seed being soaked for twelve or fifteen hours.

COPPER SULPHATE AND SULPHURIC ACID SOLUTION. — Another, and a rather restricted use of copper sulphate, is to make a saturated solution, and to this add about 1 per cent of commercial sulphuric acid. The preparation is, of course, used only upon dormant wood, and is especially recommended for anthracnose of the grape.

The price of copper sulphate varies greatly. The granulated form may be bought for four to fifteen cents per pound, and the crystals at four to eight cents.

COPPER SULPHATE AND AMMONIUM CARBONATE MIXTURE. — See JOHNSON'S MIXTURE.

COPPER SULPHATE, ANHYDROUS. — When copper sulphate crystals ($CuSO_4 + 5\,H_2O$) are heated, the water of crystallization is driven off and only a pale blue powder remains ($CuSO_4 + 2\,H_2O$). This dissolves readily in water, and possesses the properties of the original crystals, although the weight is reduced, which leaves a greater proportionate amount of actual copper. The powder has been applied when mixed with sulphur or other powders for the prevention of mildew, but it is now little used.

CORNELL MIXTURE. — This preparation consists of a mixture of Bordeaux mixture, kerosene emulsion, and an arsenical compound. The combination is made with difficulty, but success may follow if a few points are observed. The Bordeaux mixture must be exactly neutral, and here the ferrocyanide of

[1] *American Agriculturist*, middle edition, 1895, July 20, 34.

potassium test is of value. The kerosene emulsion should be made according to the Hubbard-Riley formula, and then be poured into the Bordeaux mixture. And finally the arsenite may be added. Unfortunately, even if the combination be successfully made, the various ingredients appear to lose much of their value when so applied, and as yet the preparation cannot be generally recommended.[1]

CORROSIVE SUBLIMATE. See MERCURIC CHLORIDE.

CUPRAM. — A term applied to copper carbonate dissolved in ammonia, which see.

CUPRIC STEATITE. See SULPHOSTEATITE.

CUPROSTEATITE. — This powder closely resembles sulphosteatite in its composition, but while the latter contains about 10 per cent of copper sulphate, the copper in cuprosteatite is in the form of the hydrate, about 15 per cent of the powder being of this material. On this account the fungicide is said to be less caustic to foliage than sulphosteatite. Both powders are applied in the same manner.

CYANIDE OF POTASSIUM. See HYDROCYANIC GAS.

DALMATIAN INSECT POWDER. See PYRETHRUM.

DAVID'S POWDER; DRIED BORDEAUX MIXTURE. — The old formula for preparing the powder called for

Copper sulphate	4 pounds.
Quicklime	16 pounds.

As little water as possible was used for dissolving the sulphate and for slaking the lime; the two were then united and the product dried. It was then ground to a powder and applied. The ingredients used at present in making the Bordeaux mixture can be similarly treated. When the dried mixture is used in place of that suspended in water, it has been found that about four times the amount of the materials is required, and the distribution is on the whole not so satisfactory. The powder has never been used to any great extent, and for the reasons given will probably never become popular.

EAU CÉLESTE (Audoynaud process).

Copper sulphate	1 pound.
Hot water	2 gallons.

[1] See also Slingerland, *Science*, xxii. No. 551, 105. Also, Bailey, *Annals Hort.* 1893, 43.

When the crystals are dissolved and the liquid has cooled, add

Ammonia (22° Beaumé)	$1\frac{1}{2}$ pints.
Water, to make	25 gallons.

This fungicide has a caustic action upon foliage and cannot be recommended with safety. According to Professor Chester, "the probable reactions taking place in the preparation of the eau céleste are:[1]

1. $\underset{\text{normal copper sulphate}}{3[CuSO_4, 5\,H_2O]} + \underset{\text{ammonia water}}{4\,NH_4HO}$

$$= \underset{\text{basic copper sulphate}}{CuSO_4,\ 2\,Cu(OH)_2} + 2(NH_4)_2,\ SO_4 + 15\,H_2O.$$

2. $CuSO_4,\ 2\,Cu(OH)_2 + 2(NH_4)_2,\ SO_4 + \underset{\text{In excess.}}{8\,NH_4HO}$

$$= \underset{\text{ammonium copper sulphate}}{3(CuSO_4,\ 4\,NH_3,\ H_2O)} + 9\,H_2O."$$

Nevertheless, the fungicide is not a safe one to use.[2]

EMULSIONS. — Of the insecticides which kill by contact there are none more effective than those which are composed of emulsion of soap solutions and such penetrating liquids as mineral oils. The kerosene emulsions are the best known and most generally used. (See under KEROSENE.) But the following liquids have been recommended[3] as suitable substitutes for this oil. The percentages of the amounts to use in the emulsions are given for comparison:

Benzine emulsion, containing from	0.5 to 2.0 per cent.
Kerosene emulsion, containing from	0.5 to 2.0 per cent.
"Nitro benzina" emulsion, containing from	0.5 to 0.75 per cent.
Bisulphide of carbon emulsion, containing from	0.5 to 0.75 per cent.

The general method of procedure for preparing these emulsions is as follows:

"Active principle (oils, etc.)	0.5 to 1.0 per cent.
Soft soap	0.5 to 2.0 per cent.
Water of preparation	1.0 to 3.0 per cent.
Water of dilution	99.0 to 97.0 per cent."

[1] *Del. Agric. Exp. Sta. 4th Ann. Rept.* 1891, 68.

[2] Perret, in *Jour. d'Ag. Prat.* 1887, June 23, 878, says that the precipitate first formed when ammonia is added to a copper sulphate solution is a hydrated oxide of copper (oxide de cuivre hydraté). The clear liquid contains the sulphate of ammonia, which has a tendency to injure foliage.

[3] Ad. Targioni Tozzetti, "Mostra di Sostanze e di Emulsioni Insetticide," 1891, 17.

These ingredients are mixed in a definite order:

(*a*) Dissolve the soap in the insecticide.

(*b*) Add this solution to the water of preparation, and agitate.

(*c*) The water of dilution may then be added, and the emulsion again thoroughly agitated.

In America the method followed is to dissolve the soap in the "water of preparation," after which the oil is added. This mixture is then thoroughly agitated, commonly by means of a force-pump, until all the oil is emulsified. If the liquids are hot, an emulsion may be produced more easily.

Ferrocyanide of Potassium; Yellow Prussiate of Potash; K_4FeCy_6. — The only value this material possesses in connection with spraying is to assist in making the Bordeaux mixture, and to serve as a test for discovering the presence of sulphate of iron. The test solution may be made by dissolving the compound in water:

Ferrocyanide of potassium	1 ounce.
Water	1 pint.

The test solution forms a reddish-brown precipitate, or discoloration (the ferrocyanide of copper, Cu_2FeCy_6), with a dissolved copper salt, but a blue precipitate with an iron salt. See page 151.

Fish-oil Soap. —

Crystal potash lye	1 pound.
Fish-oil	3 pints.
Soft water	3 gallons.

Dissolve the lye in the water, and when boiling, add the oil, and boil for two hours. One pound of the soap may be dissolved in 5 to 10 gallons of water. This is of value as an insecticide.

Flour. — Flour is sometimes added to liquids to render them more adhesive. It may be used at the rate of 1 pound to 40 or 50 gallons of the preparation, but such additions are rarely, if ever, advisable. An exception may be made in the case of powders, especially those containing the arsenites. With these, the addition of flour, at the rate of five to ten times the bulk of the poison, may be of service in rendering the mixture more adherent to the foliage. But this condition is often followed by serious injury, undoubtedly due to the fact that the poison is not washed off, but remains to burn the foliage. The addition of lime to the mixture would probably be beneficial.

Fostite. See Sulphosteatite.

Fuma. — A form of carbon bisulphide, which see.

Gas Treatment. See Hydrocyanic Acid Gas.

Glue. — Glue is frequently recommended as a valuable addition to insecticides and fungicides; it is supposed to increase their adhesive properties, and probably does so to a limited extent. In general practice its use is unnecessary, but in case liquids do not adhere to foliage when the application is first made, the addition of some cheap glue, used at the rate of 1 pound to 50 gallons of liquid, may prove of value.

Glue and Arsenites. —

Common glue	1 pound.
Paris green	1 ounce.
Hot water	2 gallons.

The glue is first dissolved in hot water, after which the Paris green is stirred in, and the remainder of the water added. This is said to be of value in protecting trees from borers, but the applications may cause serious injury, and the remedy should be used cautiously. The mixture may also be used upon foliage, in which case dilute with about 15 gallons of water.

Grison Liquid; Eau Grison; Sulphur and Lime Mixture. — For the original formula of this liquid, see page 16. It is at present commonly made by using

Flowers of sulphur	3 pounds.
Quicklime	3 "
Water	6 gallons.

These should be boiled until the amount of liquid is reduced to 2 gallons. It should then be allowed to settle, and the clear liquid be drawn off and tightly corked in bottles. Dilute with 100 parts of water before using. The preparation is particularly valuable in treating the European mildew of the grape, and also for use against various mildews which attack plants grown under glass. See, also, Lime Sulphide.

Gypsine. See Arsenate of Lead.

Hellebore; White Hellebore; European Hellebore; Veratrum album. — The roots of this plant and also of *Veratrum viride*, American hellebore, when ground into a powder possess considerable insecticidal value. The powder is of a light yellowish-brown color, and possesses an odor which is not wholly disagreeable. The active principle of the root, known as Jervine, is a very powerful alkaloid. It generally destroys an insect by being eaten with the food, but it appears probable that it also possesses a certain value when it merely comes in contact with the insect's body. Hellebore is much less poisonous than the arsenical compounds, and it also soon loses its strength when exposed to the air. For these reasons it should be preferred to the mineral poisons when the plants to be treated are bearing products which are nearly ready for market, as ripening currants, or heading cabbages. If properly applied, it is very effective in destroying chewing insects, and more than two applications are rarely necessary. Only the fresh powder should be used. It may be applied either in dry form or when mixed with water. When used in the form of a dry powder, it is generally applied pure, but may be successfully diluted with once or twice its bulk of plaster, lime, or flour, the last causing it to adhere more firmly to the foliage. In cases where the insect does not yield readily to treatment, applications of the pure powder may be advisable. The powder should be sifted uniformly upon the foliage.

When used in water the following formula may be successfully employed:

Hellebore (fresh)	1 ounce.
Water	3 gallons.

Some recommend the addition of an ounce of glue to the above mixture, or a small amount of flour, in order to render it more adhesive; yet for general practice such additions are scarcely necessary. The use of one ounce of powdered soapstone with the mixture of hellebore and water has also been recommended as possessing especial value. The cost of good hellebore varies from twelve to twenty-five cents per pound.

Hot Water. See Water.

Hydrocyanic Acid Gas; HCN. — D. W. Coquillet was the first to suggest and use this gas for the destruction of scale insects. His experiments began in September, 1886, in the orange grove of J. W. Wolfskill, of Los Angeles, Cal. Its use has been followed by such good results that all other gases have been abandoned in treating these pests. The gas is prepared by using

Cyanide of potassium, 60 per cent ......1 ounce.
Commercial sulphuric acid ....1 fluid ounce.
Water ....3 " ounces.

Potassium cyanide of 90 per cent has also given excellent results. The water is first placed in an open, glazed vessel, and then the acid is added. When the parts to be treated are all covered, the diluted acid is placed under the tent, the cyanide of potassium is dropped in, and the tent immediately closed. The gas is exceedingly poisonous, and should not be inhaled. The amount formed with the above materials is sufficient for a confined space containing 150 cubic feet. It is safer to use the gas upon dormant trees, and during cool weather or at night, since trees are more easily injured during a high temperature. The treated parts should remain covered about an hour.

"The following table, giving height of trees and the proportions of chemicals and water, will be found suitable for districts in the interior or beyond ten miles in a direct line from the seacoast:

Height of Tree — Feet.	Diameter through Foliage — Feet.	Water — Fluid Ounces.	Sulphuric Acid — Fluid Ounces.	Cyanide of Potassium — Ounces.
6	4	2	1	1
8	6	4	2	2
10	8	6	3	3
12	10	10	5	5
12	14	14	7	7
14	14	16	8	8
16	16	18	9	9
18	16	20	10	10
20	16	22	11	11
22	18	24	12	12
24	20	26	13	13
26	20	27	13½	13½
30	20	28	14	14

"One would suppose that an [orange] tree having a dense foliage would fill up the space within the tent and require less gas to be effective. But the cold surface of the leaves condenses the gas, and fumigators find that a slightly heavier charge of chemicals is necessary for such a tree, and where the foliage is scant a less amount than is given in the table will answer. Some orchardists and fumigators consider that the work has not been effective unless some of the leaves or tender twigs have been injured. This is not necessary, for in our early experiments we have treated trees and killed the scale without even injuring the most tender twig or blossom. As the trees recover very quickly, even when seriously scorched, a slight burning is no detriment and is evidence that the work has been effective, except in the case of 'black scale' (*Lecanium Oleæ*), during the early summer when the eggs are under the females. The proper time to fumigate for this scale is during the fall or early winter, when they are in the larva state."[1]

"In order to make the canvas used for fumigation perfectly air-tight, to prevent the gas escaping, the tents have been treated with a light coat of boiled linseed oil. The great objection to the oil has been that it had a tendency to stiffen the canvas and add considerably to its weight, so a cheaper and more flexible preparation was sought. The following mixture, used by Commissioner Scott, of Los Angeles County, [Cal.] during the past season, made the tents gas-tight and left the canvas soft and pliable. The chief essential ingredient is a supply of common prickly-pear cactus (*Opuntia Engelmanni*) that grows in abundance in the southern counties of the state. It is the flat-leaf species, and parties living in sections to which it is not indigenous could have it sent in boxes. To make the cactus extract, chop up enough cactus to fill a barrel two-thirds full, then fill up the barrel with *cold* water. It should stand for twenty-four hours, when it will be ready for use. Do not prepare more than is required for immediate use, otherwise it will sour and become worthless. Stir well, then strain ten gallons of the liquid into another tub or barrel; dissolve two pounds of common glue and add to the cactus extract, with sufficient yellow ochre or Venetian red to give it a good body. After thoroughly mixing the ingredients, it is ready for use. Both

[1] Craw, *California State Bd. of Hort.* 1894, Bull. 68, 18.

sides of the canvas should be painted, and the dressing well rubbed into the fiber with a flat paint-brush. If oil is used, the canvas should be spread out and thoroughly dried before it is rolled up, or it is liable to be destroyed by spontaneous combustion. When dry there is no danger from this."[1]

IRON CHLORIDE (probably FERROUS CHLORIDE, $FeCl_2$). — This material has been successfully used in checking certain coffee diseases, and its use appears to be restricted almost entirely to this plant. Very dilute solutions were applied, and these proved to be exceedingly adhesive. The remedy is at present little known.

IRON SULPHATE; COPPERAS; GREEN VITRIOL; $FeSO_4$. — Copperas is formed by the union of sulphuric acid and iron. It is a green crystalline substance, and when finely broken up it bears a certain resemblance to granulated copper sulphate, and as it is much cheaper than the latter, it has been used as a means of adulterating the copper salt. Iron sulphate dissolves readily in water. The ferrocyanide of potassium may be used as a means of detecting the presence of this compound. This test gives a *reddish-brown* precipitate with a concentrated solution of copper sulphate, but with a dilute solution it merely gives the same color to the liquid, without the formation of a precipitate. With the sulphate of iron, the test forms a *deep blue* precipitate, very easily distinguished. If there is any question as to the purity of copper sulphate, this test may easily be used and the adulteration detected, provided the sulphate of iron has been used as an adulterant.

Iron sulphate is of no practical value as an insecticide, and its use as a fungicide is very limited. Iron is not nearly so efficient in this respect as copper is, so the latter is almost invariably preferred except when the plants to be treated are dormant. The iron salt may then be used as follows:

Iron sulphate	4–8 pounds.
Water	1 gallon.

All parts should be thoroughly treated with this solution; but the value of the operation has, in most cases, still to be determined.

[1] Craw, *California State Bd. of Hort.* 1894, Bull. 68, 20.

Against anthracnose of the grape the following application has shown itself to be of great value, and it is regularly used by European vineyardists:

Water (hot)	100 parts.
Iron sulphate, as much as the water will dissolve.	
Sulphuric acid	1 part.

Great care should be exercised in using this preparation, as it is exceedingly caustic and will injure machinery, clothes, and nearly everything with which it comes in contact. It is generally applied with a swab made by tying rags about the end of a stick. Dormant vines are uninjured by the treatment.

JOHNSON'S MIXTURE; COPPER SULPHATE AND AMMONIUM CARBONATE MIXTURE. — This preparation is almost identical with the modified eau céleste, ammonium sulphate being formed by the reactions instead of sodium sulphate. The former is injurious to foliage, and for this reason the mixture never has been used to any extent. It contains dissolved copper carbonate, as does the ammonia solution of the same compound, and that fungicide should be consulted in connection with Johnson's mixture.

Copper sulphate	8 ounces.
Ammonium carbonate	1 pound.

Dissolve in a pail of warm water and then dilute with

Water	25 gallons.

KEROSENE; COAL OIL; (PETROLEUM). — Kerosene has been used to destroy insects almost from the time of its first general introduction for illuminating purposes. It was originally used in two ways: first, when pure, in which case it was carefully used and applied as much as possible only to the insects to be destroyed; and second, when mixed with water, generally at the rate of 1 gill to 1 or 2 gallons of water. Since the oil is lighter than water, such mixtures were imperfect, and a certain amount of skill was required to obtain a mixture sufficiently uniform to prevent injury to the foliage. A small hand-syringe was the instrument generally employed, but now special machinery has been devised for the same purpose. Such applications are still made, but to a limited extent. Most plants are easily injured by the oil. Coleus, grape, peach, pea, and eggplant appear to suffer less than others. Paraffine, a closely related product, may be used at the rate of a wineglassful to a watering-can of water, the mixture being sprayed upon the insects.

Pure kerosene will destroy trees and branches which are several years old if a sufficient amount of the oil be applied. The beneficial results of such treatment are open to doubt, and the practice can hardly be advised except in isolated cases, when some unusual danger is feared. Howard has found that the oil may be used to advantage in the destruction of the mosquito. These breed in stagnant water, such as is commonly found in pools, etc., and by the use of 1 ounce of oil to 15 square feet of water surface, a film is formed which is very effectual in destroying all forms of aquatic insect life.

KEROSENE AND MILK EMULSIONS. — By emulsifying kerosene with some other material a very uniform dilution of the oil may be obtained, and it may be used of any desired strength. Milk has been very extensively used as an emulsifying agent, and it possesses particular value in those regions in which it is difficult to obtain soft water, hard water being unsuited to assist in making emulsion when soap is used instead of milk.

Kerosene and Condensed Milk Emulsion. —

Kerosene	2 gallons.
Condensed milk	3 pints.
Water	6 "

It is unnecessary to heat the ingredients, but they may be mixed and immediately churned or agitated by means of a force-pump until a perfect emulsion is obtained.

Kerosene and Sour Milk Emulsion. —

Kerosene	2 gallons.
Sour milk	1 gallon.

These liquids should be agitated in the same manner as the preceding. The mixture will soon assume a thick buttery consistency, and when the entire mass is in this condition the oil is properly emulsified. The addition of a little vinegar is said to hasten the process, especially if the milk is sweet instead of sour. If sweet milk is used, the emulsion is not formed so readily, but in other respects the two are equally valuable. If the applications are not to be made immediately, it is better to put the concentrated emulsion in air-tight jars until wanted, otherwise fermentation will take place, and after a week or more the preparation will be of little value.

These emulsions should be diluted fifteen or twenty times with water, depending upon the insect to be destroyed and the foliage to be treated.

Kerosene and Soap Emulsions. — Soap is very generally preferred to milk for emulsifying kerosene and other oils. Hard soap is easily obtained, and is therefore more commonly used. Whale-oil soap is said to be the best for this purpose. If soft soap is at hand, it may be used as well as the hard soaps, since the actions of the two are practically identical. One quart of soft soap is considered to be the equivalent of one-fourth pound hard soap.

Cook's Soft Soap Emulsion. — "Dissolve one quart of soft soap in two quarts of boiling water. Remove from the fire, and, while still boiling hot, add one pint of kerosene and immediately agitate with the pump as described above. In two or three minutes the emulsion will be perfect. This should be diluted by adding an equal amount of water, when it is ready for use. This always emulsifies readily with hard or soft water; always remains permanent, for years even; and is very easily diluted, even in the coldest weather, and without any heating. In this last respect it has no equal, so far as we have experimented. The objections to it are: we cannot always procure the soft soap, though many farmers make it, and it is generally to be found in our markets; it occasionally injures the foliage, probably owing to the caustic properties of the soap. We have used this freely for years and never saw any injury till the past season. In case of any such trouble we may use only half the amount of soap — one pint instead of one quart." The emulsion should be diluted so that about one-fifteenth of the liquid is kerosene, the amount varying under different circumstances.

Cook's Hard Soap Emulsion. — "Dissolve one-fourth pound of hard soap, Ivory, Babbitt, Jaxon, or whale-oil, etc., in two quarts of water, add, as before, one pint of kerosene oil, and pump the mixture back into itself while hot. This always emulsifies at once, and is permanent with hard as well as soft water. This is diluted with twice its bulk of water before use. The objection to a large amount of water sinks before the fact that this secures a sure and permanent emulsion, even though diluted with hard water. This also becomes, with certain soaps, lumpy and stringy when cold, so that it cannot be readily diluted with cold water unless first heated. Yet this is true with all hard soap emulsions in case of certain soaps. We can, however, always dilute easily if we do so at once before the emulsion is cold, and we can also do the same either by heating an emulsion or diluent, no matter how long we wait." (Page 81).

Hubbard-Riley Kerosene Emulsion. —

Hard soap	½ pound.
Kerosene	2 gallons.
Boiling soft water	1 gallon.

The soap should first be dissolved in the boiling water, after which the kerosene is added, and the two churned for five or ten minutes. One essential condition of success in making this emulsion is that the liquids should be as warm as possible. My own practice has been to heat the two after the kerosene has been added, taking care that the oil did not catch fire. It is also necessary that the water be as soft as possible, for if much mineral matter is present the emulsion will not be permanent, and the oil will soon separate and rise to the surface. With very hard water it is almost impossible to obtain a good emulsion.

If these conditions are all fulfilled, however, this emulsion is an excellent one, as the amount of kerosene used is large, and in other respects the preparation is easily handled. It should be diluted with from 4 to 20 parts of water before being applied, hard water being again avoided. When diluted with 4 parts of water, the emulsion contains about 29 per cent of kerosene; when diluted with 20 parts of water it contains nearly 9 per cent of the oil.

Kerosene Emulsion and Arsenites. — The attempt has frequently been made to obtain a uniform mixture of these two materials, but with only partial success. The results have not been satisfactory, and the use of such a mixture cannot be advised since the arsenicals and a certain amount of the emulsion appear to separate in the form of clots that adhere with surprising firmness to the sides of the vessel in which the preparation is made, and render its use practically impossible.

KEROSENE EMULSION AND BALSAM OF FIR.—The addition of two ounces of fir balsam to the Hubbard-Riley emulsion is said to increase its efficiency and also its adhesive properties.

One-half pint of turpentine may be used for the same purpose.

KEROSENE EMULSION AND BORDEAUX MIXTURE.—A mixture between these two preparations may be obtained without much difficulty, but the fungicide should be made with as little lime as possible. For this purpose, employ the ferrocyanide of potassium test. Applications of the mixture can scarcely be advised, however, since both fungicide and insecticide appear to lose a certain degree of their efficiency, since such even distribution on the foliage cannot be obtained as when the two are applied separately.

KEROSENE-PYRETHRUM EMULSION.—This emulsion is made in the same manner as the preceding ones, but pure kerosene is not used. A decoction of pyrethrum is made by filtering 1 gallon of the oil through $2\frac{1}{2}$ pounds of the powder, and this decoction is then treated like pure kerosene. It is little known.

LEAD ARSENATE. See ARSENATE OF LEAD.

LIME.—Quicklime is the most valuable form of the metal calcium to be used in spraying, although the compound does not remain in this form. Quicklime is the oxide of calcium, CaO. When water is added to it, there is formed the hydrate of lime, or calcium hydroxide, $Ca(OH)_2$, or water-slaked lime, as it is more commonly called. When exposed to air, quicklime sooner or later combines with carbonic acid gas and is thus converted into the carbonate of lime, or air-slaked lime, $CaCO_3$; this is the same, chemically, as limestone, or chalk.

The milk of lime is formed by slaking quicklime in water. It possesses little value when used alone, either for combating insects or fungi, but is extensively used to avert the caustic action of other preparations. If sprayed upon plants, it may be found desirable to strain out the coarser particles to prevent clogging the machinery. Air-slaked lime has been used in making the Bordeaux mixture, but in that case twice as much lime should be used as called for by the formulas in which quicklime is mentioned.[1]

The action of lime upon foliage has been studied by Cuboni.[2] When this material was first used by the Italians, their endeavor was to cover the grape foliage with a thick and uniform layer. The work of Cuboni shows that light acts upon the chlorophyll under the treated parts in a perfectly normal manner, for treated leaves had a coefficient of transpiration of 7 grams per square centimeter in one hour, while non-treated leaves, under the same conditions, had a coefficient of 7.25 grams, a very insignificant difference. It would thus appear that no injurious influence of this nature need be feared from applications of lime or of the Bordeaux mixture.

Quicklime may be applied alone as follows:

Lime	½–2 pecks.
Water	40 gallons.

This formula allows of much modification, but the thicker the mixture is made the more difficult it is to apply. Its value as a fungicide rests largely in the mechanical action of the lime; it forms a coating over the parts treated, so that the germinating spore cannot penetrate to the leaf tissue. In other respects its effect is but slight.

Air-slaked lime is of greater value as an insecticide when used dry, than when mixed with water. In the dry condition, it is effective in destroying snails, slugs, and the larvæ of some insects, as the cherry slug. It may also be used as a diluent of poisonous powders, as hellebore, arsenites, etc. It causes the death of angleworms, whether used dry or with water, and flower pots may easily be rid of them by the use of this material, a saturated solution containing sufficient quantities for the purpose.

Quicklime can be bought for 60 cents to $1.50 per barrel.

Lime, Salt, and Sulphur Wash. — 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

[1] See, also, Millardet et Gayon, *Jour. d'Ag. Prat.* 1888, May 17, 693 *et seq.*

[2] Cited by Viala, "Les Maladies de la Vigne," 1893, 118.

orchards as well as on the sheep. It is used against insects and fungi.

Lime (unslaked)	25–40 pounds.
Salt	15 "
Sulphur	20 "
Water	60 gallons.

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 lime and 15 pounds of salt — slake and add enough of 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 effects on the fruit-buds or on the tree itself.

Lime Sulphide; Sulphide of Lime; CaS. — This substance is made by boiling together sulphur and quicklime, using equal parts of each, until the liquid assumes a reddish yellow color. Even twice the amount of sulphur may be used with the above quantity of lime, and an excellent article will still be produced. Lime sulphide is of a white color, the compound being CaS. As the boiling is continued, a yellow color appears, caused by the formation of the bisulphide of lime, CaS_2. Upon prolonged boiling the yellow is replaced by an orange-red, which is the color of a third compound, the pentasulphide of lime, CaS_5. This is particularly rich in sulphur. The most popular method of using lime sulphide is described under Grison Liquid, which see. The compound is not a very energetic fungicide, but is valuable in treating surface mildews, such as the oidium of the grape. It is also of value in controlling mildew upon plants grown under glass, such as the peach, cucumber, rose, etc. With few exceptions, however, the copper compounds are to be preferred.

Linseed Oil Emulsion. — This remedy has been recommended by S. T. Maynard for the destruction of the San José scale insect, it having proved to be very efficient in controlling various scale insects found upon cacti, English ivy, rose, apple, pear, ash, thorn, and willow.

Hard soap	½ pound.
Boiling water, enough to dissolve the soap.	
Linseed oil	1 gallon.

Churn thoroughly until a pasty emulsion is formed. Dilute with from 12 to 24 gallons of water. The remedy has not yet been thoroughly tested.

LIVER OF SULPHUR. See POTASSIUM SULPHIDE.

LONDON PURPLE. See under ARSENITE OF LIME.

LYE. — The success following the use of soaps for destroying insects has lead to treatments of lye for the same purpose. It may be used as follows:

Concentrated lye	1 pound.
Water	3 gallons.

One and one-fourth pounds of potash may be used in place of the lye. These solutions are very caustic, and should only be used upon dormant wood. They are especially useful in destroying scale insects, but soft-bodied insects may also be exterminated by using:

Concentrated lye	1 pound.
Water	40 gallons.

It is well to wash this solution from delicate foliage in the course of half an hour, to prevent any injury which might follow if the insecticide were allowed to remain.

LYE AND SULPHUR WASH. —

Concentrated lye	1 pound.
(Potash 1¼ pounds.)	
Sulphur	1½ pounds.
Water	3 gallons.

This is recommended for the destruction of scale insects, but should be used only upon dormant wood.

LYE AND WHALE-OIL SOAP WASH. —

(*a*) Concentrated lye	1 pound.
Water	1 gallon.
Sulphur	1½ pounds.

Boil until all the ingredients are dissolved.

(*b*) Whale-oil soap	14 pounds.
Water	54 gallons.

When the soap is dissolved, unite solutions (*a*) and (*b*), and boil for a short time. The remedy is particularly valuable in treating scale insects just as they hatch in spring. It is more effective if used warm, at a temperature of 130° F., taking care to reach as many insects as possible.

MERCURIC CHLORIDE; CORROSIVE SUBLIMATE; $HgCl_2$. — It is made by subliming a mixture of mercuric sulphate and common salt, the resulting product being one of the deadliest poisons. Recommendations for its use as an insecticide are occasionally advanced, but the poison has such a caustic action upon foliage, that it cannot be used with safety.

It possesses some value as a fungicide, however, especially in preventing scab upon potatoes. For this purpose use:

Corrosive sublimate	2 ounces.
Water	16 gallons.

Scabby seed potatoes should be soaked in this solution for about an hour and a half before planting.

MERCURIC CHLORIDE WASH. —

Corrosive sublimate	1 ounce.
Soft soap	10 gallons.
Alcohol or wood spirit	1 pint.
Water, sufficient to make a stiff paint.	

The corrosive sublimate should first be dissolved in the alcohol, and this solution then added to the soap. The wash is used upon the bases of apple trees to prevent the entrance of borers, and for this purpose it has been highly recommended.

MIXTURE NO. 5 (*of the U. S. Department of Agriculture*). —

Ammoniated copper sulphate	1 part.
Ammonium carbonate	1 "

Twelve ounces of the mixture should be dissolved in 22 gallons of water, when it is ready for immediate use. A more concentrated solution, consisting of 1 pound to 25 gallons of water, has also been recommended. The fungicide has not been generally adopted, as it frequently causes injury to foliage. Before being dissolved, the mixture should be kept in air-tight receptacles, or its composition will change.

MODIFIED EAU CÉLESTE. — This well-known fungicide is one of the best now in use. In composition it is practically the same as the ammoniacal solution of copper carbonate, since this compound is first formed, and is then dissolved by ammonia. A solution of sodium sulphate is also present, but this is scarcely objectionable. The freshly precipitated carbonate of copper is much more easily dissolved by ammonia than the dry article is, and in this respect the preparation is superior to the common ammoniacal solution. But there is also present a certain amount of the sulphate of soda, yet, if properly diluted, no injury should result from this source. Modified eau céleste is readily prepared as follows:

Copper sulphate	2 pounds.
Sal-soda	2½ "

Dissolve these separately with a small quantity of water and slowly unite them. When chemical action has stopped add

Ammonia, 26° Beaumé	1 quart.
Or ammonia, 22° Beaumé	3 quarts.

This concentrated solution should be diluted before an application is made, with from 50 to 100 gallons of water, the last being probably none too much. The fungicide is cheap and effective. The price of sal-soda varies from 1¼ to 5 cents per pound.

MOLASSES. See SUGAR.

OIL. — None of the oils is used in a pure form, with the exception of kerosene; a few others are occasionally applied in connection with some other substance.

OIL AND ALKALI WASH. —

1.	Whale-oil	1¼ gallons.
	Sal-soda	25 pounds.
	Water	25 gallons.

The sal-soda is first dissolved in the boiling water, after which the oil is added. Apply when cooled to 130°. Use during winter for scale insects.

2.	Concentrated lye (American, 80 per cent)	1 pound.
	Potash	½ "
	Water	6 gallons.

In place of the lye, one can use ⅘ pound of Greenbank powdered caustic soda, of 98 per cent; or 1 pound of solid caustic soda, of 76 per cent; or $1\frac{1}{2}$ pounds of solid caustic soda, of 63 per cent. This is used in the same way and for the same purpose as No. 1.

OREGON WASH. — The Oregon wash is practically the same as the California lime, salt, and sulphur wash, with the exception that sulphate of copper is substituted for salt. The formula, as given by Henry E. Dosch, of the Oregon State Board of Horticulture, is as follows:

"Place 100 pounds of sulphur and 80 pounds of lime in a boiler with 100 gallons of water, and boil slowly until the sulphur is dissolved. Dissolve 8 pounds of sulphate of copper in hot water, add to 20 pounds of slaked lime, and mix the whole together. When ready to spray, take 1 pound of the mixture and $2\frac{1}{2}$ gallons of hot water, for *winter* use, applying lukewarm; 1 pound of the mixture to 8 or 10 gallons of water for *summer* spray. The water in the mixture will boil away, leaving a solid mass, which, however, dissolves readily when hot water is added for spraying."

PARAFFINE. See KEROSENE.

PARIS GREEN. See page 121.

PATENT INSECTICIDES. — The Division of Entomology of the United States Department of Agriculture made an exhibit at the Columbian Exposition, in 1893, of forty-two different patented insecticides; and many more exist. Some possess value, while others are positively unsafe to handle. As a rule, it is better and cheaper for each grower to prepare the insecticides and also the fungicides which are to be applied, since then there can be no doubt as to their composition.

PERSIAN INSECT POWDER. See PYRETHRUM.

PRECIPITATED CARBONATE OF COPPER. See COPPER CARBONATE.

PODECHARD'S POWDER. —

Copper sulphate	45	pounds.
Water, enough to dissolve.		
Lime, air-slaked	225	"
Ashes	30	"
Flowers of sulphur	20	"

The copper sulphate solution should be poured upon the lime, which in turn must be surrounded by the ashes to keep the liquid within bounds. After standing twenty-four hours the sulphur should be added, and then all the ingredients thoroughly mixed together. The mixture, when dry, should be passed through a sieve having eight meshes to the inch, when it is ready to apply. It has been recommended for various fungous diseases, but is not much used.

POTASH; POTASSIUM.— Various compounds of potash have been recommended for the destruction of insects, but they are not always effective, whether applied at the root or on the foliage.

Kainit	1 ounce.
Water	1 pint.

Other forms may be used in the same manner, but foliage is frequently injured.

POTASH SOAP.—

Concentrated lye	1 pound.
Cotton-seed oil	3 pints.
Soft water	3 gallons.

Boil the lye in water until dissolved, then add the oil and boil for two hours, replacing evaporated water with hot water from time to time. Use 1 pound of this soap to 8 or 10 gallons of water on lice-infested plants or trees, and wash the trunks and branches with a stiff brush.

POTASSIUM SULPHIDE; SULPHURET OF POTASSIUM; LIVER OF SULPHUR; K_2S.— This substance is used when dissolved in water at the rate of $\frac{1}{4}$ to 1 ounce in 1 gallon of water. The solution soon loses its strength, so should be made only just before using. It possesses considerable value in the treatment of certain fungous diseases, as gooseberry mildew, but is not so energetic as the copper compounds. Cost, fifteen to twenty-five cents per pound.

PYRETHRUM; BUHACH; DALMATIAN INSECT POWDER; PERSIAN INSECT POWDER.— This powder is obtained from plants of the genus Pyrethrum. It owes its value to the presence of an oil which is exceedingly poisonous to most insects, but apparently harmless to the higher animals. The oil acts upon the insect only when in contact with it, in the same manner as kerosene and similar insecticides. The oil is particularly abundant in the flower-heads just before they open, and the plant is best cut at this time. The stems also are used, and they may form about one-third of the mass to be ground into powder. The oil is very volatile, so the dried plants should not be exposed to the rays of the sun, to a high temperature, nor to moisture. After being dried, they should be placed in a receptacle which can be tightly closed; and it is imperative that the powder be so treated, else it will quickly lose its strength.

There are two species of Pyrethrum which furnish the bulk of the commercial articles. *P. roseum* is the plant that is native to the province of Transcaucasia, and from it is obtained the form sold as Persian insect powder. *P. cinerariæfolium*, however, is native to Dalmatia, and Dalmatian insect powder is the product derived from this plant. Buhach is obtained from a cultivated form of the same species. This plant is the one mostly grown in California, and for this reason Buhach is the most reliable powder to use. The insecticidal value of the plant does not appear to diminish under cultivation, and, as Buhach is made in this country, it is more apt to be fresh. Both species are cultivated as ornamental plants, and it is probable that they have equally valuable insecticidal properties.

Pyrethrum can be used in a great variety of ways, of which the following are the most important:[1]

"1. *In solution.* — One ounce to 3 gallons of water.

"2. *Dry, without dilution.* — In this form it is excellent for thrips and lice on roses and other bushes. Apply when the bush is wet. Useful for aphis on house plants.

"3. *Dry, with dilution.* — Diluted with flour or any light and fine powder. The poison may be used in the proportion of 1 part to from 6 to 30 of the diluent.

"4. *In fumigation.* — It may be scattered directly upon coals, or made into small balls by wetting and moulding with the hands, and then set upon coals. This is a desirable way of dealing with mosquitoes and flies.

"5. *In alcohol.* — (1) Put 1 part of pyrethrum (buhach) and 4 parts alcohol, by weight, in any tight vessel. Shake occasionally, and after eight days filter. Apply with an atomizer. Excellent for greenhouse pests. For some plants it needs to be

[1] Bailey, "Horticulturist's Rule-Book," third edition, 1895, 10, 11.

diluted a little. (2) Dissolve about 4 ounces of powder in 1 gill of alcohol, and add 12 gallons of water.

"6. *Decoction.* — Whole flower-heads are treated to boiling water, and the liquid is covered to prevent evaporation. Boiling the liquid destroys its value.

"7. *Water extract.* — Pour 2 quarts hot water through about a half-pound of pyrethrum, held in a coarse bag, and then add cold water enough to make 2 gallons, and it is well to stir in the powder itself. For aphis and cabbage worms. It will keep but a few days. Or the extract can be made as follows: Make a paste of 2 tablespoonfuls of pyrethrum by adding water. Stir this into 2 gallons of water, and apply with a fine nozzle. This is recommended for the rose-chafer.

"8. *Pyrethro-kerosene emulsion.* — See under KEROSENE-PYRETHRUM EMULSION."

The cost of pyrethrum varies from twenty to nearly seventy-five cents per pound.

QUASSIA. — The wood of *Picræna* (or *Picrasma*) *excelsa* contains a principle which is fatal to many insects when brought in contact with them. The wood has an extremely bitter taste, and for this reason it has been supposed that seeds placed in water in which the wood had been soaked would be protected from birds and vermin. Its value for this purpose is, however, doubtful. Quassia wood is generally sold after having been cut into "chips," and it is commonly used as follows:

Quassia chips	1 pound.
Water	8 gallons.

Boil until reduced to 6 gallons.

Another formula has been recommended which is probably more effective than the preceding:

Quassia chips	¼ pound.
Water	1 gallon.

The chips are boiled in the water for about fifteen minutes; the liquid should then be strained, and to the solution is added

Soft soap	¼ pound.

When thoroughly mixed, the liquid is ready for use. This insecticide is not very energetic, but possesses a certain value in destroying plant lice. Quassia chips are worth from six to ten cents per pound.

QUASSIA CHIPS AND WHALE-OIL SOAP.—

Quassia chips	8 pounds.
Whale-oil soap	7 "
Water	100 gallons.

"Soak the chips twelve hours in 8 gallons of water, or if hot water is used, less time will be required. Dissolve the soap by boiling in sufficient water to cover it; strain the extracts from the quassia and add the two ingredients together. Stir thoroughly and dilute to make 100 gallons.

"This solution is used successfully among the hop growers for exterminating hop lice in the large fields. It is not injurious to foliage. . . . For some species of aphis [upon other plants] a stronger solution may have to be used, and in such cases dilute only to 80 gallons instead of 100."[1]

QUICKLIME. See LIME.

RESIN SOAP.—

Resin	2 pounds.
Caustic soda	1 pound.
Tallow	1 "

Dissolve the caustic soda in 1½ gallons of water. In this, dissolve the resin and tallow with moderate heat, adding water to make 22 pints of brown, thick soap. For use dilute with 44 gallons of water and apply as a spray. It is used as a summer wash to destroy insects.

RESIN WASHES.—The history of these washes has been discussed on page 85. Their action is of two kinds. Some insects are killed when these washes come in contact with their bodies, an action similar to that of the kerosene emulsions. But scale insects are often so well protected that they cannot be directly reached by the applications. The action of the resin washes is then to form a covering over the insect so that both air and moisture will be excluded. In this manner the pest is literally smothered to death. These washes are particularly valuable in destroying scale insects. In the East, where such insects are less troublesome, kerosene emulsion is more commonly recommended,

[1] *Washington State Board of Hort. 2d Biennial Rept.* 1893–94, 71.

and it may be that the insects are also more easily treated here. But in California and in the South, the resin solutions are very highly valued, as they appear to be more efficient than those containing kerosene.

Applications are made to dormant as well as to growing trees. In the former case stronger mixtures are used with success, but if used during summer, the same ones might cause much damage. When selecting from the formulas given below, the nature of the treatment must be kept in mind, to avoid injuring the trees. It is advisable to use a covered iron kettle for boiling the ingredients of the insecticides.

Resin	20 pounds.
Caustic soda (70 per cent)	5 "
Fish-oil	2½ pints.
Water to make	100 gallons.

The first three ingredients should be placed in a large kettle and covered with four or five inches of water. Boil for one or two hours, or until the liquid has a dark brown color resembling coffee.

The use of a 98 per cent granulated caustic soda shortens the required time of boiling. In case this is used, its amount may be reduced to 3 pounds, and 3 pounds of fish-oil should also be added. Under such circumstances, these ingredients may be boiled a moment with but 15 gallons of water and a stock solution thus obtained, which may be diluted at will. (The total cost is about five and one-third cents per gallon.) These two formulas are very extensively employed in the work of the United States Department of Agriculture.

When water is added to the solutions, it should be poured in slowly and thoroughly mixed. Dilute as required, in greenhouses 1–3, or 1–4. For use in summer.

Resin	40 pounds.
Caustic soda (98 per cent)	10 "
Potash	10 "
Tallow	40 "
Water to make	50 gallons.

Dissolve the soda and the potash in about 10 gallons of hot water. The resin and the tallow should be heated, and when dissolved and thoroughly mixed, pour the two solutions into a barrel holding 50 gallons, and stir well. Allow the mixture to stand about two hours, when the barrel may be slowly filled with warm water, the contents being continually stirred as the water is added. One pint of the preparation may be used in a gallon of warm water. For use in summer.

Resin	20 pounds.
Caustic soda	8 "
Fish-oil	1 gallon.
Water to make	100 gallons.

The caustic soda is first dissolved in about 16 gallons of water, after which half of the solution is taken out and the resin added to that remaining in the kettle. When all the resin is dissolved, the fish-oil is added to it, and the whole thoroughly stirred, after which the balance of the caustic soda solution is added very slowly and boiled for about an hour, or until it will readily mix with water. Use an iron kettle. For use in summer.

Resin	17½ pounds.
Soda (60 per cent)	7 "
Fish-oil	3 "
Petroleum	2 "
Water	100 gallons.

Boil the first three ingredients together for four hours in 20 gallons of water, after which the petroleum should be poured in, the whole being well stirred. The 80 gallons of water may then be added, and an emulsion made by active agitation. For use in summer.

Resin	8 pounds.
Caustic soda	1 pound.
Water to make	22 gallons.

Dissolve the caustic soda in about 1 gallon of water. When dissolved half the solution is taken out, and the resin added to the remainder and boiled until dissolved, after which the balance of the soda solution is added very slowly. The mixture is then boiled over a hot fire, being stirred almost constantly; and when cooked sufficiently it will assimilate with cold water like milk, which it much resembles. Dilute as above, and apply during summer.

Simple solution of resin:

Resin	2 pounds.
Crystallized sal-soda	1 pound.
Water	2 quarts.

Boil the above until a clear brown solution is obtained. This is an excellent method of obtaining a stock solution of resin. It is as valuable as any soap to increase adhesive properties of Bordeaux mixture, and costs much less.

Resin	30 pounds.
Caustic soda (70 per cent)	9 "
Fish-oil	4½ pints.
Water	100 gallons.

Place the first three ingredients in an iron kettle and cover with five or six inches of water. Boil for an hour or two, or until the liquid has a dark brown color, after which the remainder of the water may be slowly added. It is not necessary that all should be immediately used, since the liquid may be diluted as well later. For winter use.

Resin Washes and Arsenicals. — Paris green, London purple, and even arsenious acid will mix readily with resin compounds, especially those which consist of resin, caustic soda, and water. The poison may then be used at the same rate as in clear water. Arsenious acid has been used in this manner upon orange trees at the rate of 1 pound to 300 gallons of the wash.

Salt; Sodium Chloride; NaCl. — Common salt has very frequently been recommended as an insecticide, and there is no doubt that it is capable of killing many insects. But its effective use requires such strong solutions that the remedy is generally worse than the disease, and for this reason it is rarely applied.

Scheele's Green. See Arsenite of Copper, page 120.

Schweinfurth's Green. See *Paris Green*, page 121.

Skawinski's Iron Sulphate and Sulphuric Acid Solution. —

Iron sulphate	110 pounds.
Sulphuric acid (53°)	1½ pints.
Warm water	26 gallons.

The acid should first be poured upon the iron crystals, after which the water may be added. This preparation is almost identical with one already described under IRON SULPHATE, and it is used for the same purpose. It has shown itself, in the hands of Skawinski and others, to be a very efficient remedy against grape anthracnose, being applied exclusively to dormant wood.

SKAWINSKI'S POWDER.—

Copper sulphate, powdered	22 pounds.
Alluvial earth, or soot	33 "
Coal-dust	165 "

Mix thoroughly and apply in the form of a powder. The preparation has been successfully applied in Europe for treating grape mildews, but is at present little used.

SNUFF.— Fresh snuff is as valuable as other forms of tobacco in destroying insects. It may be used dry or as a decoction; for the latter use see Tobacco. When dry it is very serviceable in destroying insects where more energetic measures cannot be taken, as in dwelling-rooms and small conservatories. The powder should be blown upon the insects.

SOAP.—Probably all soaps are of value as insecticides, and they were among the first remedies used. They kill by coming in contact with the insect, destroying it directly, as does kerosene, and probably also by closing the breathing pores, and so smothering it. Common soap may be used at the rate of

Soap	1 pound.
Water	5–8 gallons.

The proper strength of the preparation varies with the insect and the plant to which it is applied. For plant lice, the weaker solutions are sufficiently strong, but for mealy-bug and similar pests the more concentrated forms are desirable.

SOAP AND ARSENITES.—

Soap	4 pounds.
Paris green or London purple	4 ounces.
Lime	4 "
Water	50 gallons.

Dissolve the soap in 1 to 2 gallons of hot water, then add the poison and the lime. Dilute just before using. This preparation combines certain properties of those insecticides which kill by contact, and those which are first eaten. It possesses value for all insects, but only soft-bodied organisms are overcome by the soap. Kerosene emulsion or the resin washes are commonly to be preferred. The lime is added to the preparation to prevent injury.

SOAP AND FISH-OIL. —

Potash lye	1 pound.
Fish-oil	3 pints.
Soft water	3 gallons.

First dissolve the lye in the water by boiling, then add the oil and boil two hours longer. Dilute with 6 to 10 gallons of water to every pound of the soap which is formed. The mixture is especially valuable for destroying soft-bodied insects.

SOAP AND LIME WASH. —

(*a*)	Potash	5 pounds.
	Lard	5 "
	Boiling water	5 gallons.
(*b*)	Quicklime	1 peck.
	Boiling water	5 gallons.

When (*a*) and (*b*) have been thoroughly acted upon by the hot water, mix the two liquids. Dilute before using by adding 2 gallons of boiling water to each gallon of the mixture. This preparation has been recommended for borers, but it is of doubtful value.

SOAP AND SODA WASH. — Add a strong solution of common wash soda to soft soap until the latter thickens to a thick paint. The mixture is of value in destroying bark lice and similar insects.

SOAP AND TOBACCO. —

Soft soap	8 pounds.
Rain water (warm)	12 gallons.

When this has cooled, add

Strong tobacco decoction	1 gallon.

This has been recommended for the destruction of soft-bodied insects, and undoubtedly possesses considerable value.

SODA AND ALOES.—

Washing soda	2 pounds.
Bitter Barbadoes aloes	1 ounce.

Dissolve the above in hot water, and when cool add

Water	1 gallon.

The preparation has been recommended for destroying plant lice, but in order to be effective the plants must be dipped in the mixture, and in half an hour syringed off with clear water.

SODA AND RESIN WASH.—

Sal-soda	3 pounds.
Hot water	1 pint.

Then slowly add

Resin	4 pounds.
Hot water	2 pints.

These should be thoroughly mixed, and before using should be diluted with 5 gallons of water.

SODA AND WHALE-OIL SOAP WASH.—

Sal-soda	25 pounds.
Water	25 gallons.

Boil until dissolved, when $1\frac{1}{4}$ gallons of whale oil should be added. It is applied only to dormant wood, and is particularly useful in destroying scale insects. Apply at a temperature of 130° F.

SODIUM ARSENATE. See ARSENATE OF SODA.

SODA WASH.—

Washing soda	$\frac{1}{2}$ pound.
Water	2 gallons.

The liquid is ready for use as soon as the soda is dissolved. It has a caustic action upon foliage, so should be used only upon dormant wood. It is said to be of value against borers and scale insects.

SODIUM HYPOSULPHITE; $Na_2S_2O_3$.—Solutions of the hyposulphite of soda have been very thoroughly tested in respect to their fungicidal value, but the results have not been so satisfactory as with the copper compounds, and therefore the substance is but little used. The solution may be prepared by dissolving 1 pound in 10 to 20 gallons of water, although there has been recommended the application of only ½ ounce in 10 gallons. The latter, however, can have but little value. The cost of this substance varies from six to fifteen cents per pound.

SODIUM SULPHIDE WASH.—

(*a*)	Whale-oil soap	30 pounds.
	Hot water	60 gallons.
(*b*)	American concentrated lye	3 pounds.
	Sulphur	6 "
	Boiling water	2 gallons.

Mixture (*b*) should be very thoroughly boiled until it is of a dark brown color. Chemically it is the sulphide of soda. Solutions (*a*) and (*b*) should then be mixed and boiled half an hour. Before using, dilute with 90 gallons of warm water. The remedy is of value for scab diseases of oranges.

SUGAR.—Sugar or molasses is sometimes added to copper compounds to assist in holding a certain amount of the copper in solution. It has long been known that when concentrated solutions of sugar and copper sulphate are mixed there is produced a bluish-white precipitate, known as a sulpho-saccharate of copper. It is soluble in water, but when heated the compound is broken up, and the copper is deposited in the form of a red powder, the protoxide of copper. Recommendations have been made to add molasses at the rate of one-tenth by weight of the amount of copper sulphate, or one-twentieth its weight of sugar. This renders a portion of the copper in the Bordeaux mixture immediately soluble; but the advantage of the practice is doubtful. (See, also, page 50.) The presence of an excess of lime in the Bordeaux mixture is essential to the proper manufacture of the fungicide with these materials.

The following analysis represents approximately the composition of a high-grade molasses:

Sugar	50 per cent.
Other organic matter	20 "
Ash	10 "
Water	20 "

A poor quality of molasses has been found to possess

Sugar	44.00	per cent.
Glucose	1.47	"
Ash	12.96	"
Water	41.57	"

SULPHATED SULPHUR; BLIGHT POWDER. —

Copper sulphate, anhydrous	3–8	pounds.
Flowers of sulphur	90–100	"

Mix the two materials and apply in the form of a powder. The mixture was formerly supposed to possess strong fungicidal properties, but it is now little used. It is of some value in treating surface mildews, the sulphur probably then being the active principle.

SULPHATE OF COPPER. See COPPER SULPHATE.

SULPHATE OF IRON. See IRON SULPHATE.

SULPHATINE POWDER.—

Anhydrous copper sulphate	2	pounds.
Flowers of sulphur	20	"
Air-slaked lime	2	"

The ingredients should be thoroughly mixed, when they may be applied. The powder is supposed to be of value as a fungicide, but is very little used.

SULPHIDE OF LIME. See LIME SULPHIDE.

SULPHOSTEATITE; CUPRIC-STEATITE; FOSTITE. — Sulphosteatite is an exceedingly fine blue powder consisting of steatite or talc, and containing also from 2 to 10 per cent of copper sulphate. It is obtained in Europe, and was first introduced into America by C. H. Joosten, of New York, in 1893; he changed the name to "Fostite" the following year. The copper contained in the powder is largely soluble, and in consequence foliage is frequently injured by the use of the fungicide. It has been recommended as an insecticide, but I have failed to derive any benefits from its use for this purpose. It is not so valuable as other copper compounds, yet it has the desirable quality of being remarkably adherent to foliage.

SULPHUR; FLOWERS OF SULPHUR; S. — Sulphur is valuable both as an insecticide and as a fungicide. Its use for the first purpose is practically confined to greenhouses and conservatories, and even there only few insects are affected by it. It is most rapidly applied by evaporating in a sand bath over an oil stove, but extreme care must be given that it does not take fire, as then it will instantly destroy all the plants. Red spider and related insects are said to be destroyed by the fumes, and treatment should be made as soon as they are discovered, or even before. Sulphur may also be evaporated successfully by placing it upon the heating pipes. It is well to mix it with an equal amount of lime, and then add water to form a thick paint, with which the pipes may be covered. When applied in a dry form directly to the plants, it possesses little value as an insecticide. A moist atmosphere in the house probably renders the fumes more effective.

Sulphur is one of the most valuable fungicides for the treatment of surface mildews, and it has long been used for this purpose. Previous to 1880, it was almost the only fungicide used in Europe, and it did excellent service in controlling the European mildews which attacked the vine and many other plants, whether grown under glass or in the open. Out of doors it was commonly applied in a dry condition, being blown upon the plants by means of hand bellows. Under glass it was used in three ways: in the form of powder, when mixed with water, and when evaporated from the heating surfaces. The first method was executed in the same manner as out-doors. When mixed with water both the sulphur and the water assist in destroying many pests, and it is a common practice to make such applications. The proportions of the two vary greatly. It has been recommended to use 1 ounce of sulphur to 5 gallons of water, and also as much as 1 pound to 1 gallon. The more dilute mixtures are more easily applied, and if the work is thoroughly done, are, on the whole, equally valuable. The fumes of sulphur for treating mildews are obtained as described above. When the powder is used out of doors the value of the remedy undoubtedly rests in the fact that the sulphur gradually gives off fumes on account of the heat of the sun, and the mildews yield for the same reason that they do when the powder is evaporated under glass.

One of the most valuable preparations of sulphur is known as Grison's liquid, which see.

Sulphur generally sells for about three cents a pound wholesale, and ten cents retail.

SULPHUR AND LIME POWDER.—

Flowers of sulphur	1 part.
Air-slaked lime	1 "

Mix and apply in form of a powder. The mixture is of value for surface mildews, but is little used in America. The European grape mildew is easily controlled by it.

SULPHUR AND SNUFF.—

Flowers of sulphur	1 pound.
Scotch snuff	1 "
Quicklime	1 "
Soft soap	1 "
Lampblack	½ "
Water, enough to make a thin paint.	

This formula contains an excellent variety of materials, but other and simpler ones are undoubtedly equally effective in the destruction of plant lice, for which the above is particularly recommended. It should be used only upon dormant wood.

SULPHUR AND WHALE-OIL SOAP WASH.—

Sulphur	⅓ pound.
Boiling water	½ gallon.

Boil the sulphur for fifteen minutes. To this add

Whale-oil soap	1 pound,

and boil for five minutes. Allow the mixture to stand a week, and before using, dissolve 1 pound in a gallon of hot water, making the application when the temperature has fallen to 130°. It is supposed to be a repellent of various burrowing larvæ, as the currant borer, and others.

SULPHURET OF POTASSIUM. See POTASSIUM SULPHIDE.

SULPHURIC ACID. See IRON SULPHATE.

TOBACCO; NICOTIANA TABACUM.—The active principle of tobacco is nicotine, and this compound gives the plant its value as an insecticide. It kills by coming in contact with the insects, and so long as this occurs, the method of its application is of minor importance. It is most commonly used for the destruction of plant lice, although other soft-bodied insects may also be overcome by the applications. The mid-veins, or "stems," are the parts sold for insecticidal purposes. The simplest method of using them in greenhouses is to strew them under the benches, making the layer two to four inches thick, and renewing the stems every five or six weeks. Tender plants may easily be injured in this manner. Another common practice is to burn the stems in the houses, placing them in a sheet-iron receptacle having the form of an enlarged stove-pipe placed upon end, and having a perforated bottom. Legs should be attached at the bottom to keep the fire from the floor. Paper or shavings may be used for starting the fire, yet the stems themselves should never come to a blaze, but only smolder, so that large volumes of smoke may be produced. If the stems are dampened, the operation is more effective. About one-half pound of the stems to every 500 square feet of glass is the quantity generally used. On account of the disagreeable smell left in the house this remedy cannot always be employed. In place of it there may be used semi-fluid extracts of tobacco which are now upon the markets. When evaporated these are very efficient in destroying aphis, and only a slight odor remains.

A decoction of tobacco stems is commonly employed. It is prepared by steeping the stems in an amount of water sufficient to cover them, and when their strength has been well drawn out, the liquid is diluted so that it has the color of fairly strong tea. It is then sprayed upon the plants, care being taken that the insects to be destroyed are reached by the applications. This remedy can be used successfully where fumigation is not advisable, and it is cheap and effective.

Powdered tobacco or snuff may also be used with success. The plants to be treated should first be sprayed with clear water, and then the powder may be blown on them. The water causes it to adhere, and the decoction which probably results acts energetically in destroying the pests.

A tobacco decoction is frequently employed in place of pure water in the preparation of other insecticides, and the presence of the nicotine renders the preparation more efficient. With kerosene emulsion, however, my experience has been such that its use for this purpose cannot be advised.

VERATRUM ALBUM OR V. VIRIDE. See HELLEBORE.

VERDET. See COPPER ACETATE.

VERDIGRIS. See COPPER ACETATE.

WASHES. — Many washes have been recommended and used for preventing injury from insects and fungi. The majority of them consist largely of soapy materials, and if the applications are accompanied by a rubbing of the affected parts good results will follow, especially in destroying insects. But in such cases the mechanical action is perhaps as effective as the material applied. Clay has been used for centuries on account of the benefits which are supposed to have followed its use when mixed with water. It has been particularly recommended as an agent for preventing the entrance of borers into trees, and has been widely used for this purpose. The actual value of the operation is probably not so great as is frequently stated, and much profitless labor has undoubtedly been performed in this direction.

The following formula is inserted here not because it possesses any marked value, but rather for the purpose of illustrating the varied combinations of different substances which have been used for the purpose of rendering these washes more efficient. This one has been well recommended for preventing the entrance of borers into plum and peach trees, and it represents but one of a considerable class of such remedies:

Carbolic acid	1 quart.
Soft soap	3 gallons.
Lime	4 pounds.
Water	40 gallons.
Clay, enough to make a thick wash.	

This wash is very adhesive, and on this account has attracted attention.

WATER; H_2O. — Water is used as an insecticide in three different ways: as a means of drowning the insect, as a means of forcibly dislodging and indirectly destroying it, and as a conveyance for killing it by means of heat. The first method is employed frequently in the culture of the cranberry, the entire bog being flooded for a certain period, so that it is impossible for the insects to escape. European vineyardists make use of the same expedient in treating their vines for the phylloxera, the ground remaining covered with water for several weeks during the winter, when the plants are dormant. It is only in exceptional cases that water can be used in this manner to advantage.

The practice of dislodging insects by means of a stream of water forcibly applied is confined almost wholly to florists. Plants grown under glass may easily be kept clean in this manner, provided the water may be used freely; it is one of the best remedies for mealy-bugs and similar pests. The presence of red spider upon greenhouse plants is principally due to a dry atmosphere, and no good gardener need be troubled by this insect, unless some very good reason exists why the plants should not be syringed or sprayed. A moist atmosphere will also check the growth of certain fungi, but as a rule such conditions favor their development.

The value of hot water in destroying insect life has long been known. If an insect be treated with water having a temperature of 125°–130° F., it will succumb almost immediately, and no injury to the plant will result. Rose chafers will yield readily to this treatment, but great difficulty is experienced in maintaining the proper temperature. A spray is cooled instantly, and when a solid stream is used the operation is slow and difficult. For this reason the remedy is little used.

Cold water, that having a temperature little above freezing, has been recommended against soft-bodied insects, as the cabbage worm, but satisfactory results rarely follow such applications.

WHALE-OIL SOAP. — The value of this soap for destroying insects was discovered many years ago. (See page 14.) The oil from which the soap is made is probably the active principle. The dissolved soap has proved itself to be of particular value in destroying scale insects when used at the rate of 1 pound in about 5 gallons of water. Mealy-bugs may also be destroyed by such a solution, but care must be taken to see that the insects are wet by the liquid. Plant lice are easily killed with much weaker solutions, using 10 gallons to the pound.

Whale-oil soap may also be highly recommended for use in preparing emulsions of the various oils, since the union of two good insecticides cannot fail to make the mixture more effective than is either substance alone. The soap varies in price from eight to twenty cents per pound.

WHALE-OIL SOAP AND SULPHIDE OF POTASH WASH. — The following formulas for a summer wash have been recommended by the Horticultural Commissioners of Sutter County, Cal.:

"Whale-oil soap (80 per cent strength)	20 pounds.
Sulphur	3 "
Caustic soda (98 per cent strength)	1 pound.
Commercial potash	1 "
Water to make 100 gallons.	

"Place the sulphur, caustic soda, and potash together in about 2 gallons of water and boil for at least an hour, or until thoroughly dissolved. Dissolve the soap in the water by boiling; mix the two and boil them for a short time; use at 130° F. in the vessel.

"Professor Hilgard recommends, in bad cases of scale and in fighting red spider, an addition of kerosene in the form of an emulsion, to the above wash:

"Kerosene	1 gallon.
Whale-oil soap	¼ pound.
Water	½ gallon.

"Dissolve the soap in the water and when boiling hot add the kerosene. Churn the mixture for five or ten minutes with a hand spray-pump until it forms an emulsion. If the emulsion is perfect it will be of a creamy nature, no oil appearing on the surface. Add this to the 100 gallons of spraying material.

"The sulphide of potash and the kerosene emulsion are often made up in large quantities, and the proper amount is added to the whale-oil soap as required. Keep this wash well stirred when using.

"It is very important that the whale-oil soap should be at least 80 per cent strength. To test the soap, spread five or ten ounces of it on a tin plate counterpoised on a pair of upright scales reading to ounces, and then dry the whole by setting it on top of a pot of boiling water. The loss in drying will indicate the amount of water in the soap. Thus, if five ounces were taken and one ounce was lost in drying, the soap would be of 80 per cent strength."

WHITE HELLEBORE. See HELLEBORE.

YELLOW PRUSSIATE OF POTASH. See FERROCYANIDE OF POTASSIUM.

CHAPTER V.

SPRAYING DEVICES AND MACHINERY.

THE development of spraying machinery received an impetus about the same time that the injury of insects and fungi began to threaten and destroy so many of our cultivated plants. For a long term of years very little had been done towards developing apparatus of this character, and many crude contrivances were used. The early history of the industry reveals many appliances which are no longer in use, the names even being nearly as obsolete as the machines.

I. HISTORY OF SYRINGES AND PUMPS.

The simplest device for making liquid applications to the stems and foliage of plants was probably a whisk of heath, straw, or some similar material; the stems were tied in small bundles, the part above the tie serving for a handle (Fig. 1). Brooms were also used for the same purpose. The liquid was applied by first dipping this crude brush or broom into it, and then throwing upon the plant what adhered to the brush. A fairly good application can be made in this manner, although the process is a tedious one. This device was, nevertheless, used as late as 1882 in France for the purpose of applying mixtures composed of the sulphate of copper and lime. It is probable that the density of this preparation pre-

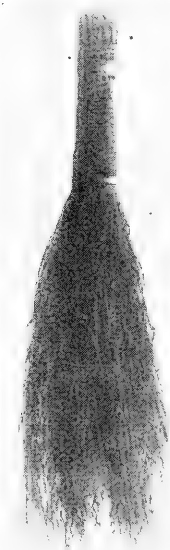

FIG. 1. — Heath whisk, the first device used for applying Bordeaux mixture.

vented it from being applied by means of other devices then known. Since brooms were used in applying liquids and semi-liquids to plants even less than twelve years ago, it is not impossible that in certain sections the practice may still be in vogue. For many plants it is surely much better to use a device of this character than it is to make no application, for low-growing plants can be fairly well treated, and they should be benefited nearly as much as if more costly machinery were used. The character of many crops grown during the past few seasons indicates that plants will repay treatment whatever be the nature of the method followed. An improved brush is shown in Fig. 2. The liquid, which was carried in a tank on the back of the operator, entered the hollow handle through a tube connected with the bottom of the tank. The fluid then ran along the fibers of the broom, and was thrown from the extremities. The flat broom was attached to a broad piece of oilcloth, which assisted in making a uniform application. A stopcock was inserted in the handle so that the liquid could be shut off when desired. This device was used in France for applying the Bordeaux mixture.

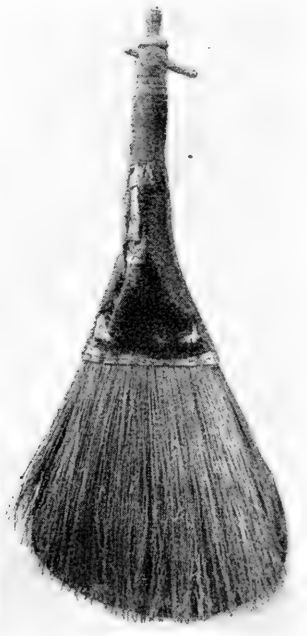

Fig. 2. — An improved brush for distributing Bordeaux mixture.

The watering-can is one of the first contrivances made for applying liquids upon plants. Its structure, as a rule, is very simple, being composed of nothing more than a cylindrical reservoir capable of containing one or more gallons of liquid. This device is still in very common use, especially among florists. The water or other liquid is poured out through a tube which projects on the outside of the reservoir, and which springs from the bottom or from near the bottom of the can. These tubes or sprouts are of varying lengths and shapes, and are often jointed; the cans also differ much from each other. The water may be broken up into fine drops by means of a perforated disk, or rose, which covers the outer opening of the spout, the size of the drops varying with the size of holes in the rose. Watering-cans are used advantageously only on very low-growing plants, as the liquid leaves the spout by the force of gravity, and not by pressure applied by the operator. Very thorough applications can be made by means of these cans, but they are wasteful of materials.

Small hand pumps, commonly called syringes, came into use at an early day. They were very simple in construction, and were at first used almost entirely for throwing clear water upon cultivated plants. They consisted practically of nothing but a tube in which a piston and piston-rod could play. The water was thrown out of the same orifice through which it entered. Such a contrivance admitted of considerable variation, and several styles have been described in very early publications.

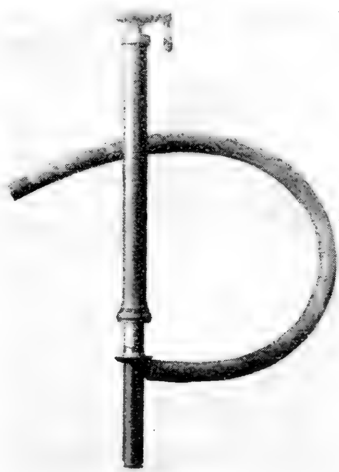

Fig. 3. — Small hand syringe having separate inlet and outlet orifices.

A more complicated form of syringe includes those which are supplied with valves, generally two (Fig. 3). In such syringes the liquid does not leave the cylinder through the same orifice at which it entered, but it passes out through another. These orifices are each supplied with a valve which allows of the free passage of water in the desired direction, but prevents its return. The earlier forms of these syringes were made principally by the English, and several more or less modified forms have been described. The principal ones appear to have been Read's,[1] Macdougal's,[2] Warner's,[3] Johnston's portable garden engine,[4] and Siebe's universal garden syringe.[5]

[1] "Loud. Ency. of Gard." 1878, 546.

[2] *Gard. Mag.* Vol. vi. 305.

[3] *Ibid.* Vol. viii. 353.

[4] "Loud. Ency. of Gard." 1878, 547.

[5] *Ibid. loc. cit.*

Many other syringes could be mentioned, but the above represent the principal ones in use in England as well as in other European countries. American gardeners also used them extensively, and this type of syringe is still very commonly found, although in a much modified form. The following syringe is one of the most popular recently used (Fig. 4): "In applying Paris green or any other solutions to fruit or ornamental trees, Whitman's fountain pump is invaluable. It will throw a stream thirty feet high, sixty feet horizontally, and works so easily that a child five years old can work it. It can also be used advantageously in watering plants, cleaning carriages and windows, and might enable one to prevent much destruction in case of fire. The pump now retails at seven and one-half dollars."[1]

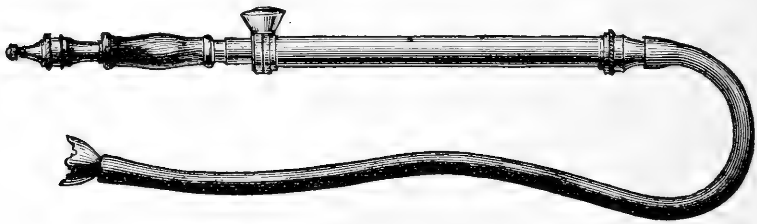

FIG. 4. — Whitman's fountain pump.

Garden engines were designed to throw larger amounts of liquid than could be well done with hand syringes, and they were also generally arranged so that a considerable amount of liquid could be transported from one part of the grounds to another. A large number of different kinds were made, but the majority of them consisted of a force pump fastened upon a tank. The pumps, tanks, and the devices for transporting the outfit, differed considerably. All were designed to throw clear water, or solutions which contained no coarse particles. The nozzles used were also designed for the same purpose, and were very simple in construction. Fig. 5 represents one of the early machines used in America.

The spraying implements in use in America and in Europe were until recently very similar. The comparatively small amount of work which had been done in fighting insect and fungous enemies previous to 1880 could be fairly well accom-

[1] Cook, *Rept. Mich. Pom. Soc.* 1878, 236.

plished with the machinery then made, and the demand for more efficient apparatus was not sufficient to stimulate inventors to introduce new devices. But increasing necessities soon created a demand for improved machinery, and this quickly brought about the production of new implements which were adapted to the wants of the horticulturist.

It is interesting to note that for about a century the needs of American and European growers were practically the same, and that the apparatus used by the one was also adopted by the other. Then suddenly all changed. The Europeans, and particularly the French, branched off and made machinery for which there was at first no demand in this country, and for which there is even now comparatively little. The Americans, on the other hand, manufactured machinery that is not used to any great extent in Europe, even to this day. It was between the years 1870 and 1880 that the American growers began searching for pumps which were better suited to their purpose; but it was not until 1880 to 1885 that this demand had much effect upon manufacturers. In France, new machinery was demanded also between the years 1880 and 1885, so it may indeed be said that the breaking away from old methods after a century of uniformity, took place simultaneously in France and in America.

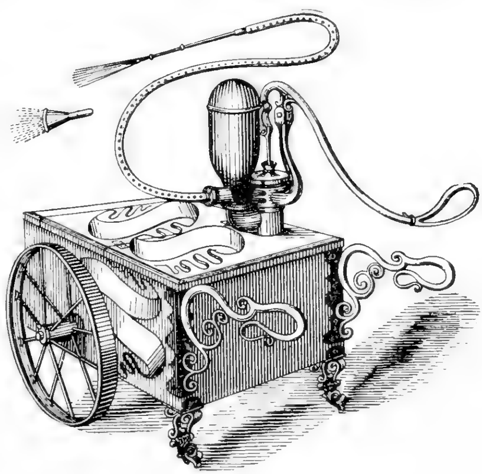

Fig. 5. — An early form of garden engine.

The appearance of the potato beetle in the central and eastern portions of the United States, between the years 1860 and 1875, familiarized farmers with the use of Paris green, the use of this poison proving to be the easiest and most effectual method of dealing with the insect. The poison was applied both in the form of powder, and suspended in water. But the latter method was not so generally adopted, as difficulty was experienced in making the application. In 1874, Frank M. Gray, of Jefferson, Cook County, Ill., sent to Professor C. V. Riley, then of Missouri, a sprinkler which was designed to spray two rows of potatoes at once.[1] It consisted of a tank holding about eight gallons, and was so arranged that it could be strapped to the back of the operator. Two leads of hose were attached at the bottom of the tank. At the outer extremity of each hose was a nozzle or sprinkler which broke the liquid up into fine drops. The flow was due to the force of gravity, and could be shut off at will by clamps placed upon the hose. This is the first case which has come to my knowledge of the principle of a knapsack sprayer being used in combating the pests of cultivated plants. It will be noticed, however, that no pump was fastened to this machine. Several devices, resembling the above more or less, have since been constructed, but they have not met with much favor.

W. P. Peck, of West Grove, Penn., made another machine for applying Paris green in water.[2] He also used a tank strapped to the back, but atomized the liquid by means of a crank which operated a pair of bellows. The machine was also provided with an automatic agitator which prevented the poison from settling.

The first knapsack pumps used in America were imported from France, and it was not until 1890 that Americans began seriously to consider their manufacture. In France, their use is also very recent, since, at the close of the year 1885, these machines were scarcely known. The manufacture of two forms had just begun, their structure having undoubtedly been suggested by the conditions under which the Bordeaux mixture could be most thoroughly applied. One machine was made by Gaillot, of Beaune (Côte d'Or).[3] It was constructed so that air was forced, by means of an exterior pump, into the liquid at the bottom of the tank, and the contents were kept agitated by the rising air. The other form was manufactured by Katterbach, also of Beaune; but, as it appears to have been little used, it cannot have been of much value. Four or five different

[1] Riley, "Potato Pests," 1876, 63.

[2] *Ibid.* 64.

[3] Ricaud, *Jour. d'Ag. Prat.* 1885, Dec. 3, 795; also Gaillot, *Ibid.* 1888, May 24, 733.

machines were exhibited at a fair held in Montpellier, France, during February, 1886, and a great number were manufactured and sold within the next few years. Hand or barrel pumps were rarely used. The most popular knapsack pumps now made in France are the Éclair, the Vigouroux, the Japy, and the Albrand. The first (Fig. 6) is manufactured by Vermorel, Villefranche (Rhône). It is made without a piston, the liquid being propelled by means of a circular rubber disk *B* which is fastened at the edges, but moves up and down in the center, thus forcing on the liquid contained between the disk and the bottom of the tank, *C*. The liquid in the reservoir, *R*, flows through the valve, *L*, entering the space above the disk. When the latter is forced upward by the action of the handle, *K*, the fluid is forced through a second valve, *V*, into a second receptacle, which serves as an air chamber, *D*. From here it passes through the orifice, *H*, and is discharged at the end of a hose provided for the purpose. When the center of the disk is lowered, more fluid is drawn in from the reservoir, and in this manner the pumping is performed.

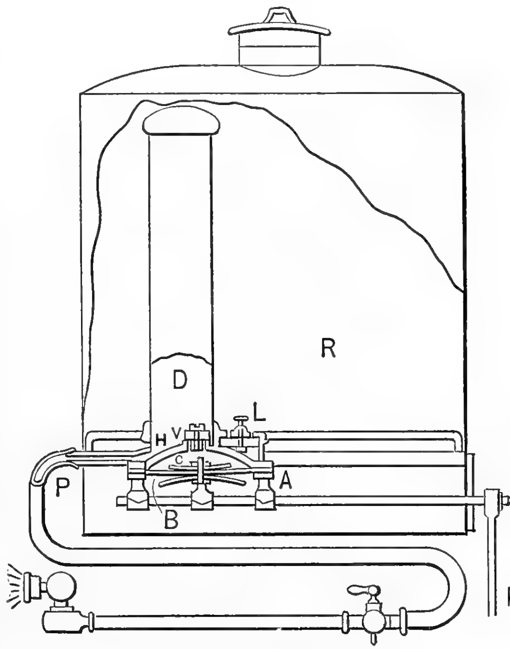

FIG. 6. — The "Éclair" knapsack pump.

The Vigouroux pump contains an air chamber and piston pump within the tank. The piston is moved by means of a rod which ascends through the top of the tank, and, after turning sharply, descends on the outside to below the tank, where it is attached to the lever which serves as a handle. Another form, one which is provided with a second pump for filling the tank without removing it from the back, is also made by the same manufacturer.

The Japy pump (Fig. 7) is very like the preceding, but the piston rod is worked by a lever situated within the tank, the lever in turn being moved by a rod extending through the top of the reservoir. Both the cylinder and the air chamber project below the tank. For plans of an improved Japy pump, designed by B. T. Galloway, see *Journal of Mycology*, Vol. vii. No. 1, 39.

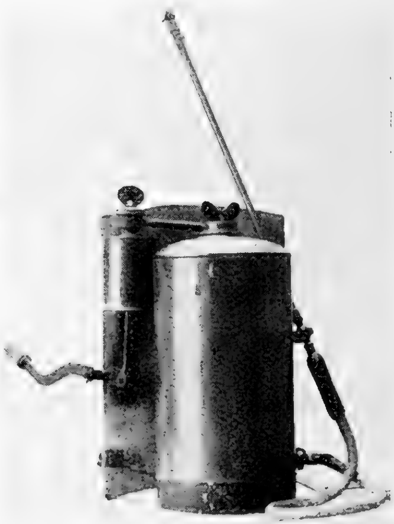

FIG. 7.—The "Japy" knapsack pump. FIG. 8.—The "Albrand" knapsack pump.

The Albrand (Fig. 8), manufactured by Valloton, Lyons, France, is provided with an air pump situated on one side of the tank, near the top. Air is forced into the reservoir, the outlet of the conducting tube being near the bottom, thus agitating the liquid. The pressure of the air within the tank forces out the liquid.

B. T. Galloway, of the United States Department of Agriculture, was the first in this country to publish detailed plans for the construction of knapsack pumps.[1] His recommendations have been followed more or less closely to the present time, but

[1] *Journal of Mycology*, Vol. vi. 1890, Sept. 10, pp. 26 and 51.

several minor changes have been made. His pump (Fig. 9) consists of a knapsack tank carried on the back of the operator. The pump proper is composed of a tube or cylinder which projects a short distance above the top of the tank, the lower end being near the bottom of the reservoir. The piston is moved by means of a handle which extends forward in such a manner that it can be worked easily by the person carrying the pump. No pressure is brought to bear upon the air above the liquid, but all necessary force is applied directly to the liquid by means of the working parts of the pump. The Galloway knapsack sprayer, as the machine is commonly called, was first manufactured by two firms in Washington, D.C.[1] A few other manufacturers almost immediately began the construction of this class of pumps, but on account of the limited demand, they were not produced in nearly such large quantities as were the various hand and barrel pumps. One company[2] put an enormous air chamber above the tank the first year it sold the machine; as this feature was advertised only one year it is good evidence that its use was not advisable. Later styles of these pumps have varied in the shape of the tank, and many desirable features have been added, but the general plan has remained unchanged. They are almost without exception made of copper and brass, and consequently withstand the corroding action wrought by many of the materials applied. Rumsey & Co. has departed from the Galloway sprayer, and now manufactures a pump in which air is forced into the tank by means of a pump, and this air pressure forces out the liquid.

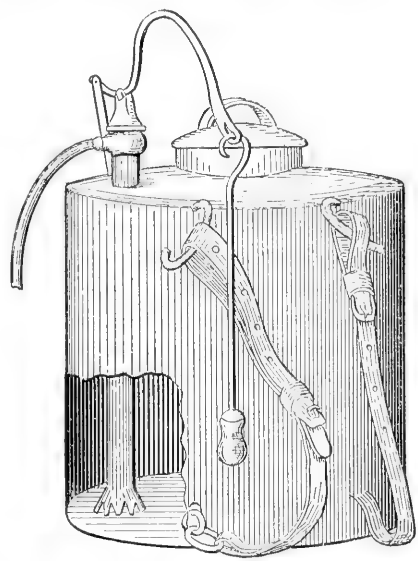

Fig. 9.—The "Galloway" knapsack pump.

[1] Albinson & Co.; Leitch & Sons.
[2] Field Force Pump Co., Lockport, N.Y.

Several French machines are built in this manner, one of the advantages claimed being that the outfit is more durable, since the materials applied do not come in contact with the working parts of the pump. The Galloway type, however, is at present more popular.

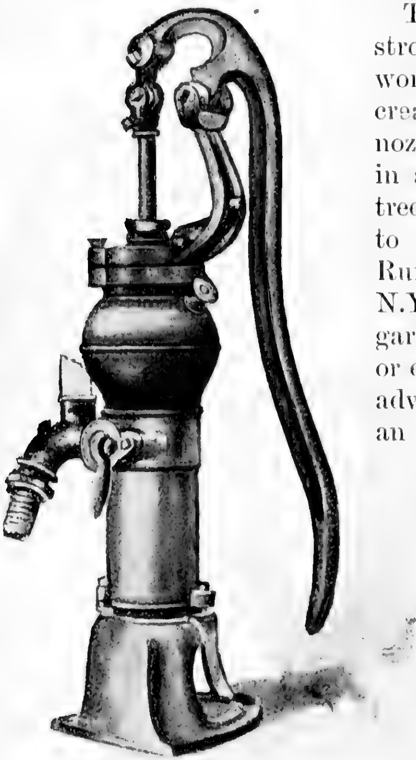

Fig. 10.—The "Florida" barrel pump, the first form especially designed for spraying purposes.

The use of Paris green to destroy the plum curculio, cankerworm, and the codlin-moth, soon created a demand for pumps and nozzles which would be effective in applying sprays to well-grown trees. Several firms soon began to supply this demand. C. J. Rumsey & Co., of Seneca Falls, N.Y., had been supplying various garden engines as early as 1858, or even before. In 1860 the firm advertised a garden engine as an instrument for "the throwing of liquid compounds, such as whale-oil, soapsuds, tobacco-water, etc., for destroying insects on trees, roses, and other plants." The outfit consisted of a tank resting on two wheels in front and on two legs behind; it was moved about as a wheelbarrow is. The pump had an enormous air chamber, a part which has fortunately been reduced in size during later years. Various small hand or bucket pumps were sold soon after.

On Nov. 6, 1860, Messrs. W. and B. Douglas, of Middletown, Conn., obtained a patent on a garden or greenhouse engine, and in the same year the same company patented its "Aquarius," a bucket pump still advertised.

It was not until the year 1880 that the pump manufacturers of this country fully realized the necessity of taking steps towards supplying the growing demand for pumps especially designed for spraying purposes, and the next five years showed that many were giving the matter serious attention. New firms were organized with the special object of manufacturing and selling pumps and other materials which were in demand by those who sprayed.

In 1880 Rumsey & Co. offered for sale the "Florida" pump (Fig. 10), which seems to have been the first barrel pump designed especially to meet the requirements of a good sprayer. The firm writes me that "its introduction was followed by a demand we were unable to supply." This statement is emphasized by the fact that in 1882 the well-known firm, the Field Force Pump Co., of Lockport, N.Y., was founded, to supply the demand of local fruit growers for a pump which would be satisfactory as a sprayer. The leading entomologists of the country were urging the farmers to spray, and these in turn made demands upon the manufacturers; and thus the industry arose. In 1882 the latter company received a patent upon its combined cistern and force pump (Fig. 11). This pump was provided with a three-inch cylinder, but a larger size had one that was three and one-half inches in diameter. A later form was made with a two and one-half inch cylinder.

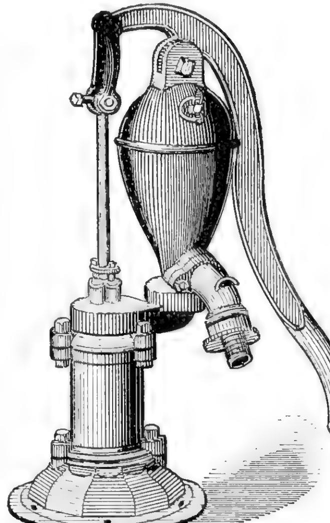

Fig. 11. — Combined cistern and force pump.

In 1889 another firm, the Nixon Nozzle & Machine Co., came into prominence. At this time it advertised two garden engines, the "Little Giant" and a "Barrel Machine"; the "Little Climax" pump was also catalogued. These machines were all very powerful, and were made particularly to supply the growing demand for spray pumps.

Morrill & Morley, Benton Harbor, Mich., in 1894 introduced a pump shown in Fig. 12. This style is a radical departure from older forms. The cylinder is placed at the bottom of the pump, directly in the liquid. No stuffing-box is used, and as the piston and cylinder are surrounded by the fluid, no priming is necessary. These pumps are simple, powerful, and durable, and many are now in use.

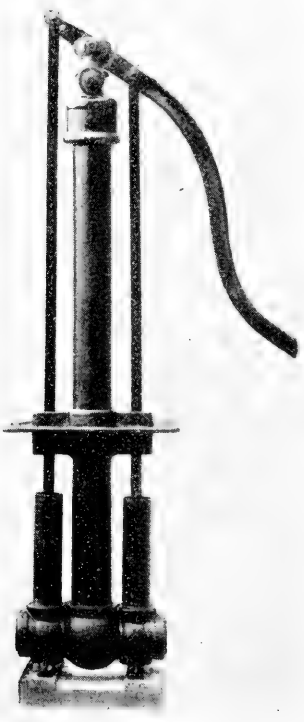

FIG. 12. — A new type of spray pump.

In recent years many of the leading pump manufacturers have added spray pumps to their catalogues, and other firms have been established which make a specialty of this class. As so many different men have been engaged in the work, it is not strange that a great variety of pumps should have been made. Some of them are excellent, but others do not answer all requirements so well as might be desired. One form that has been little used and which yet has some very promising features is that made by the Bean-Chamberlin Manufacturing Co., of Hudson, Mich. The firm offers a number of pneumatic pumps which differ radically from the pumps sold by other dealers. Instead of using directly the force obtained by the moving piston, this force is directed toward compressing air in a reservoir. Fig. 13 illustrates the general plan upon which these pumps are built.

The pump proper, *B*, is situated at the right of the large tank or reservoir. It is used for forcing liquids into the reservoir, *C*, from below. As the liquid enters the tank the air is compressed, and this allows a large amount of fluid to enter. Most of these pumps are made so that they will withstand 160 pounds of pressure, a steam gauge, *G*, being fastened to the tank of each pump to indicate the pressure under which the work of spraying is done. These pumps are made of different sizes.

The Nixon Nozzle & Machine Co., Dayton, O., was the first to manufacture a geared spraying machine. It was called the "Field and Orchard Machine," and was designed by A. H. Nixon, the founder of the firm. The machine was introduced in 1887, it being sent to several persons to be tested. In 1888 it was offered to the public. Fig. 14 illustrates the general construction of the machine as first sold. It will be noticed that the four nozzles are situated in front of the wheels, instead of at the rear as is now generally the case. The tank held 100 gallons, and was built in the form of a cube, instead of barrel-shaped. The price was seventy-five dollars.

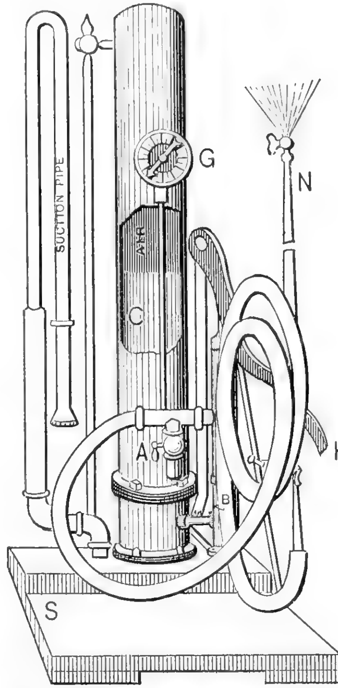

Fig. 13. — Pneumatic spray pump.

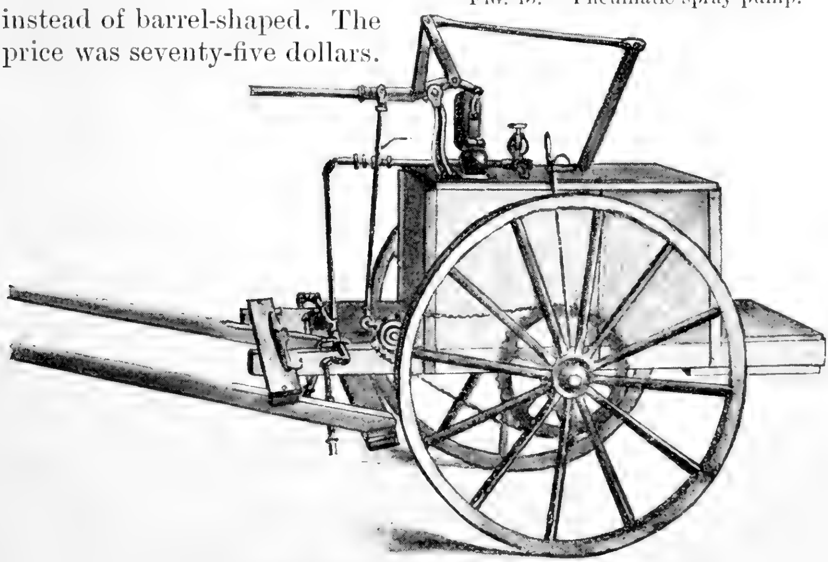
Fig. 14. — The first geared spray machine advertised in America.

Various excellent machines of this type are now manufactured by several firms.

During the past few years, many machines adapted to the spraying of potatoes and other low-growing plants have been manufactured. They are of two kinds: First, those in which the flow of liquid is produced by gravity; second, those in which the fluid is forced through the outlet orifice with the aid of a pump. Some of the machines belonging to the first class break

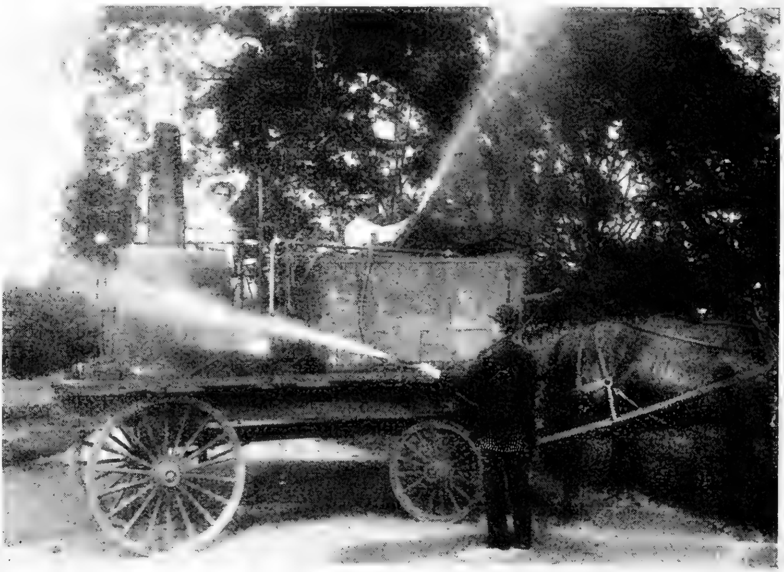

FIG. 15. — The first successful spraying outfit using steam power.

up the liquid by means of revolving brushes,[1] or by a blast of air,[2] but the majority are modifications of common street sprinklers.

The second class includes both hand pumps and power machines, and as a rule these are the most satisfactory. Less trouble is experienced from clogging, and more uniform applications may be made. One of the first machines of this character was the "Climax," this having been sold in 1890. It was manufactured by Thomas Peppler, Hightstown, N.J., and is

[1] J. R. Steitz, Cudahy, Wis. [2] Seth K. Samms, Byberry, Philadelphia, Penn.

still upon the market in an improved form. In 1895 the Deming M'f'g Co., Salem, O., first made the "Monarch," a powerful machine, which is also suitable for vineyard work.

The first successful use of steam power for spraying was made, so far as I have been able to learn, by Stephen Hoyt, New Canaan, Conn. The outfit (Figs. 15 and 16) was first operated in 1894, and the following year it was again used with most satisfactory results.[1] Large shade trees were sprayed thoroughly and rapidly by the outfit. Mr. Hoyt writes me as follows regarding its operation:

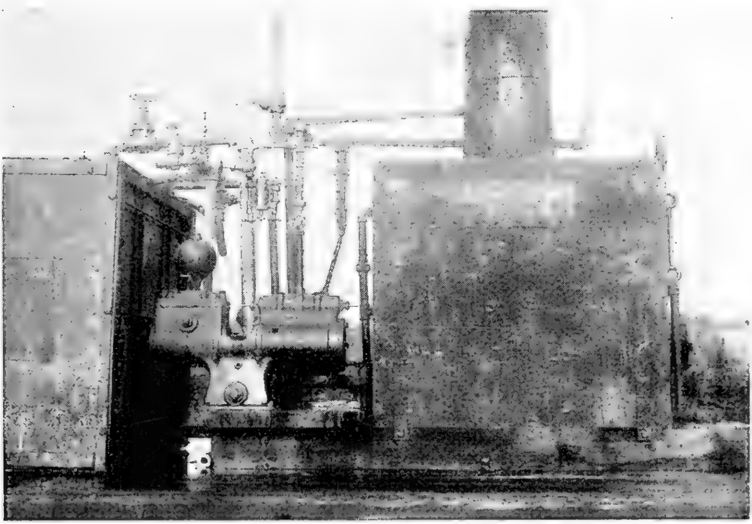

Fig. 16. — Tank, boiler, and pump of the outfit shown in Fig. 15.

"The machine is made to throw four streams, two of which are to work at the same time; two men are to go up the trees to the crotch and spray, while the other two are either preparing to go up the next or are coming down from the two which they have sprayed. The hose is fixed so as to shut any one of them off at any time, and so when two of the men are through spraying, the other two can start or keep on as they choose.

"The two streams in the picture have a water pressure of from 125 to 150 pounds per square inch, and with a steam pressure

[1] *Connecticut Agric. Exp. Sta.* 1895, July, Bull. 121, 4.

of 100 pounds. We can produce a spraying pressure of over 200 pounds, but is not necessary as it is too big a strain on the hose. I have had three streams going at one time with a water pressure of 100 pounds.

"We use the McGowen nozzle, it being the most economical and does not use so much of the liquid as some others, and if necessary, can make the spray nothing but a mist. But for elm-tree spraying we use the McGowen straight stream, as the pressure is so great that it tears the stream into a good spray for tree spraying."

Various modifications and improvements have already been suggested for the above, and the time must soon come when some such apparatus will be generally employed for preserving the long-suffering shade trees of our cities from the ravages of insects. The smooth roads will allow the use of heavier and more simple machinery than could be worked in many of our large orchards. The cost of the treatments would be distributed among so many, and the benefits derived would be so great, that such outfits may soon come into general use.

Gas engines have also been employed. During 1895, W. R. Gunnis, of San Diego County, Cal., applied kerosene emulsion to his trees, using power of this nature. "The apparatus is placed on the platform of a light wagon, and on the front end is a tank of a capacity of 100 gallons, filled with the emulsion. A small electro-vapor engine on the wagon operates a double-action, high-pressure, cylinder pump, and to this eight lines of hose may be attached. The pump can be worked at a pressure of 200 pounds, rendering the spray fine and strong, and capable of reaching to the tops of the tallest trees, where the hose is supported by ten-foot bamboo canes. Twenty-five or thirty acres of four-year old trees may be sprayed in one day with the labor of four men."[1]

A device for mixing kerosene and water has been invented by Professor Goff, and during 1894 the Nixon Nozzle & Machine Co. offered it for sale in connection with the "Climax" pump, and other firms attached it in a modified form to knapsack sprayers. Experiments for obtaining such a mixture had been made in 1888,[2] but it was not until about the year 1893

[1] *Insect Life*, 1895, vii. No. 5, 413.
[2] Goff, *N. Y. State Agric. Exp. Sta. Ann. Rept.* 1888, 148.

that dealers considered the matter seriously. The principle underlying the construction of the apparatus is that the movement of the piston draws into the cylinder a certain amount of water through one opening, but through a second one kerosene is drawn in. The two liquids become intimately mixed by their passage through the pump before being thrown from the nozzle, and thus a dilute kerosene may be evenly applied. The flow of kerosene into the cylinder may be regulated by a stopcock.[1] An improved form of such an attachment on a knapsack pump is shown in Fig. 17. The Deming Co., of Salem, O., and Professor H. E. Weed, of Agricultural College, Mississippi, have been most active in perfecting these machines.

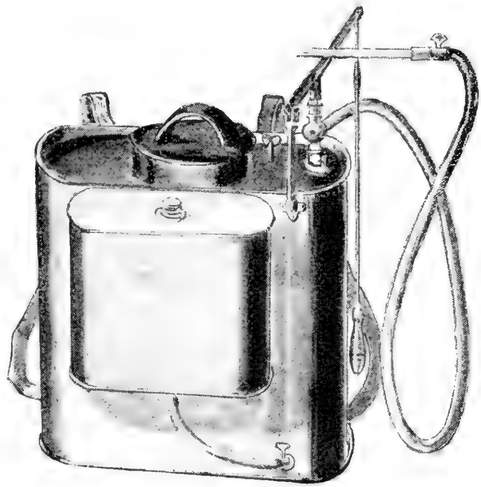

FIG. 17. — An improved form of a kerosene reservoir attached to a knapsack pump.

II. EVOLUTION OF NOZZLES.

The production of the spray nozzle is one of the most interesting of the many problems which have taxed the ingenuity of inventors. So long as the materials applied were in the form of clear liquids, or when they were used only in small quantities, not much attention was paid to this part of the machines. But with the use of the garden engine and force pump, and more dense fluids, there also arose the demand for proper devices by means of which the liquid thrown could be broken up more or less finely.

The simplest, and probably the first form of nozzle was one

[1] See also *Wis. Agric. Exp. Sta. Ann. Rept.* 1891, 162, and *Garden and Forest*, vii. 1895, 143.

which would throw a solid stream. It was constructed so that the volume of liquid was gradually contracted as it approached the outlet orifice, and the stream was not broken up until it had been carried some distance from the nozzle. The stream was often changed to a spray by screwing a rose, or some similar device, to the end of the nozzle. The openings in these attachments still allowed the passage of solid streams of liquid, but these were so reduced in size that the fluid was broken up into much smaller drops.

Three principles have been utilized in the construction of all spray nozzles now in use. These principles form a basis for the natural division of nozzles into three main groups, these allowing of still further subdivision:

1. Spray nozzles in which the stream is more or less broken directly in consequence of the modifying action of the margins of the outlet orifice.

2. Spray nozzles in which the stream, having passed the outlet orifice proper, is modified by obstructions which affect its free and direct outward passage.

3. Spray nozzles in which a strong rotary motion is given to the liquid, and in consequence of this motion, the stream leaving the outlet orifice immediately assumes the form of a spray.

These principles are mentioned in the order in which they probably came into use. Some of the later nozzles combine the first two principles, and others seem to form a connection between them, although one principle or the other strongly predominates. Some of the nozzles belonging to the various groups are here briefly considered.[1]

The first group was long represented by nozzles throwing a solid stream, the outlet orifice being circular. A new type of nozzles, a modification of these, began to be made about 1875. This class became known as graduating spray nozzles, from the fact that the character of the liquid thrown could be varied from a solid stream to that of a fine spray, by introducing into the outlet orifice a pointed piece of metal or lance. This entered the orifice from the inner side, and the further it was introduced, the smaller became the opening and the finer was the

[1] For a more complete description, with illustrations, of many of the nozzles here mentioned, see *American Gardening*, 1893, May, 266.

spray. It was moved by turning some part of the nozzle which was connected with the lance. The "Peerless," "Lowell," and "Gem" (Fig. 18 *a*) are good examples of this class.

In 1878 a patent was granted to the Belknap Company on a new nozzle called the "Boss" (Fig. 18 *b*). It has two outlet orifices, and the stream is directed into the one or the other by means of a hollow stopcock which is perforated in such a manner that it partially or entirely closes one or both of the openings. The "Eureka," "Masson," and "Bordeaux" (Fig. 18 *c*) are modified forms which have since appeared. The spray is varied by changing the size of the opening, this being easily done by turning the perforated stopcock.

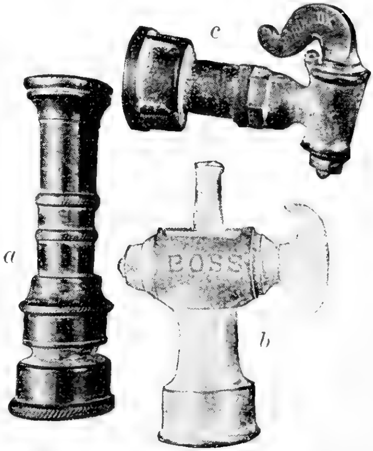

Fig. 18.—Spray nozzles. *a*, graduating spray "Gem"; *b*, "Boss"; *c*, "Bordeaux."

In 1858 Rumsey & Co. advertised a nozzle called the "Fantail" (see Fig. 5). It consisted of a flat spreading tip having a long, narrow opening which discharged the liquid in the form of a spray resembling in outline the flame of a gas jet. This principle of having the liquid issue between two flat, parallel pieces of metal has been retained in more or less modified form in many of the nozzles now in use. One of the most primitive forms was made by hammering a nozzle designed to throw a solid stream in such a manner that the opening was long and narrow instead of circular. It was even recommended that they should be made in this manner.[1] Little was done towards improving this class of nozzles until about 1889, when a patent was granted on the "New Bean." In this nozzle the width of the opening could be adjusted by means of a screw, one side of the orifice being of rubber packing. In 1890 Bailey published a description of a device, by means of which the end of a hose could be contracted so that a fan-shaped spray was produced[2]

[1] *Cultivator and Country Gentleman*, 1871, Aug. 3, 486.
[2] *Cornell Agric. Exp. Sta.* 1890, July, Bull. 18, 39.

(Fig. 19 *a*). The size of the opening was entirely under the control of the operator, and in case of clogging it could be opened to its fullest extent.

It was about this time that the "Wellhouse" nozzle was first made[1] (Fig. 19 *b*). It is made after the pattern of a gas jet, but much larger.

In 1892 the first automatic cleaning nozzle was invented (Fig. 19 *d*), it having been suggested by the device shown in Fig. 19 *c*. It has since been offered for sale, in a modified

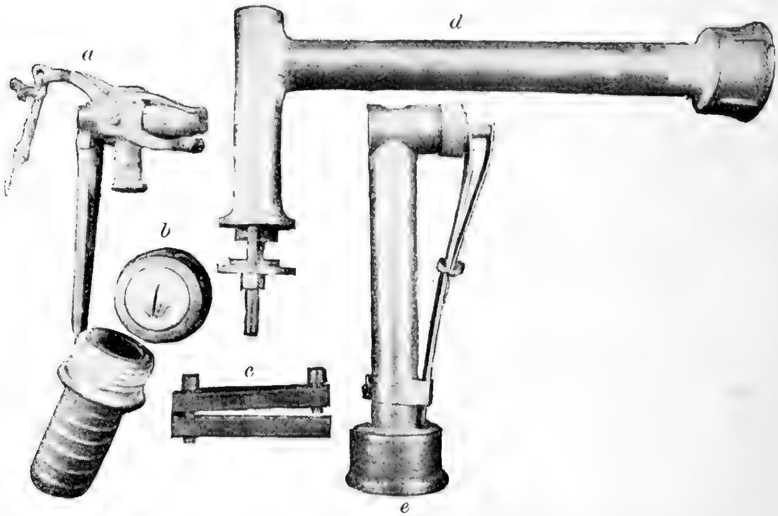

Fig. 19. — *a*, "Bailey"; *b*, "Wellhouse"; *c* and *d*, forms which led to the construction of *e*, the "McGowen."

form, having been named the "McGowen," after its inventor.[2] In this nozzle (Fig. 19 *e*) the opening is formed by two pieces of metal which remain in contact when not in use. One piece is movable and is in the form of a piston which moves backward and forward in a cylinder placed at right angles to the main shaft. As the pressure in the shaft increases, the size of the opening enlarges, and in this manner any obstruction which may become lodged at the outlet orifice will cause an increase

[1] Invented by Walter Wellhouse, Fairmount, Kan. See a full illustrated account in *Rep. Kan. Hort. Soc.* xviii. 99.

[2] John J. McGowen, Ithaca, N.Y.

of pressure which forces the piston back to its fullest extent, thus allowing the passage of the obstruction. This nozzle is in many respects a radical departure from all forms made at the time of its introduction, and its automatic action marks it as a distinct advance in the evolution of spray nozzles.

The second group of nozzles, including those in which the stream of liquid is broken by some obstruction preventing its free outward passage, is represented by fewer specimens than is either one of the others. Although such nozzles were among the first made, their construction apparently does not admit of so many modifications as are feasible in the other groups.

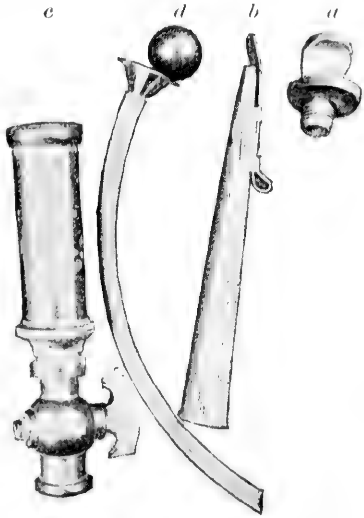

Fig. 20. — *a*, "Vigouroux"; *b*, "Lewis"; *c*, "Climax"; *d*, "Ball."

The form first sold was known as a "Diffuser." It was made by extending a portion of one side of the outlet orifice into a broad, fan-shaped piece of metal against which the liquid was thrown at a very slight angle. This caused the stream to spread over the surface of the projection, and in this manner it was broken up into a coarse spray. Fig. 20 *a* represents a form at present used in France, the "Vigouroux." The fan-shaped projection has in recent years been so constructed that it may be brought close to the orifice or it can be removed entirely[1] (Fig. 20 *b*). It is generally made of metal, but there is now sold one form in which a piece of rubber answers the same purpose. The rubber is pressed over the opening in the nozzle, and the size of the orifice as well as the character of the spray may be varied to a considerable extent.

In 1884 a patent was granted to the Nixon Nozzle & Machine Co.,[2] on a nozzle known as the "Climax," in which the liquid was forcibly thrown as a solid stream against a piece of wire

[1] P. C. Lewis Manufacturing Co. Catskill, N.Y.
[2] Nixon Nozzle & Machine Co. Dayton, O.

gauze (Fig. 20 *c*). It was here broken up into a spray varying in character with the size of the meshes in the wire netting. These nozzles were widely recommended and sold, and they are the most important which can at present be found in this group.

The "Ball" nozzle (Fig. 20 *d*) is a new modification which was first extensively advertised in 1895. At the end of a hose is fastened a hollow conical piece of metal in which a light ball loosely rests. As the liquid is forced against the ball the latter is not ejected, but remains to break up the fluid into a fairly light spray. The serious objection to the device is the amount of power required to throw even a moderate amount of fluid.[1]

There is another class which may be included here. It is composed of those nozzles in which the obstruction is not a solid, but consists of a stream of liquid. Two openings are made at the outer extremity of the nozzle, and these incline toward each other in such a manner that the two streams issuing from them come forcibly in contact with each other, and are immediately changed to a fine spray. The "Lilly," or "Calla," and one modification of the "McGowen," are good examples of this form.

The history of the third group of nozzles is very recent, yet many forms have been produced. Several of the most popular nozzles now in use may here be classified together. They are collectively known as the cyclone or eddy-chamber nozzles, from the fact that the liquid, upon entering the nozzle, is forced to whirl with great rapidity in a circular chamber before it passes through the outlet orifice. This cyclonic motion causes the fluid to be broken up into particles which vary in size with the size of the opening, the smaller orifices causing the formation of a spray which is exceedingly fine, so fine that it floats in the air like steam, and does not fall to the ground.

William S. Barnard appears to have been the first to conceive the idea of making spray nozzles in which the above principle should be utilized.[2] During the summer of 1880 he was

[1] American Ball Nozzle Co. 837–847 Broadway, N.Y.

[2] "On such evidence it must be held that Barnard originated the basic idea of the improvement in question." Decision of the Commissioner of Patents and of U. S. Courts in Patent Cases as recorded in *The Official Gazette of the U. S. Patent Office*, Vol. 59, No. 12, 1922.

engaged as an agent of the United States Entomological Commission, and was stationed in the South to conduct experiments for the destruction of the cotton-worm. It was probably while engaged in the work of throwing liquids that the idea suggested itself, and that it was soon put into execution is shown by an affidavit made by Professor C. V. Riley, April 14, 1886.[1] During 1880 the principle was tested with the aid of watch crystals, these being chosen from the fact that in them the action of the liquid could be easily observed. Other contrivances were also employed, and thus began the series which eventually led to the construction of the nozzle that became widely known as the "Riley," "Cyclone," or "Eddy-chamber" spray nozzle (Fig. 21 *a*). Unfortunately, the name "Barnard" has not been more closely connected with the invention, which is without doubt one of the most important of the many bearing on the subject of spraying. The nozzle was briefly mentioned in the annual report of the United States Commissioner of Agriculture for 1881–82, and again in the report of 1884. In the latter report, on page 330, Dr. Riley makes the following statement: "The final form of chamber adopted is the result of numberless experiments carried on by Dr. Barnard in my work, both for the United States Entomological Commission and the Department of Agriculture."

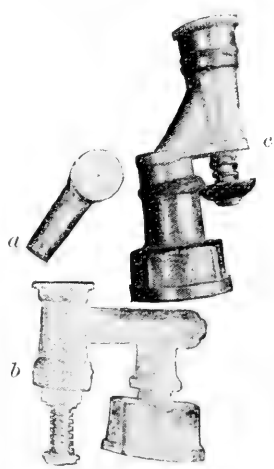

FIG. 21.—*a*, "Cyclone"; *b*, old form of "Vermorel"; *c*, modified form of "Vermorel."

Dr. Riley visited France in 1884, and in an address delivered June 30, to the Société Centrale d'Agriculture de l'Hérault, he mentioned Barnard's nozzle, and this no doubt hastened its adoption in that country.[2] The nozzle was easily clogged, and on this account it gave considerable trouble, yet it was conceded to be one of the best, and was used by several experimenters in 1885. It attracted the attention of French manufacturers, the firm of V. Vermorel, Villefranche (Rhône), being perhaps

[1] *Official Gazette U. S. Patent Office*, Vol. 59, No. 12, 1922.
[2] *Messager Agricole*, 1884, July 10, 261.

the first to manufacture this nozzle, which is there called the "Riley." Vermorel informs me that it was during 1886 and 1887 that he added the attachment by means of which the outlet orifice can be cleaned when it becomes clogged. The improvement consists of a pin or lance which can be pressed forward until the point penetrates the orifice and thereby forces outward all obstructions. Fig. 21 *b* represents one of the earlier forms. Vermorel also made a few minor changes during 1889 and 1890. His improved form of the cyclone nozzle became known as the "Vermorel," and it was almost immediately adopted in America, to the exclusion of the older forms made by Barnard. The name "Vermorel" has also been retained. The nozzle is at present one of the best in use. Although many modifications of it have been made, the original form is fully as serviceable as the later ones, and it is generally preferred.[1]

The elbow in the Vermorel nozzle is one feature which is open to slight objection, and many attempts have been made to avoid it (Fig. 21 *c*). Several nozzles have also been made in which the eddy chamber and outlet orifice are situated directly in line with the main shaft. These nozzles look a little neater, and they are more easily moved about among branches, but in other respects they possess no advantage. The spray as a rule is no better than that of the true Vermorel, and the parts are cleaned with greater difficulty in case of clogging. The class is represented by the "Marseilles," "Bean's Cyclone," "Myers," "Acme," and others.

Vermorel nozzles are also made with a shaft about eighteen inches long. Connections are made with the lance which cleans the orifice by means of a rod which is operated by a lever. This form is used almost wholly with knapsack pumps.

III. Bellows and Powder Guns.

Powders have long been used for the control of fungi and insects. In Europe sulphur was generally so applied, previous to 1885, against the grape mildew, and special apparatus had been devised for making these applications. The most popular instrument for the purpose was a hand bellows, upon which

[1] For French modifications of the cyclone nozzle, see Riley, *Insect Life*, 1889, Vol. i. No. 8, 243; and *Ibid.* No. 9, 263.

was fastened a small reservoir for holding the material (Fig. 22). Bellows are easily operated, distribute the powders evenly, and in addition are cheap, so they are still very commonly used, in modified and improved form, both in Europe and in this country. When large areas are to be treated, however, the work progresses but slowly, and this has led to the invention of machines which force a current of air through a tube by means of a revolving fan, the powder being mixed with the air. A type of this class of machines is shown in Fig. 23. Their action is certain and rapid, and although they are more expensive, their greater effectiveness well warrants the outlay. The first powder gun made in America appears to have been invented by Legget, who began its manufacture as early as 1854.

FIG. 22. — Hand bellows for blowing powders.

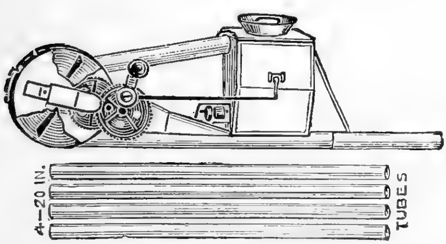

FIG. 23. — Gun for applying powders rapidly.

Another advance was made in 1895, when there was advertised a horse-power machine called the "Sirocco Dust Sprayer."[1] A powerful air blast is produced by gearing a revolving fan to the main wheels, and large amounts of any dry powder may be quickly and evenly distributed.

IV. Comparison of Liquids and Powders.

Having thus very briefly discussed the gradual introduction and development of the machinery used in making applications of insecticides and fungicides, it now remains to discuss the

[1] The Sirocco Company, Unionville, Lake County, O. The device was invented by W. R. Monroe.

all-important question, "Which is the best?" Before going into details it may be well to obtain a clear idea with regard to the comparative value of liquids and powders.

Powders are more easily handled than liquids, and with the machinery now made they can be just as evenly applied; yet it is only in exceptional cases that their use is advisable. Powders cannot be thrown any considerable distance, and this necessarily limits their profitable application to the lower growing plants. This becomes especially emphatic when a wind is blowing, for every current of air will change the direction in which the particles move, and a considerable loss of material will take place. A quiet day is therefore generally the best for making such applications.

Another defect is that powders cannot always be made to adhere so firmly to foliage as the liquid applications do. When the foliage is dry it commonly occurs that scarcely any of the powders will adhere, and this necessitates wetting the parts to be treated, or else waiting until dew or rain shall have moistened them so that the particles will remain where they are applied. Plants having smooth foliage are particularly difficult to treat. Another objection, and so far as fungous diseases are concerned, the most serious one, is that we have no powders which are as effective as the liquids, and for this reason alone the latter are to be preferred. With insecticides, however, the case is different. The best insecticides are in powder form, and when low-growing, rough-leaved plants are treated while the foliage is damp, the poisons can be profitably and economically applied. Plants grown in greenhouses can also be successfully treated in the same manner, since here there are almost no air currents, and the moisture may be controlled with ease.

Liquids can be applied under nearly all circumstances. If proper machinery is used, it makes comparatively little difference whether the plants are one or thirty feet high. In case of a wind the material can still be thrown, although not so well, and the operator is also under less discomfort. Liquids will adhere to the parts to which they are applied, with only few exceptions, and on this account greater protection is afforded by them. Both fungicides and insecticides can be thrown equally well by the same appliances, and since the two are generally used, it would seem that liquids are to be preferred. This is especially true when several different crops are to be treated.

If powders are preferred, the hand bellows will be found very serviceable when only a small area is to be covered. For more extensive work, machines with revolving fans to produce stronger air blasts will answer the purpose better, since the work can be done more easily and also more rapidly.

V. Merits of the Various Spraying Devices.

The bulk of insecticides and fungicides are applied in liquid form, and so much machinery for making the applications is offered for sale that the selection of the best is by no means an easy matter. The conditions under which the materials are used are so exceedingly varied, that recommendations which apply in one case have little value in another. Only general statements can be made with safety, and each individual must select that which in his judgment promises to be most effective. Several of the ideas here advanced are not in accord with those of some writers whose opinions are entitled to very careful consideration; but since they are the result of personal experience and observation in the field, and of experiment in the laboratory, the conclusions reached are given with the belief that no one who follows them will go far astray. The subject is the more difficult to treat from the fact that personal bias often enters, and that which suits one man may or may not suit another. The manufacturers' side must also be considered, since it is but right that their products should be justly valued. Unfortunately, it is impossible to enter into the merits and defects of all spraying contrivances offered for sale; the descriptions, therefore, will apply only to the types of the more important groups.

A few points apply in the selection of any spraying machine. As a rule, it is better to have all working parts of brass, the body of the pump being either of brass or of iron. The alloy is more durable than iron, since it is not so easily corroded by the liquids used, nor by exposure to air. The first cost is greater, but in the end the extra price is well spent. All brass, however, is not suitable for spray pumps. Ammonia water has a strong solvent action upon soft brass, that which is composed of copper and zinc, and for this reason such brass should be avoided. Hard brass is an alloy in which more or less tin is used with the copper; it is much more durable, and is to be preferred in the construction of both pumps and nozzles.

Pump valves are made of various materials. The metal ones are to be preferred as a rule, although glazed ball valves are very satisfactory. Leather is freely used as packing and in valves, and on account of the ease with which it can be replaced, it is not objectionable. Rubber, however, especially if it is soft, is unsafe to use in a spray machine. Kerosene will cause it to swell to such an extent that the pump is rendered worthless until a new valve is put in, or the old one is given time to shrink, — a process which may require months.

Knapsack pumps have several features to recommend them. Liquids can in this manner be carried and applied in places inaccessible to wheeled vehicles. Vineyards are frequently set in such locations, as are also espaliers and fruit-walls, and under such conditions a knapsack pump has no equal. On small home grounds, where the nature of the spraying is varied, these pumps may also be used to advantage. But trees cannot be successfully treated by them, as the liquid is not thrown far enough. Nor is their use in even moderately large plantations advisable, since the labor of carrying the pump is onerous, and the machine is not easily operated. Other unpleasant features will also be forced upon the man who works the machine, and when possible a different device should be preferred.

Hand syringes are practically out of the question when liquid applications are to be made, except in case of plants grown under glass; then the syringe is much used, although water under pressure is now so generally piped to greenhouses that even here the use of syringes is steadily decreasing, the more so, since a stream of water forcibly applied is a very popular way of controlling insect pests. Fungicides may be applied to plants under glass, either with syringes or by means of knapsack or bucket pumps.

Bucket pumps, such as represented in Fig. 24, are very powerful for their size, and they will throw considerable quantities of liquid. Moderate-sized trees may be thoroughly treated by them, and when little work is to be done these pumps may well be substituted for the knapsack sprayers. Statements are frequently seen, asserting that these and similar pumps may be used successfully in orchard work, and so they may. But the work is so tedious and slow, that the experiment will rarely be tried more than once. A larger pump will throw a greater quantity of liquid and throw it easier, so that it is a mistake to purchase a small pump for any but very limited plantations. Fig. 25 represents another serviceable pump of this kind.

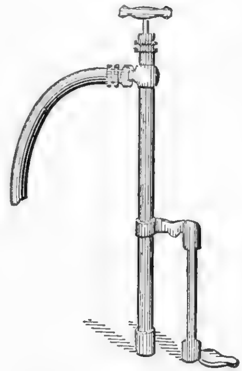

Fig. 24. — Bucket pump.

The greatest variety of pumps may be found among those which are suited for work on a barrel, or

Fig. 25. — Improved bucket pump.

tank, and here is where the greatest difficulty occurs in making a selection. Items of cylinders, pistons, handles, air chambers, agitators, bases, etc., require attention, and as they are all of importance, they will be briefly considered.

Experience has led to the conclusion that no barrel spray pump should have a cylinder less than 2½ inches in diameter, and one with a three-inch cylinder is perhaps to be preferred. This assumes that more than one nozzle is to be attached to the pump, otherwise a smaller pump will answer, especially if an eddy-chamber nozzle is used. But with nozzles designed for heavier work, such as the "Wellhouse," the "McGowen," or the "Bordeaux," the above dimensions are none too large. The stroke should be at least four inches in length, and a longer one would probably be better.

Pistons may be packed with leather or with metal rings. The latter are more durable, but the wear of the cylinder is greater, and they are now little used in spray pumps. Leather or candle-wicking is cheaper, and is at present preferred.

The handle of a pump is a more important item than may at first be supposed. It requires considerable force to move a three-inch piston with the accompanying body of water, and at the same time to drive the liquid through a hose and nozzle with such force that it shall be broken into a spray. If the handle is long, the work can be done with comparative ease. By a long handle is meant one which is from 25 to 30 inches from the pivot to the outer end, the distance from the pivot to the piston-rod being from four to five inches additional. Full allowance is here made for the length of the handle, since many are made which are faulty in this respect.

Air chambers have been almost universally regarded with great favor both by the manufacturers of pumps, and by those who purchase apparatus. The strong point in their favor is that they cause a more uniform flow of liquid, which, to a certain extent, is highly desirable. The question is entirely one of degree, since the presence of an air cushion unquestionably produces a more uniform flow. The assertion is also occasionally made that greater power may be obtained by the use of an air chamber, and that in consequence the spray is better and more easily thrown. Having many pumps and nozzles at my disposal, the different sides of the question have been examined. Some of the chambers have been tapped and aircocks inserted. Any desired amount of air could thus be displaced by the water, or the chamber could be completely filled. Different styles of nozzles were used with the varying capacity of the air chambers, so that the experiments might be as conclusive as possible. A sensitive steam gauge was also attached so that the pressure could be measured.

The results showed that no greater force could be obtained whether a large or a small air space was present; the pump did not appear to work more easily with a large chamber than with a small one, nor did the character of the spray appear to be modified. A great difference could be seen, however, in the length of time required for a nozzle to throw its best form of spray, since the character of the spray of most nozzles varies with the pressure of the liquid. It was also noticed that the flow of liquid continued much longer when a large air chamber was attached, but as the pressure decreased, the value of the spray decreased, so that only the main flow was suitable for making applications. As many nozzles are not provided with a stopcock for shutting off the flow of liquid, there is more or less loss of material whenever the pumping ceases. There is also a loss of time and material when the pressure is increased, since the flow from the nozzle is delayed as the capacity of the air chamber increases. The work indicated that for all practical purposes an air chamber having a capacity of one pint to one quart is sufficient for any barrel pump or for any nozzle. It allows a quick application of pressure, and its almost immediate removal, while the air cushion is sufficiently large to produce a uniform spray.

The agitation of most of the liquid insecticides and fungicides is, unfortunately, necessary; otherwise the undissolved particles settle at the bottom of the tank, and, in consequence, the applications are uneven. Even a knapsack pump will not maintain proper agitation, although it is thoroughly shaken by the man carrying it. Some certain means of agitating the liquid must, therefore, be adopted. Attempts have been made to force a return stream of the liquid into the barrel or tank, and the currents so produced were supposed to answer the desired purpose (see Fig. 28). But the results have not shown this to be the case, and this class of agitators is being gradually abandoned. Another, and more effective, method is to attach a paddle or dasher to the handle or other moving part of the pump, so that at every stroke the liquid will be more or less thoroughly stirred (Fig. 29). These have proved successful so far as the agitation is concerned, but all who have worked a spray pump know that the labor is sufficiently severe without the addition of an attachment which necessarily consumes considerable force. Since the agitation must be accomplished, the use of some of these devices is one of the best ways out of the difficulty. My own practice has been, however, to insert a long-handled paddle into the opening through which the barrel is filled, and to stir the liquid in this manner, directly by hand, whenever it is necessary. This method is, on the whole, probably the easiest and most satisfactory. The work can be done as thoroughly as desired, and with but little extra labor.

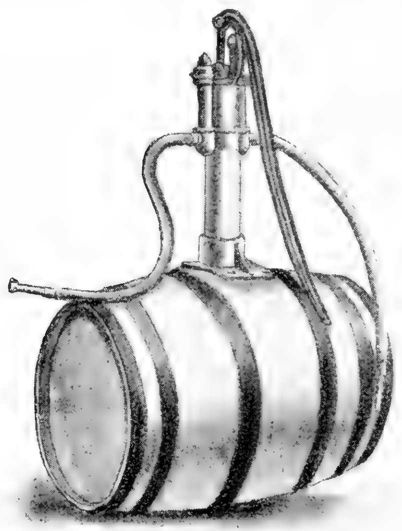

FIG. 26. — A spray outfit, the pump properly attached to the barrel.

The liquid contained in large barrels or tanks can be agitated very easily by means of a permanent device consisting of one or more paddles which are moved by a lever that projects above the reservoir. At short intervals the lever may be moved until the fluid is thoroughly stirred. When long tanks are employed, several paddles should extend crosswise of the tank, near the bottom, and, if these are properly connected, one movement of the lever will cause a movement of all the paddles, thus quickly and easily agitating the contents of the tank.

If a pump is to be used upon a barrel, as is the most common practice, the base-casting should be curved. It is better to turn the barrel on its side (Fig. 26) and fasten the pump in this manner. When it lies on its side, the sediment collects very near one central point, and can easily be dislodged and mixed with the water. But, if the barrel is on end, the sediment collects in an even layer over the entire bottom, and it is much more difficult to maintain an even mixture. Large tanks are unsatisfactory in this respect, since the bottom is generally flat, and it is difficult to reach all the sediment with the agitator. When power sprayers are used, and the horse does the pump-

Fig. 27. — A compact and powerful spray pump.

ing, it does not make so much difference if the labor is harder, and the agitator can be attached to a moving part of the pump with very satisfactory results.

Fig. 27 represents a type of pump sold by several manufacturers, which answers most of the requirements above mentioned. The air chamber is in the piston rod, where it is entirely out of the way, yet it is large enough for all practical purposes. These pumps are exceedingly compact, powerful, and durable, and can be recommended with confidence. Fig. 28 illustrates another form very similar to the preceding. The air chamber surrounds the upper half of the pump, causing the enlargement. These two pumps are amongst the most compact and serviceable ones now sold.

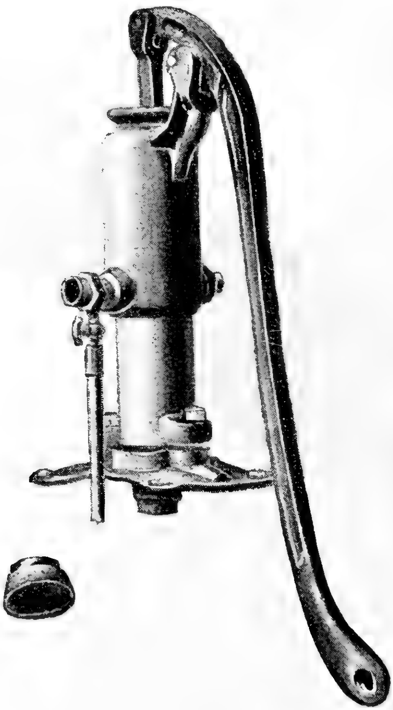

FIG. 28. — A good barrel pump, with a return pipe for agitation, and a strainer.

Fig. 29 shows a style of pump of which there are several modifications (see also Fig. 34). The most striking feature of this type is the very large air chamber. Many of these sprayers are in use, and as they appear to give satisfaction they must have points of decided merit. Such air chambers are of particular value upon power sprayers.

Several manufacturers advertise a horizontal-acting pump, as shown in Fig. 30. These are of various sizes, the cylinder not being smaller than $2\frac{1}{2}$ inches, and in some it is as large as 5 inches in diameter. These pumps are little used, as they seem to be harder to operate, and they are limited in their use more than the forms adapted to barrels.

FIG. 29. — Spray pump, with large air chamber; the paddle at the bottom of the barrel acts as an automatic agitator.

In some localities, semi-rotary pumps (Fig. 31) are in demand, no other form being thought equally effective. The action of these pumps, when new, leaves little to be desired. They are easily worked and powerful, and at first appear to approach the

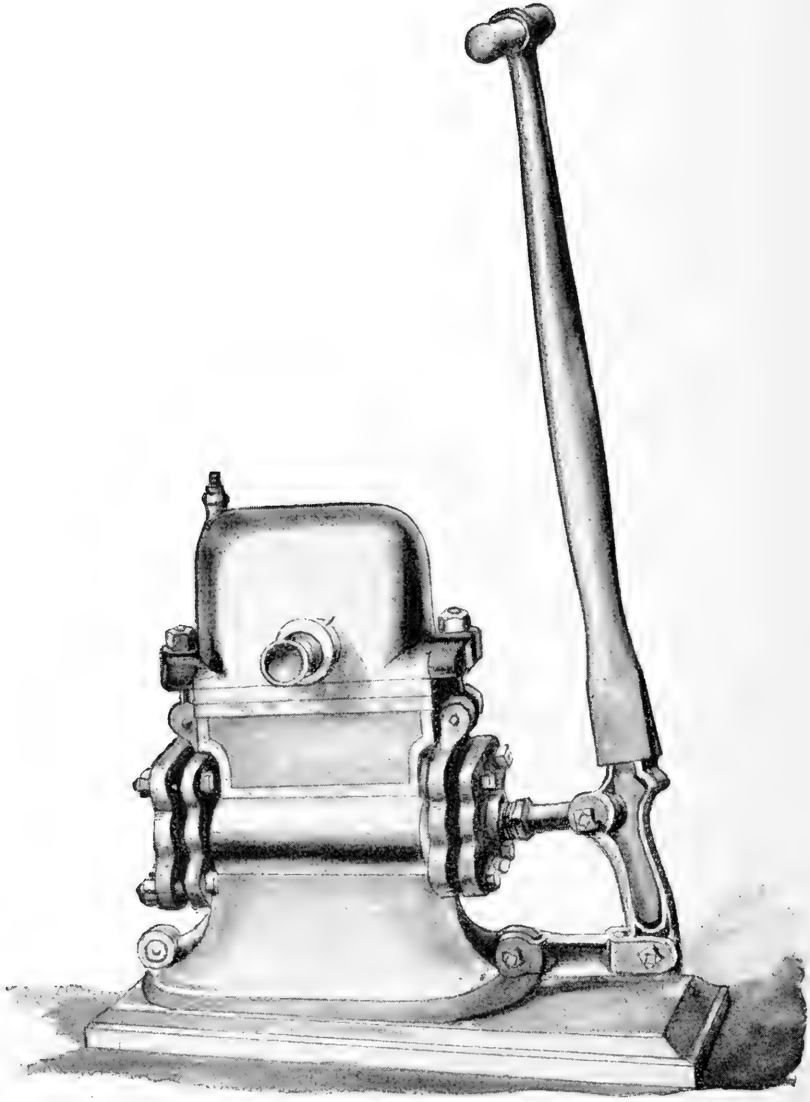

FIG. 30. — A powerful horizontal spray pump.

ideal spray pump. Yet the manufacturers have admitted that these pumps are not so durable as the other styles, and this necessarily follows from the manner of their construction.

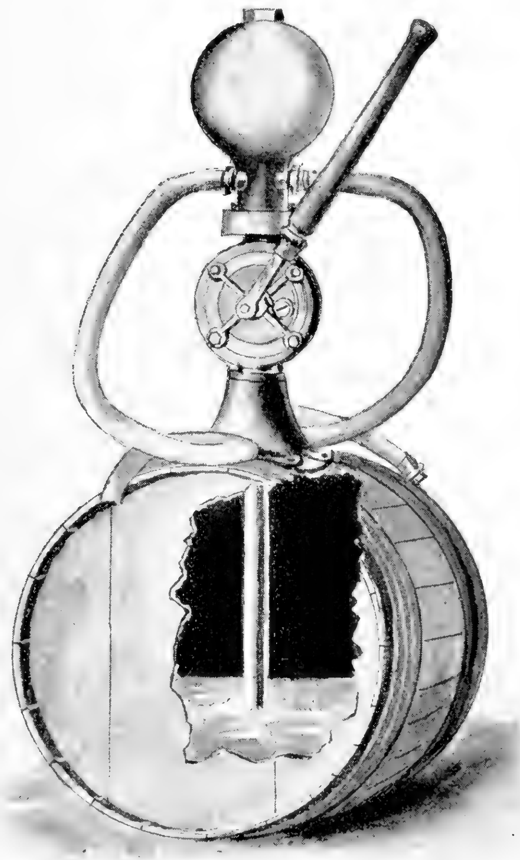

FIG. 31. — Semi-rotary or "clock" pump.

They are also more delicate, and will not bear the abuse which appears to have no effect upon other forms. When clear solutions are applied there is little to wear the inner parts, but with gritty preparations, such as the Bordeaux mixture, their days of service are not very long.

Later and improved forms of the pump represented by Fig. 12 have been extensively used during the season of 1895, with very satisfactory results. One cylinder has been replaced by a metal sheet, which is fastened at the base of the pump, but the outer end is free to be carried up and down at every stroke of the handle. This is one of the best and most easily operated agitators with which I am acquainted, and the pump has met with much favor, although but recently put upon the market.

Barrel pumps have thus far proved the most satisfactory in spraying old orchards. The operation is too slow and tedious when smaller pumps are employed, and geared power sprayers are unable to cover the trees with sufficient uniformity. Engines have not as yet been sufficiently employed to warrant their recommendation. When trees are comparatively small, a very serviceable outfit may be obtained by placing the barrel and pump on a light wagon. Two men can work most conveniently. One drives and pumps, while the other holds the nozzle, or the operations may be differently divided. If more than one lead of hose is in use, it will require a man for each hose, and another to pump.

If the trees are large, such as old apple trees, an outfit similar to that shown in Fig. 32 will prove of great service. One man drives and pumps, while behind him is the barrel or tank. The tank may be of various shapes, some growers preferring hogsheads, while others use a long, low tank, having a flat (Fig. 33) or rounded bottom, the latter being better, as the liquid can be more thoroughly agitated. Above this tank is a platform, which is from ten to fifteen feet from the ground. The men directing the spray stand upon this, and are prevented from falling by a rail which surrounds the platform. This elevation allows the spray to be thrown to the tops of very high trees, with the assistance of only a short pole. A pole is an unwieldy instrument at best, and if proper nozzles are used it may be dispensed with in the majority of cases. The work can also be more thoroughly accomplished from above, as the parts of the tree are more easily reached, and the liquid does not fall back upon the men, as so frequently occurs when the spray is thrown from lower elevations. The man who drives is at a disadvantage, but if he is properly protected by rubber clothing, the position is rendered much less uncomfortable.

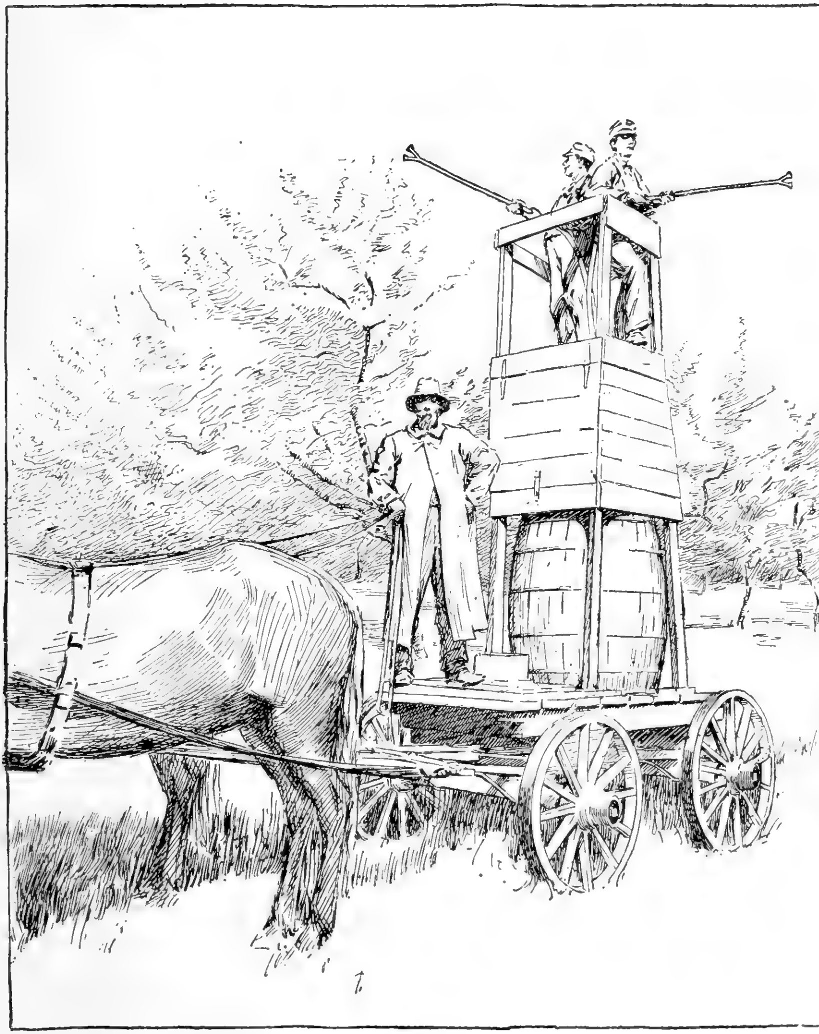

FIG. 32. — An excellent spraying outfit for tall orchard trees.

Many orchards are so thickly planted that an apparatus like the above can be driven through only with great difficulty. In such cases the branches should be cut so that the orchard may be penetrated in at least one direction. With good apparatus the trees may then be thoroughly treated.

Later improvements in spraying machinery are the power sprayers, of which Fig. 34 represents one of the best. The

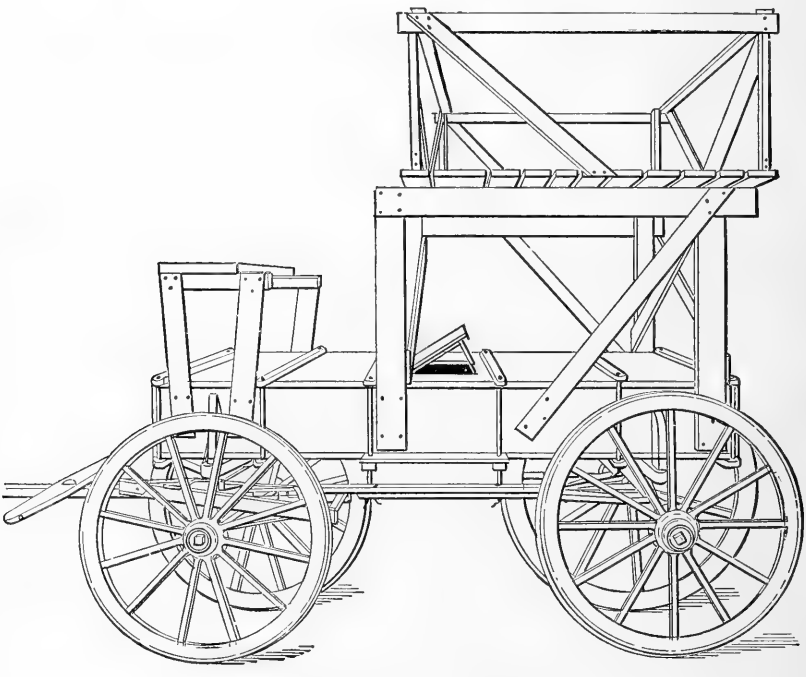

Fig. 33. — A good rig for spraying orchards.

illustration is so detailed that little need be said regarding the construction of the machine. The pumps are worked by means of a bar which is fastened to a crank. The crank is attached to wheels that connect with the large wheels by means of sprocket chains, and motion is obtained in this manner. Fig. 35 represents another type of machine of this class. The liquid is applied by means of a rotary pump. Power machines are excellent for spraying all low-growing plants or small trees, but the best work cannot be done in a bearing apple orchard, and the hand pumps must be depended upon for the most efficient service. But for potatoes, nursery stock, vineyards, orchards of dwarf trees, these machines will amply repay their cost, and with proper treatment will lessen the unpleasant features of spraying to a very great degree. Wherever sufficient work is at hand to warrant their purchase, they will be found indispensable when once used.

Fig. 34. — Power sprayer. *A*, lever attached to the gearing; *D*, bar moved by means of a crank attached to the wheels; *BB*, pumps which force the liquid into the discharge hose; *C*, tank.

As has already been stated on page 194, several machines have been built for the sole purpose of spraying potatoes. As a rule, those in which the liquid is applied with the aid of a force pump are to be preferred, although excellent machines may be found among those in which the liquid flows by the force of gravity. Some method of converting the fluid into a spray should, however, be present. Fig. 36 represents a machine in which this is done by means of a revolving brush, *BB*. Air blasts are used by some for the same purpose with marked success.

The best spray nozzle, so far as efficiency, simplicity, and cheapness are concerned, is the end of a hose and a man's thumb. Unfortunately the thumb gets sore and tired, and operations must be suspended to wait for repairs. It is the nearest approach to the ideal nozzle yet devised, if it were only more practicable. It will do all that a good nozzle should do. It throws a fine mist-like spray, one that will "float in the air

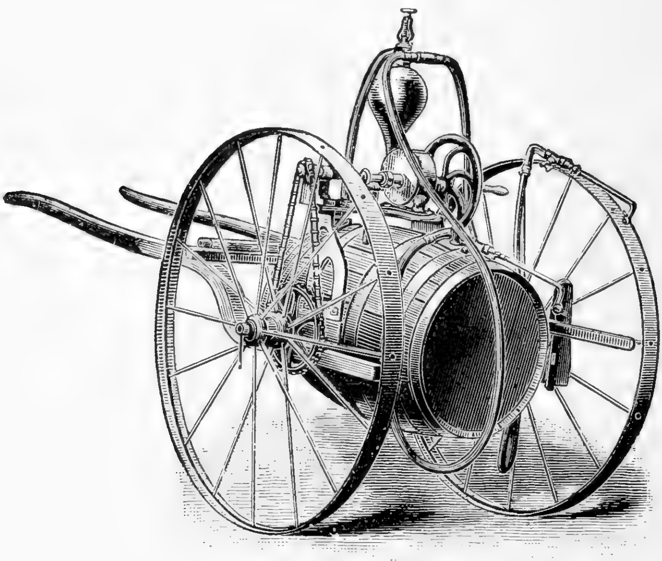

FIG. 35. — Power sprayer, with rotary pump.

like a fog," or the particles of water may instantly be made coarser, and the water thus carried to a greater distance; or still coarser and the water leave the hose in the form of a solid stream. These changes all take place instantly (after a little practice), and it makes no difference whether the parts to be sprayed are a few inches or many feet away. This nozzle never clogs, but is cleaned automatically, and as quickly as the character of the spray is varied. In fact it possesses all the desirable qualities of a spray nozzle, except durability, and for this we must turn to the metals for aid.

All operators do not desire the same kind of spray even for the same kind of work. It is commonly said that the best spray is one which most nearly resembles a fog. This is true so far as the spray is concerned, but the trouble comes in applying it. A fine spray cannot be applied so advantageously as a coarser one, nor can it be applied so rapidly for the reason that the finer the spray the less liquid is thrown, and the smaller the area treated. Whenever the wind blows, a fog-like spray will go wherever the wind carries it, and not where the operator directs

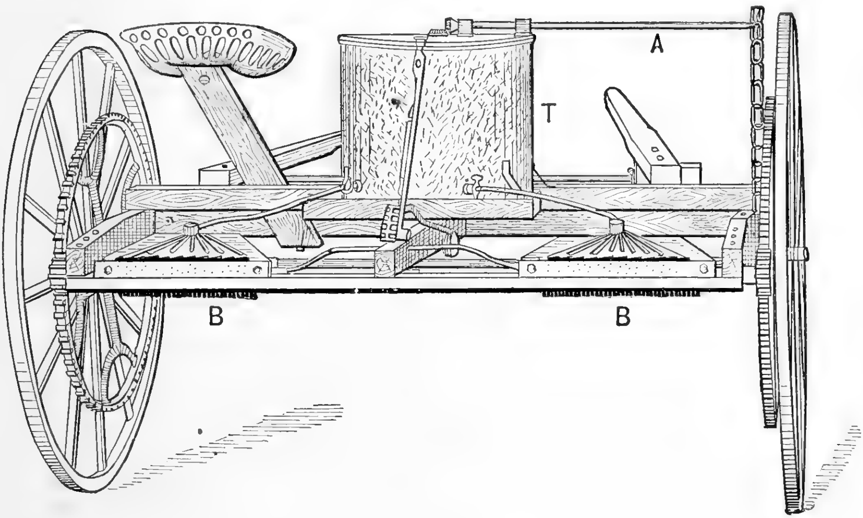

Fig. 36. — Potato sprayer; the liquid flows by the force of gravity, and is spread by means of revolving brushes, *BB*; *A*, rod attached to agitator; *T*, tank.

it. Sometimes this will be an advantage. It is especially so when the wind is blowing in the right direction. Yet when the other side of the tree is being treated the wind will come from the wrong direction, and much of the material is blown where it is not wanted. In addition to this, the work is more slowly performed, and whether it is more thoroughly done than when a coarser spray is used is still open to doubt. After having tried both kinds of sprays, it appears to the writer that if the parts to be treated are close by, a fine spray is to be preferred, as then there is less waste and an even application may be made. If the parts to be treated are more removed, being situated from ten to twenty-five feet away, a coarser spray is wanted; — the more distant the object, the coarser the spray. The work can thus be done much more rapidly, just as effectively (with the exception of some waste), and much more satisfactorily, than by the use of a fine spray. In case a fine spray is used, it is necessary to have a pole to carry the nozzle to the different parts of the tree, and this is as tedious as it is unpleasant. When a coarser spray is made, there is generally formed enough of the finer spray to float in the air and protect parts which are not directly reached by the operator.

The finest sprays are produced by the eddy-chamber nozzles, and by those in which two streams of water strike each other at an angle. With such nozzles, the spray can be made as fine as desired, the size of the outlet orifice being the main controlling factor. For long-distance work, when the liquid is to be carried ten feet or more, the best spray is formed when the fluid is forced through two flat, parallel, metal surfaces. The greater the pressure, the greater will be the amount of fine spray and the farther will it be thrown. Although the ideal nozzle has not yet been made in metal, some of the forms now sold are approaching perfection.

All good spray machinery is expensive, and only careless operators will neglect the ordinary methods of preserving it as long as possible. When the pump has been used in applying any of the preparations mentioned in Chapter IV., with the exception of clear water, it should be cleaned. No insecticide nor fungicide should be allowed to stand within the pump, but clear water should be pumped through it before it is put away. It is well to oil all the working parts occasionally, as a little oil at times may prevent the metal from being cut, and the pump will be thus preserved much longer than otherwise. Nozzles are also benefited by the same treatment. Oil can scarcely be used too freely on the inside of such apparatus, and an occasional coat of paint on the outside will assist materially in protecting the metal. The careless man pays dearly for his neglect.

CHAPTER VI.

THE ACTION OF INSECTICIDES AND FUNGICIDES.

SPRAYING has become a common practice with comparatively few cultivators. The majority still waver when it comes to doing the work, hoping that they may gather good crops even if the operation is not performed. Very few have doubts of its value, but for one reason or another, at the last moment nothing is done. Undoubtedly much of this hesitation is caused by the uncertainty whether as good results may be obtained by the novice as are obtained by those who have had experience in the work. I know of a farmer who owns a young bearing orchard, which almost every spring has promised an abundant harvest; but when fall came and the time for harvesting the crop drew near, the apples which still hung on the trees were so full of worms and so distorted by fungi that the profits derived from their sale were indeed small. The man was so impressed by the good results of spraying as practiced by one of his neighbors who grows the same varieties of apples, that in 1894 he finally made preparation to spray in earnest. He was advised as to the best methods of doing the work, and the proper materials were applied, yet at first he could not overcome the fear that his trees would not be just as thoroughly protected as others had been, and that in spite of the application the apples would turn out as they did in the past. But the fruit was fair, and his orchard will no doubt be regularly treated in the future.

Such doubts are needless. Protection by spraying will be just as efficient for one man as for another, and provided the enemies of the plants are equally serious, the results in one case will be just as marked as they are in the other, if a few points are observed. Without wishing to encourage carelessness in this matter, it may be said that few of the formulas now in use will fail to be effective even if they are slightly modified. The history of the several formulas need only be considered to show that this is the case. Spraying is not an exact science, and most of the methods allow of considerable modification. Spray, by all means, if the crops are in need of it, even though the advice of the experienced is not always followed to the letter in regard to the best method of making the application or of preparing the materials. Follow such advice as closely as possible, but no serious consequences will result if slight deviations occur. Three points, however, cannot be too strongly emphasized:

First, be on time. Make an application when it will do the most good, and never allow that time to pass if it can possibly be avoided. Every delay is of advantage to the parasite, and it will be used so well that in most cases the injury cannot be repaired. The destruction of one insect may mean the destruction of hundreds, and one application made at the right time may mean, and generally does mean, the protection of a plant against millions of spores of fungi which are endeavoring to gain a foothold. Be ready for action at a moment's notice, and when the moment comes, spray!

Second, be thorough. When spraying a plant, spray it well. With a little care, a complete success may be obtained instead of only a partial one. When the work is finished, the grower should have the feeling that it is well done, and then no fear as to the result need be entertained. Spraying is not always pleasant work, and the temptation to slight it is often strong; but the operator will be rewarded just to the extent to which he has been painstaking, and to that extent only.

Third, apply sprays intelligently. This is really the most important factor in the work, although good crops can be obtained without it, provided directions are followed. The first two points cannot be neglected without injury to the crops, but this one can be. The crop is in need of the applications only, but the grower should know the reasons for them, and should be in a position to modify his treatments so as to make them conform with the character of the insect or the disease which is being treated, and with the season. Every year and every day such knowledge will be of value. So many things are still unknown, and so many points still in dispute, that personal knowledge and judgment about individual cases are not only desirable, but are very essential. Directions covering the majority of cases can be given, but now and then one will come up which seems to differ from all others, and it is then that this knowledge will prove most valuable. A few of the general principles upon which this work rests are mentioned below.

The principal organisms against which the cultivator has to contend are insects and fungi. They are widely different in their organization, and entirely different substances are required for their destruction. Any substance which is used to destroy or repel insects may be termed an insecticide; and any substance which destroys fungi, or which prevents their injurious growth on vegetation, is a fungicide. No substance, so far as known, will answer both purposes equally well.

I. Upon Insects.

Practically all the applications which are made to destroy insects are designed to act in one of two ways. The substance may be destined to enter the digestive system of the insect and thus cause death, just as many poisons cause death when taken into the stomachs of higher animals. This method is by far the cheapest, and when possible it is advisable to make use of it.

The second method does not consist in putting poison on the food of the insect, but the material is put directly upon the insect itself. It then causes death either by stopping up the breathing pores, or it penetrates the outer coverings and so enters the body directly. This method cannot be used with success against all insects, as some have very tough and dense coverings which are not readily penetrated by any material that we can use for the purpose. Beetles, for example, can scarcely be destroyed in this manner. But all soft-bodied insects, such as aphides, worms, and caterpillars, yield readily to the treatment if sufficient material comes in contact with their bodies.

This method of killing insects by means of substances which cause death merely by penetrating the creature's body, is rather expensive, and it is resorted to only when the pest cannot be treated by poisoning its food. It thus comes that most worms and caterpillars are destroyed by means of poisons which are eaten, though they yield to the other treatment equally well.

The food of many insects, however, cannot be poisoned, since they feed upon the juices of plants and do not eat the external coverings. It is fortunate that most of these insects have soft bodies, so that they yield readily to treatment if the poison comes in contact with them. Their mouth parts are formed for penetrating the external coverings of plants to a depth sufficient to reach the sap; just as the mosquitoes' bills are in the habit of penetrating human kind. All aphides belong to this class, as well as the true bugs, these having mouth parts which are adapted to suck, but not to chew. The utter uselessness of covering a plant with poisons to protect it from these pests will readily be seen. No matter how thick the poison may be, the insect's beak will penetrate this poisonous layer, and it will take no food until the beak has passed the limit of the poison and is deeply buried in the tissues of the plant.

From the above it will be seen that:

(*a*) To destroy chewing insects, such as the potato beetle, poisons must be evenly distributed over those parts *upon which the insects feed*, and this may in some cases be done even before the insect is present, or is visible. Only those poisons which cause death after being eaten should be used.

(*b*) To destroy sucking insects, such as plant lice, the materials must be distributed *upon the insects* as evenly as possible, and it is useless to make any application before the insect has appeared. Only those poisons which kill by coming in contact with the insect's body should be used.

First determine what kind of a pest it is that needs treatment, then select the proper material from among those mentioned in Chapter IV.[1]

II. Upon Fungi.

Among fungi we find many serious enemies. It is difficult to tell just what a fungus is, but some of the principal characteristics may be mentioned. A fungus is a plant; but unlike

[1] The complete transformations which many insects undergo before maturing are as follows: (*a*) the egg; (*b*) the larva, grub, or caterpillar; (*c*) the pupa or chrysalis; (*d*) the imago or matured adult insect.

flowering plants, it possesses no chlorophyll. Chlorophyll is the green-colored protoplasm found in flowering plants, and it is the only substance we know through which plants change crude food to nutritive material. We must conclude, therefore, that fungi do not prepare their own food, but feed upon organic matter which is already adapted to their wants. They possess no leaves, flowers, nor seeds. That part of any fungus which is of most interest to the horticulturist is composed of long, fine threads, either growing separately or in bundles; these threads are known as hyphæ, and collectively they form the mycelium or vegetative portion of the fungus. The mycelium corresponds to the roots and stems of flowering plants.

Spores, which are organs performing the same office as the seeds of flowering plants, are produced by this mycelium either directly, or upon branches (sometimes called sporophores) which are thrown out. These sporophores cause the white downy appearance seen upon grape leaves affected with the downy mildew. A spore, strictly speaking, is not a seed, for a seed contains a young plant, while a spore does not, being usually composed of only one cell. If a spore finds the proper conditions of heat and moisture it will germinate and send out a fine filament, which, if nourished, grows and branches, and eventually a plant like the original will be produced.

Most fungi in the North produce two kinds of spores, known as the summer and the winter spores. The summer spores are usually borne upon the exterior of the host-plant, or the plant on which the fungus grows. These spores ripen quickly and propagate the fungus rapidly. But if they do not germinate soon after ripening they lose their vitality.

The winter spores are usually produced within the tissues of the host-plant, commonly in the leaves and fruit. They are the spores which live through the winter; but in the spring, under favorable circumstances, they germinate, and thus the fungus is again developed.

Fungi may be divided into two general classes: those growing upon dead and decaying matter, or saprophytes; those feeding upon living tissue, or parasites. By far the larger portion possessing interest to the horticulturist belong to the latter class, for in this are included the fungi which do so much injury to cultivated plants.

Yet all parasitic fungi do not attack the host-plant in the same manner. Some immediately penetrate into the interior tissues, and there they flourish, being well protected from outer influences by the exterior covering of the plant. The fungi causing all the more serious diseases develop in this manner, and in fact the vast majority of plant diseases are caused by such organisms. There are others, however, in which the body of the fungus is almost entirely upon the surface of the host-plant, only a comparatively small number of threads penetrating the tissues in order to obtain nourishment. These parasites can be rubbed off, and unless the attack has been very severe, the green, healthy tissue will be seen underneath. This class may for convenience be termed "surface fungi," to distinguish them from those which grow within the host-plant; it is represented by the common powdery mildew of the grape, one mildew of the gooseberry, one of the strawberry, and a few others.

The life histories of the various fungi must form the basis for any methods of treatment which may be adopted. During certain stages of their existence, parasitic fungi may be checked quite easily, and at such times the remedies should be applied.

It is evident that when a fungus has once become established inside the host-plant, it cannot be reached without destroying the tissues of the host in the affected places, which is by no means desirable. The fungus must be destroyed before it enters the host; in other words, the spores must be killed as soon as they germinate, or better, they must not be allowed to germinate. All applications must be *preventive*, not curative, since a cure is practically impossible when the fungus is once established, unless it grows upon the surface of the host.

The line of treatment indicated is this: to cover the stems and foliage of the cultivated plant with some substance that will destroy the spores which may be present, as soon as they germinate, or with one that will have the power of preventing this germination. If that is done, the plant will remain healthy, so far as fungi are concerned; otherwise it will not, unless, indeed, no fungus attacks it. Several substances which destroy these spores, as well as the surface fungi, have already been found. They are easily applied, safe, and effective, and any grower who suffers his fruit to be ruined by these parasites is, as a rule, deserving of his loss, for means of destroying the pests are at his command. It is largely the grower's fault if his apples are scabby, if his grapes are mildewed, and if his potatoes rot in the field. Spraying is no longer an experiment, it is a necessity; and those who recognize this fact are the ones who are reaping the rewards.

III. Upon the Host-Plant.

Insecticides and fungicides are applied solely for their action upon the organisms it is desired to destroy, since in other respects most of the preparations possess no value. If properly applied they are harmless to the plants, and should not in any way interfere with their proper growth nor with the sale of the products. When some of the mineral preparations, however, are too freely used late in the season, the appearance of the crop may reduce to a considerable extent its market value, although the product may be still as wholesome as if untreated.

Fears have also been entertained that some substances are dangerous even when not visible, on account of their effect upon the crop, which was supposed to be poisoned. This subject was well agitated when Paris green and London purple began to be commonly used in the destruction of the potato beetle. Many analyses were made, but no arsenic could be found, either in the tubers or in the parts above ground, and soon all fear of arsenical poisoning disappeared, and potatoes treated with the arsenites were used without question. Another equally groundless objection was raised in England regarding American apples which had been sprayed for the canker-worm or codlin-moth. It was said that the bloom found on American apples consisted largely of the arsenic which had been applied to the trees to destroy insects, and that such apples were unfit for use. These reports have led to many chemical examinations of sprayed fruit, and only in rare cases has even a trace of arsenic been found. It is only when very late applications are made, such as are utterly useless, that any of the poison is found upon the fruit, and then the quantities are so minute that they could in no way cause injury to the consumer. But even though all the poison sprayed upon the apples in making necessary treatments should remain there undisturbed, a person would be obliged to eat at one meal eight or ten barrels of the fruit in order to consume enough arsenic to cause any injury. As a matter of fact, however, the poison all disappears during the growth of the apples, and these are as wholesome as if no treatment had been made, or even more so.

Similar objections have also been raised in the case of grapes sprayed with the Bordeaux mixture. In the fall of 1891, the board of health of New York city seized considerable quantities of grapes which showed the presence of Bordeaux mixture, and threw them into the river. The following report of the board appeared after an investigation had been made:

"1. A copper salt is found only upon a very small part of the grapes offered for sale, and the grapes which are to be avoided are easily recognized by the greenish-colored substance upon the berries and stems.

"2. Whenever the substance is apparent upon the berries or stems, the grapes should be washed before they are used as food or in the manufacture of wine.

"3. The board urges all dealers and consignors in this city to advise shippers and consignors of grapes to send no more grapes to the market upon which this substance is apparent. The board further states that it does not object to the use of Bordeaux mixture as recommended by the proper authorities; but such mixture, or any mixture containing poisonous substances, should not be sprayed or otherwise placed upon the grapes immediately before or after they have matured, and should not appear upon them when sent to market or offered for sale."

This subject is equally interesting from a hygienic standpoint, for whether grapes are sold in the open market or not, their effect upon the consumer should be understood. The following paragraph is a clear and concise statement of the facts bearing upon the question:[1] "Accepting, then, 0.5 gram as the maximum amount of copper in any of the forms discussed that may with safety be daily absorbed, let us see how these figures compare with the quantity of this metal found in connection with properly sprayed fruits, as well as some other foods and drinks. Analyses to determine the amount of copper in sprayed grapes have been made in Germany, France, America, and other countries. The results of all these

[1] *U. S. Dept. Agric. Farmers' Bulletin* No. 7, 19.

show that grapes sprayed intelligently rarely contain more than 5 milligrams (0.005 gram) of copper per kilogram, the average being from 2½ to 3 milligrams per kilogram. In other words, 1,000,000 pounds of grapes sprayed in the usual way with the Bordeaux mixture would contain from 2½ to 5 pounds of copper. To reduce the figures still further, each 1000 pounds of fruit would contain 17.5 to 35 grains of copper. On this basis an adult may eat from 300 to 500 pounds of sprayed grapes per day without fear of ill effects from the copper. This shows how ridiculously absurd are the statements that fruits properly sprayed with the Bordeaux mixture or any other copper compound are poisonous."

The effect of applying soluble arsenic upon foliage has been considered on page 117, but there still remains a point in regard to the injury done by arsenical poisons to animals consuming the grass beneath. Professor Cook has carefully experimented in this direction, and his results are so conclusive that they are here given in full: "In tree No. 1 a thick paper was placed under one-half of a rather small apple tree. The space covered was six by twelve feet, or seventy-two square feet. The paper was left till all dripping ceased. As the day was quite windy, the dripping was rather excessive. In this case every particle of the poison that fell from the tree was caught on the paper. Dr. R. C. Kedzie analyzed the poison and found four-tenths (.4) of a grain [of arsenic]. Tree No. 2 was a large tree with very thick foliage. Underneath this tree was a thick carpet of clover, blue grass, and timothy just in bloom. The space covered by the tree was fully sixteen feet square, or equal to two hundred and fifty-six square feet. As soon as all dripping had ceased, the grass under the tree was all cut very gently and very close to the ground. This was taken to the chemical laboratory and analyzed by Dr. R. C. Kedzie. There were found 2.2 grains of arsenic. Now, as our authorities say that one grain is a poisonous dose for a dog, two for a man, ten for a cow, and twenty for a horse, there would seem to be small danger from pasturing our orchards during and immediately after spraying, especially as no animal would eat the sprayed grass exclusively. To test this fully, I sprayed a large tree over some bright, tender grass and clover. I then cut the clover carefully, close to the ground, and fed it all to my horse.

It was all eaten up in an hour or two, and the horse showed no signs of injury. This mixture, remember, was of double the proper strength, was applied very thoroughly, and all the grass fed to and eaten by the horse. This experiment was repeated with the same result. I next secured three sheep. These were kept till hungry, then put into a pen about a tree under which was rich, juicy, June grass and clover. The sheep soon ate the grass, yet showed no signs of any injury. This experiment was repeated twice with the same result. It seems to me that these experiments are crucial, and settle the matter fully. The analyses show that there is no danger, the experiments confirm the conclusion.

"Thus we have it demonstrated that the arsenites are effective against the codlin-moth, that in their use there is no danger of poisoning the fruit, and when used properly no danger to the foliage nor to stock that may be pastured in the orchard."[1]

The danger following the use of copper compounds on foliage is naturally even less than when a form of arsenic is applied. One case is on record in which poisoning has followed when grape foliage was eaten by sheep, this having been sprayed with the Bordeaux mixture.[2] Since sprayed foliage is probably never fed regularly to stock, there need be no cause of apprehension in this respect.

The extent to which copper is absorbed by foliage still remains an open question. The researches of Millardet and Gayon show that a certain amount of copper is absorbed and retained by the cuticle of the leaf.[3] The investigations of Rumm, however, show that such is not the case.[4] If the copper is actually absorbed the quantities are exceedingly minute. That it possesses a stimulating action upon foliage is also doubtful. Lime may have such an effect, since several cases are on record in which the application of Bordeaux mixture produced a greener appearance of the healthy foliage.

[1] A. J. Cook, *Ann. Rept. Mich. Bd. Agric.* 1889, 320.

[2] *Wiener Landw. Ztg.* 1892, 494.

[3] *Jour. d'Ag. Prat.* 1887, Jan. 27, 123, and Feb. 3, 156.

[4] "Ueber die Wirkung der Kupferpräparate bei Bekämpfung der sogenannten Blattfallkrankheit der Weinrebe." *Ber. d. Deut. Bot. Ges.* Bd. 11, Heft 2, 1893, 79–83; *Ibid.* Heft 7, 445–452. See, also, adverse critical review by Zimmermann in *Bot. Centralbl.* 1893, No. 23, 308; Nos. 29, 30, 119, 120; and Aderhold in *Bot. Zeit.* No. 11, 1893, 162. Cited by Fairchild in Bull. 6, *Sec. Veg. Path. U. S. Dept. Agric.* 27.

The benefits derived have not yet been fully determined. It has been estimated that the germination of spores of certain fungi may be prevented by solutions of lime containing 1 part to 10,000 of the liquid; or iron sulphate, 1 part to 100,000 of water; or copper sulphate, 1 part to 10,000,000 of water.[1] This readily explains the energetic action of the copper compounds, and why such small amounts may be applied to advantage.

For further information concerning the action of copper compounds when applied to plants, consult R. Otto, "Untersuchungen über das Verhalten der Pflanzenwurzeln gegen Kupfersalzlösungen" (*Zeitschrift für Pflanzenkrankheiten*, Bd. iii. 1893, Heft 6). The plants studied in these investigations were *Phaseolus vulgaris, Zea Mays, Pisum sativum.* It was found that "copper exercises a poisonous influence upon the plants, it interferes with the development of the roots and lessens the activity of the functions of the plant, or kills the latter outright, when the roots of the plants are growing in more or less concentrated solutions of copper sulphate." It was also found that practically no copper was absorbed by the roots, and the parts above ground were entirely free from the metal. See review in *Botanisches Centralblatt*, 1893, Vol. 55, 340–342.

See also, A. Tschirch, "Das Kupfer vom Standpunkte der gerichtlichen Chemie, Toxicologie, und Hygiene. Mit besonderer Berücksichtigung der Reverdissage der Conserven und der Kupferung des Weins und der Kartoffeln." Stuttgart (F. Enke), 1893. The entire question of the use of copper compounds upon cultivated plants is thoroughly discussed by the author. In general his conclusion is, "to remove all copper from articles of diet means forbidding the plant to absorb it from the soil, and also considering as injurious to health the use of bread and chocolate." See *Botanisches Centralblatt*, 1893, Vol. 55, 170–175, for a detailed review of the work.

IV. Upon the Soil.

Doubts have been very frequently expressed as to the final outcome of the continual addition of insecticides and fungicides to the soil, it being supposed that the roots of the plants as well as the soil itself would eventually suffer. Scientific inves-

[1] Millardet et Gayon, *Jour. d'Ag. Prat.* 1885, Nov. 12, 707.

tigation has shown these fears to be groundless, as it has so many other doubts formerly entertained. The following extracts should prove sufficiently convincing even to the most skeptical: [1]

"Former analyses of unsprayed top soils of the station farm have shown no trace of copper in their composition. Recent analyses of top soils taken from an old potato field which has received many applications of Paris green (an aceto-arsenite of copper), show from three ten-thousandths to three and one-third ten-thousandths of one per cent of metallic copper. Analyses of top soils from a portion of the same field to which Bordeaux mixture was applied last season for the potato blight show four ten-thousandths of one per cent of metallic copper, equal to about sixteen ten-thousandths of one per cent in the form of copper sulphate. English writers frequently speak of using from 22 to 32 pounds of copper sulphate per acre in one season's application of Bordeaux mixture for potato blight. To impregnate such soil as that which was used in the above analysis to the depth of one foot with one per cent of copper sulphate would require about 32,625 pounds of the sulphate, which, if applied at the rate of 30 pounds a year, would require in its application nearly 1100 years, provided that none of it escaped in drainage."

Some experiments conducted by Bailey in 1895 indicate that practically no danger is to be feared from very heavy applications of arsenites to soil. His conclusion is as follows: "The arsenic which falls upon the soil seems to become or to remain in an insoluble condition, and passes downward, if at all, to a very little distance, and then only by the mechanical action of water in carrying it through spaces in the soil." [2]

The results obtained by a careful European investigation [3] are also inserted here, that the subject may be viewed from different standpoints. The only conclusion to be drawn from these extracts is that proper applications of insecticides and fungicides will apparently never cause any appreciable injury either to the roots of plants or to the soil:

"1. Soluble copper salts are injurious to plants; the injurious

[1] Beach, *Country Gentleman*, 1892, 68.

[2] *Cornell Agric. Exp. Sta.* 1895, Bull. 101, 502.

[3] Haselhoff, "Injurious action of solutions of the sulphate and the nitrate of copper upon soil and plants," *Landwirthschaftliche Jahrbücher*, 1892, 272–276.

action begins when 10 milligrams of copper oxide are present in 1 liter of water, but when only 5 milligrams per liter are present no marked effects can be seen.

"2. If solutions of copper sulphate and of copper nitrate are applied to soils, the plant food present, especially lime and potash, are dissolved and washed away; the copper oxide is absorbed by the soil. As a result of these two processes, the fertility of the soil is more or less decreased.

"3. Barley and oats suffer more than grass from solutions of copper sulphate and copper nitrate; copper sulphate is more injurious to corn than to beans.

"4. The injurious action of copper sulphate and copper nitrate is counteracted if an excess of the carbonate of lime is present in the soil. But as soon as this excess has been acted upon, the injurious processes take place in the same manner as in soils in which no lime is found."

V. Upon the Value of the Crop.

It is scarcely necessary to enter into details regarding the benefits derived from proper applications of insecticides and fungicides. Experiment stations and private growers have many times demonstrated that the market value of the product is increased to such an extent that the cost of materials and of labor is returned many-fold to the grower, whenever proper applications have been made. Indeed, the conditions now are such that it is as necessary to spray certain crops as it is to cultivate them. Doubts are no longer entertained concerning the treatment of potatoes with arsenites; the operation is generally performed as one of the regular duties in obtaining a crop. The majority of the best apple growers have come to feel the same concerning apples. They spray with insecticides for the codlin-moth and other insects, and with the Bordeaux mixture for fungous diseases. The operations have passed the stage of experiment, and are now considered in the light of a necessity.

The grape is another striking illustration of the same truth. In many sections, especially in the southern states, it is practically impossible to obtain a sound crop on account of the abundance of fungous diseases. There it is not only a question of profits, for it is difficult to obtain any crop whatever. Peaches, plums, cherries, quinces, all the small fruits, and many vegetables, will generally repay proper treatment.

A secondary benefit is also derived in those products which are stored. Unsound fruit will not keep, for decay generally begins in a part which has already been injured. It has been said that sprayed fruit will keep longer than that which has not been treated, even though both are free from blemishes. The question is open to doubt, however, since no decisive experiments have yet been made. But the more nearly perfect the stored crop is when put in, the longer it will keep and the greater value it will possess, other conditions being equal.

It must not be inferred from the preceding remarks that all crops should be sprayed. The question "Does spraying pay?" can best be answered by the grower, and he must be his own judge regarding the advisability of treatments. Let the question be considered from the proper standpoint and the matter will be simplified. The final test in regard to the making of treatments may be stated in this form: does the difference between the market value of sound fruit, and the value of the product obtained when no treatments are made, warrant the expense of purchasing materials and the labor of making the applications? The grower knows the price received for his crop; he also knows the price paid for perfect or fancy crops; the difference between the two, so far as injuries from insects and fungi are concerned, shows to what extent the crop may be benefited by treatments. It is then a simple matter to determine if the applications will pay. It will be noted that little question regarding the efficiency of the applications is here entertained. It is taken for granted, and with good reason, that proper treatment *must* produce the desired result. The arsenites will destroy all chewing insects, with scarcely an exception, and the copper compounds will prevent injury from most fungi; these are established facts, but it remains for the grower to apply them. There probably exists an economical remedy for every disease of plants; the vast majority of these diseases are now under control, and although a few obstinate cases still exist, the future is encouraging when we consider the progress made in the past. Intelligence, knowledge, and good judgment, when assisted by insecticides and fungicides, will prove more than a match for these organisms which prey upon the products of man's labors.

PART II.

SPECIFIC DIRECTIONS FOR SPRAYING CULTIVATED PLANTS.

ALMOND.

FUNGOUS DISEASES.

Leaf Blight; Almond Disease (*Cercospora circumcissa*, Sacc.). — *Description.* This disease is especially serious in California, the trees often being practically defoliated during the summer. The fungus attacks the leaves and the stems. Upon the former it produces small circular spots, the diseased areas being more or less restricted by the small veins of the leaves. The spots are about an eighth of an inch in diameter, and upon the death of the tissue the discolored areas fall from the leaves, causing an appearance similar to that of the shot-hole fungus upon plum foliage. Diseased stems also show distinct spots of circular or oval outline. The dead tissue soon falls out, producing a pitted appearance on the surface of the affected twigs.

Treatment. N. B. Pierce, who has thoroughly studied this disease, recommends spraying the trees with the ammoniacal carbonate of copper, making the first application before the trees bloom, the second when the trees are in full leaf, and the third four weeks later.[1]

[1] Galloway, *Ann. Rep. U. S. Com. of Agric.* 1892, 232.

APPLE.

Fungous Diseases.

Bitter Rot; Ripe Rot (*Glœosporium fructigenum*, Berk. *G. versicolor ?*). — *Description.* Apples are often seriously injured, especially in some of the southern states, by a rot which causes

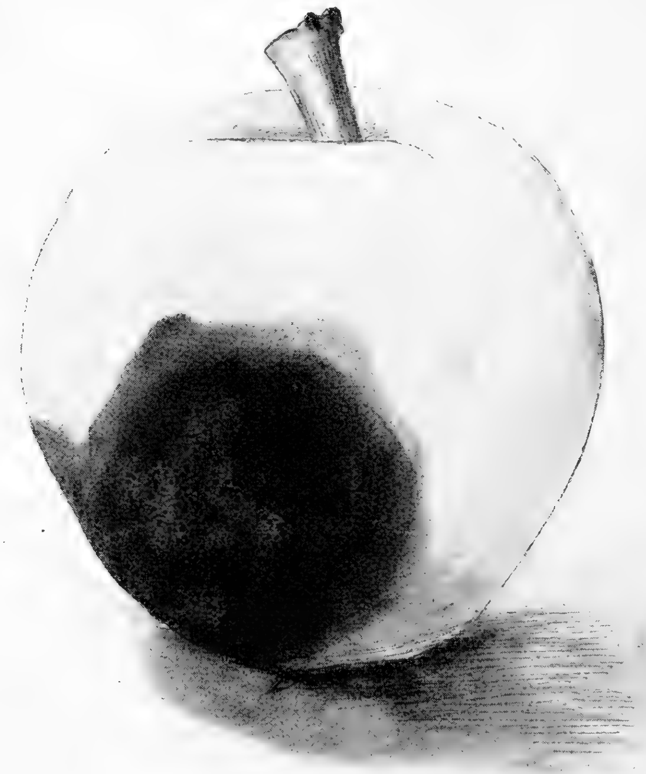

Fig. 37. — The bitter-rot of apples.

a softening of the tissues of the fruit, and changes them from their normal color to a brown (Fig. 37). This rot "takes fruit at any stage of its growth from the time it is about three-quarters of an inch in diameter until it is ripe."[1] It is by

[1] Garman, *Ky. Agric. Exp. Sta.* 1893, Bull. 44, 4.

no means uncommon in the northern states, and appears to be particularly destructive to the earlier varieties. Early Harvest, Sweet Bough, and others are very subject to the disease. Any part of the apple may be first attacked, and when the fungus has once gained a foothold it spreads very rapidly. The older portion, or the part first attacked, soon bears small black pimples, and it is said that the tissue beneath them has an exceedingly bitter taste, which has given the disease its name.

Treatment. Garman[1] recommends the use of Bordeaux mixture for preventing the development of the disease. He obtained the greatest benefit from applications made as follows: First, before the leaves expanded; second, soon after the apples had set; third, about fourteen days later; fourth, four weeks after the preceding. In this manner "thirty-one and one-sixth per cent of the whole number of apples borne by the sprayed tree during the season were saved from the rot."

The disease has also been successfully treated by the use of the sulphide of potassium. The ammoniacal carbonate of copper gave similar results. These last experiments are interesting from the fact that the first application was not made till about the middle of August. Earlier applications are, however, advisable.

Black Rot (*Sphæropsis malorum*, Berk.). — *Description.* The external characters of this disease are practically identical with those of the Bitter Rot. The remedies to be used are also the same.

Brown Rot. See under CHERRY.

Powdery Mildew (*Podosphæra Oxycanthæ*, DeBary). — *Description.* This fungus attacks the foliage of young apple seedlings very soon after the unfolding of the leaves, and continues its growth throughout the summer, very much weakening the plants, and making them unfit for budding purposes. The disease is especially serious in the southern states. The affected leaves have a grayish appearance which is caused by a powdery substance. This gray powder consists of the parts of the fungus which project beyond the leaf tissue. The leaf soon dries and is rendered worthless.

Treatment. The trouble has been successfully controlled by

[1] Garman, *Ky. Agric. Exp. Sta.* 1893, Bull. 44, 5.

the Section of Vegetable Pathology at Washington, and the following are the conclusions reached:[1]

"1. The disease can be effectually prevented by the application of the ammoniacal solution of carbonate of copper.

"2. In the nursery the total cost of the treatment need not exceed twelve cents per 1000 trees.

"3. The first application should be made when the leaves are about one-third grown, and should be followed by at least five others at intervals of ten or twelve days."

Rust (*Rœstelia pirata*, Thax., and *Gymnosporangium macropus*, Link.). — *Description.* The fungus which causes the rust of apples is one of the most peculiar in which the horticulturist is interested. Unlike many fungi, this one lives upon two host-plants during its course of development. These host-plants are the apple, and the cedar or juniper. There are probably several species of rusts which attack cultivated apples,[2] but the histories of all are essentially the same. The most common one is now supposed to be *Rœstalia pirata*, Thax.[3]

The effects of this fungus upon the apple are first noticeable during the latter part of May, or in early June. The leaves are then dotted with bright yellow spots, the so-called rust; the fruit is also attacked about the same time. Such fruit becomes worthless, as the growth is increased at the diseased point, and the swollen part produces spores, which ruins the apples. Spores are also produced upon the under side of the leaves. They appear and ripen during midsummer. They will not germinate and grow upon either the leaves or fruit of the apple, but they will develop the fungus upon the cedar. There the mycelium enters the tissues, and as growth advances, enlargements appear upon the branches of the tree. Such swellings, or "cedar-apples," as they are called, are from half an inch to almost two inches in diameter; they become full grown early in spring. During April and May, horn-shaped masses an inch or more in length are produced by the cedar-apple. They are of a bright yellow color and can readily be seen among the green branches of the cedars. Upon these soft, yellow bodies the spores are borne; these spores will not grow upon cedars, but only upon the leaves

[1] *Ann. Rep. U. S. Com. Agric.* 1889, 415.
[2] Byron D. Halsted, *Ann. Rep. U. S. Com. Agric.* 1888, 376.
[3] Scribner, "Fungous Diseases of the Grape and other Plants," 1890, 84.

or fruit of the apple. They ripen in spring, and consequently it is at this season of the year that the apple trees must be protected. Unfortunately, when a tree has once become infected, it seems that the mycelium of the rust may remain in the buds and branches for years, and in the spring when the young leaves have formed, the characteristic yellow spots may again appear, although no new infection has taken place. The disease is sometimes so serious that the tree loses all its foliage, and this alone would ruin the crop, although the apples themselves may not be attacked.

Treatment. It is difficult to combat the apple rust successfully. Since apple trees are attacked by spores which are produced upon cedar trees, it naturally follows that by removing all cedars we also remove the source of the disease. Cutting and burning the cedar-apples before the appearance of the yellow horns will answer the same purpose. In many cases, however, such a course is impracticable on account of the abundance of the trees. Scribner advises [1] the removal of all badly diseased trees in the orchard, as well as the worst branches on trees which are not seriously attacked. Then, to prevent further injury from the fungus, spray both large and small trees with some good fungicide, as the Bordeaux mixture. The applications should be made as soon as the first leaves appear. Two applications should be sufficient, the second one being made eight or ten days after the first. During rainy seasons it may be well to repeat the operation a third time. The planting of resistant varieties is one of the best methods of escaping the disease. See QUINCE.

Scab (*Fusicladium dendriticum*, Fckl.). — *Description.* This fungus attacks the fruit and the leaves of both apple and pear trees. Upon the fruit it forms dark, circular spots, the largest being about half an inch in diameter (Fig. 38). These spots are often close together or unite to form surfaces which may extend over a considerable area. The centers of the spots are dark brown or black in color, but at the edges there is a light gray or white circle. This appearance is due to the separation of the outer skin, or cuticle, from the tissue beneath. When the diseased area is large, it generally cracks, and then the hard, brown tissue within the apple may be seen (Fig. 39). Growth is checked in the diseased portions and the fruit is

[1] *Orchard and Garden*, 1890, Vol. xii. July, 134.

usually one-sided, sometimes to such an extent that the blossom end and the stem are close together. Isolated spots do not seriously injure the apple, but frequently its market value is thereby considerably reduced.

The appearance of the disease upon the leaves is similar to that upon the fruit, but the light-colored edge is wanting. The parts attacked are circular or oval, and where several spots have run together the outline is irregular. The first indication of the presence of the fungus on the foliage is the appearance of

FIG. 38. — Fall Pippin apple disfigured by scab.

small, light green areas which are easily distinguished when the leaf is held up to the light. In a few days the central portions of these areas become raised, causing the leaf to become more or less distorted. The color at the same time changes to a dull brownish-black, which is plainly visible upon the upper side of the leaf. This causes the leaf to curl, the concave or hollow side being underneath; the edges of the leaf often become brown and torn. (For colored plate of scab, see *Cornell Bull.* 84.)

The scab is undoubtedly the most serious fungous disease with which the apple grower has to contend. No other disease annually ruins such a large percentage of the crop. From the fact that the fungus also grows upon the leaves, it frequently occurs that entire orchards are defoliated. The result is that the tree receives so little nourishment that it may not bear a profitable crop for several years, even though during this time it is kept free from the disease. Wherever apples are grown, they suffer more or less from the parasite. Some years the

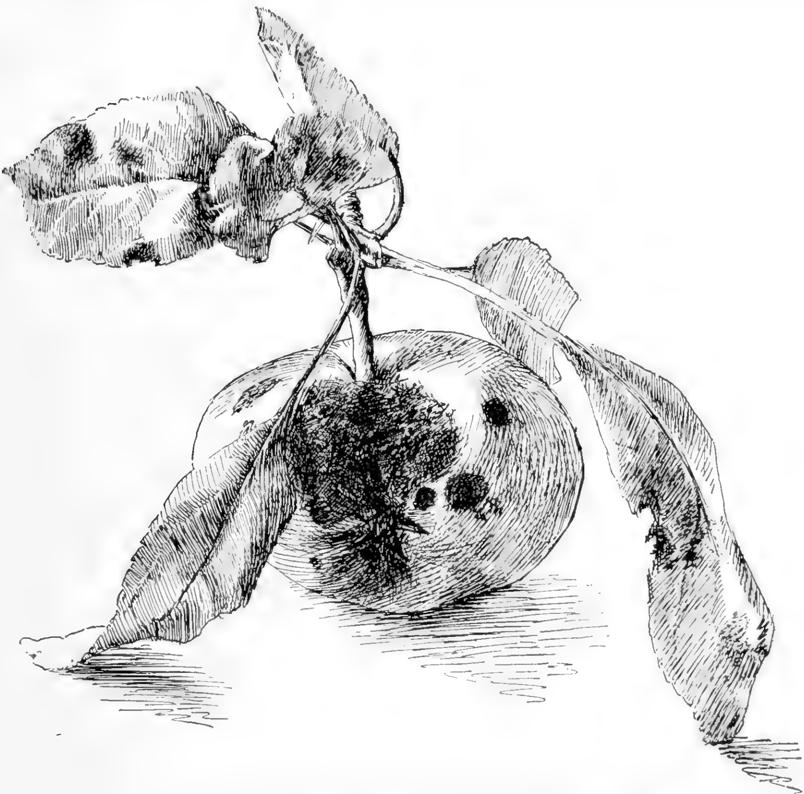

FIG. 39. — Severe attack of apple scab upon fruit and foliage.

injury may be so slight that it is scarcely noticed, and during others it may attack a tree with such intensity that there is scarcely enough fruit or foliage left to tell the tale of the cause of the destruction. Apple growers in western New York and in southern Michigan will bear evidence of the condition of orchards in the summer and fall of 1892 and 1893. The trees, especially in Michigan, appeared as if burned by fire, and it was said that in some counties there was not produced one car-load of first-class fruit. It is no wonder that apple-growing does not always pay. The wonder is that it ever does pay, when the care given the orchard is considered. The causes of the many failures are principally two: first, the neglect of the top, as regards pruning, spraying, and similar operations; second, the neglect of the roots, as regards feeding and the condition of the soil. It rests entirely with the grower if his trees shall produce scabby fruit or perfect fruit. He can make his choice, and the outcome will be as he chooses. In this statement, no variety, however susceptible it may be to the attacks of the scab, is excepted. Some varieties, as the Spitzenberg, Fameuse, Fall Pippin, Early Harvest, and in many localities the Baldwin, seldom produce uniformly good fruit, and with few exceptions, the last has been far from perfect during the past few years. Ben Davis, King, Fallawater, and many other varieties are not nearly so much affected by the scab.[1] These varieties need less care and often produce very fair crops without any special attention, but in such cases they generally bear in years of plenty, when prices run low except for extra fine fruit.

Treatment. Treatment of the apple scab should begin early in the season. This was forcibly shown in the spring of 1892.[2] The first application, using Bordeaux mixture, was made June 13, about one week after the blossoms had fallen from the trees. At the time of the second application, June 22, small portions affected with the scab fungus could occasionally be found upon the apples in places thickly covered by the Bordeaux mixture previously applied. These portions were undoubtedly attacked before the first application was made. As this occurred soon after the blossoms fell, it is clear that the trees were sprayed too late. They should receive at least one application before the blossoms open. The value of this has been demonstrated in another way. D. G. Fairchild observed the growing mycelium upon apple twigs even before the buds broke, and this would indicate that for very susceptible varieties it may be well to spray with a solution of the sulphate of copper when the buds are swelling.

[1] *Cornell Agric. Exp. Sta.* Bull. 48, 288–290.

[2] For detailed account of experiments in the treatment of apple scab, see *Cornell Agric. Exp. Sta.* Bull. 48, 265–274; also Bulletins 60 and 86.

A second application should be made just before the blossoms open, and a third as soon as the blossoms have fallen from the trees; but for these, as well as for all later ones, it is advisable to use the Bordeaux mixture or some similar preparation. Such applications may be made at intervals of ten or fifteen days, depending upon the weather, until from two to six have been made. The number necessary will depend largely upon the variety treated. In comparatively dry seasons, two applications will afford almost complete protection to resistant varieties, while those subject to the disease would repay as many as four or five. When so treated, the fruit and the foliage will be practically perfect as regards injury from scab.

The amounts of liquid necessary to protect an apple tree from the scab will vary with the size of the tree and with the season. A well-grown apple tree, twenty-five years old, will require from two to three gallons of liquid when sprayed before the blossoms open. Later in the season, when the tree is in full leaf, it will be necessary to use four or perhaps five or even six gallons to cover the leaves and the fruit thoroughly.

Insect Enemies.

Aphis (*Aphis Mali*, Fabr.).—*Description.* These small insects, commonly called lice, are often very numerous upon the young shoots and leaves of apple trees. They are generally most abundant in spring and early summer, and in the fall. They are supposed to cause considerable damage by sucking the juices from the blossoms and young leaves, but the injury done by them has probably been overestimated. During the latter part of June and July the insects disappear. While they are present, immense numbers may be found upon the stems and under side of the leaves, the latter being curled so that the pest is very well protected from any application which may be made.

Treatment. Unless the lice are very abundant it is not necessary to try to destroy them, for they do not cause any serious damage, and in a short time they naturally disappear. It is not advisable to spray entire orchards, although they may be badly infested. But if it is desired to destroy the lice upon certain trees, a cheap and efficient remedy will be found in tobacco water, or in the decoction. This should be sprayed upon the trees as soon after the lice have appeared as possible, and the applications should be repeated at intervals of two to four days if the insects persist. Kerosene emulsion is also an excellent remedy, but it is more expensive. The lice are very easily killed, and any of the insecticides which kill by contact will destroy them.

Borers (*a*) Flat-headed borer (*Chrysobothris femorata*, Fabr.); (*b*) Round-headed borers (*Saperda candida*, and *S. cretata*, Fabr.). — These insects cannot be controlled by spraying. Various washes containing carbolic acid, clay, and many other ingredients have been recommended to drive or keep the insects from the trees, but none have proved to be of much value. The best and safest line of treatment is to dig out the larvæ, or to run a wire into the burrow until the insects are reached.

Bud-Moth (*Tmetocera ocellana*, Fabr.). — *Description.* The adult, also known as the eye-spotted bud-moth, measures about three-fourths of an inch across the fore wings. "The head, thorax, and basal third of the fore wings, and also the outer edge and fringe are dark ashen gray, the middle of the fore wings is cream white, marked more or less with costal streaks of gray, and, in some specimens, this part is ashy gray, but little lighter than the base. . . . The hind wings above and below and the abdomen are ashy gray. The under side of the fore wings is darker, and has a series of light, costal streaks on the outer part."[1] The insect appears to have but a single brood in the North. The eggs are laid during June and July. According to Slingerland,[2] these hatch in from seven to ten days; the larvæ feed upon the foliage until about half grown, this requiring a period of about six weeks. They then form a small silken case, well concealed in the crevices of the twigs, and there they remain until the following spring. When the buds are swelling, and even after they have burst, the larvæ again appear. They are then small and dark brown, "about one-fourth of an inch in length, with a shining black head and thoracic shield."[3] They injure large trees, and also those in the nursery; in the latter case they are particularly destructive, since the future shape of the tree may be seriously affected by the loss of the terminal buds. The opening buds are eaten and

[1] Fernald, *Mass. Hatch. Agric. Exp. Sta.* 1891, April, Bull. 12, 7.
[2] *Cornell Agric. Exp. Sta.* 1893, March, Bull. 50, 14.
[3] *Ibid.* 10.

also the young foliage, so that even large trees frequently suffer severely from the insect. The young growing leaves are drawn together and firmly held by means of silken threads, and in this retreat the larvæ are well sheltered (Fig. 40). The insect pupates within this mass of foliage six or seven weeks after its first appearance in spring, and about ten days later the adult appears. Eggs are laid after three or four days, and thus the life circle of the insect is completed.

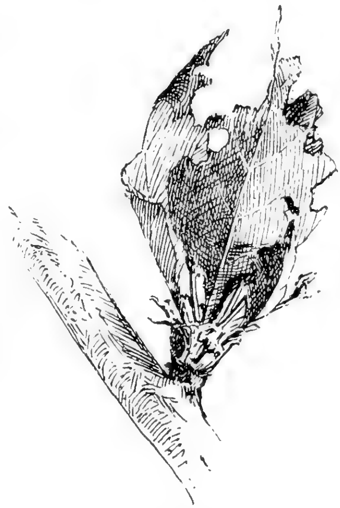

Fig. 40. — Young apple foliage injured by larva of bud-moth.

Treatment. The insect may be quite easily destroyed by thoroughly spraying the affected trees with arsenical poisons as soon as the buds have opened, so that the tips of the young leaves may be seen. Two applications, made before the blossoms open, should prove entirely effective in the destruction of this insect.

Canker-worm (*Anisopteryx pometaria,* Harris). — *Description.* This insect is commonly called the fall canker-worm, and another species, *Paleacrita vernata,* Peck, is known as the spring canker-worm;[1] they are frequently termed measuring worms, from the peculiar manner in which they move about (Fig. 41).

The caterpillars vary in color from yellow to dark brown, and are variously striped. When mature they are about an inch long. They then leave the tree upon which they have been feeding, either by crawling down the trunk or by lowering themselves from the branches by means of a fine thread. They enter the ground and spin cocoons. Here they remain until fall, when the adult moths appear. The male (Fig. 42) has a wing expanse of about one and one-fourth inches. It is of a glossy gray color, two irregular white bands being generally found upon each of the fore wings. The female is wingless (Fig. 43), from one-fourth to nearly half an inch in length, and is also gray in color. She soon crawls up the trunk of the

[1] Saunders, "Insects Injurious to Fruit," 1889, 46.

tree and deposits her eggs among the branches. The adult forms of the spring canker-worm rarely appear in the fall, but emerge early in the following year. They closely resemble *A. pometaria.*

Treatment. Various measures have been taken to keep these insects in check, the most common being to wrap the trunk of

Fig. 41. — The canker-worm at work; natural size.

the tree with some material over which the adult female cannot crawl to lay her eggs. For this purpose tar, or any sticky substance, has been in common use.[1] Cotton has been highly recommended. However, the cheapest and best method to get

[1] Raupenleim and Dendrolene are two substances recommended by Professor Smith in Bull. 111, *N. J. Agric. Exp. Sta.* 1895, Sept.

rid of the pest is to spray the foliage with Paris green or London purple.[1] This should be done early in the season, as soon as the caterpillars make their appearance. If they are seen to be injuring the trees before the blossoms are open, it may be well to make an application at that time. But generally it is not necessary to spray the trees till after the blossoms have fallen. Never apply the arsenites to fruit trees while they are in blossom, for the bees which are working among the flowers and assisting in the setting of the fruit may be poisoned, to the loss of their owner as well as to the owner of the orchard. Whether bees are actually poisoned by arsenites when applied to trees while in full bloom is still a disputed point;[2] they probably are, and the grower will do well to apply sprays either before or after the trees have bloomed. It may also be that the injury done to the delicate parts of the flower by the materials used is alone sufficient cause for avoiding this time to do the work. The time of blossoming is short, and trees should not suffer if sprays are properly applied before and after this period.

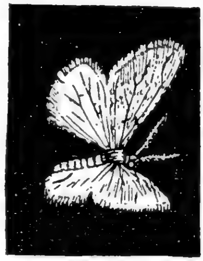

FIG. 42. — Canker-worm moth; male, natural size.

If one application of the arsenite is not effective in ridding the trees of worms, others should be made at intervals of eight or ten days until the pest is overcome. When the worms are young, they most commonly feed upon the under side of the leaves, and it is a good plan to treat these parts thoroughly. In making the applications it must be remembered that the worms will not be destroyed unless the poison is placed upon the leaves. All parts of the tree should be drenched, and if many worms remain a few days after such an application, the materials used are faulty, or they have not been mixed in the proper proportions.

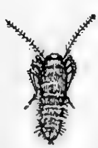

FIG. 43. — Canker-worm; adult female, natural size.

Cigar-case-bearer; Case-worm (*Coleophora Fletcherella*, Fernald). — *Description.* The appearance of this insect is so

[1] See Bailey, *Cornell Agric. Exp. Sta.* 1895, Bull. 101.

[2] Cook, *Mich. Agric. Exp. Sta.* 2d Rep. 261. Webster, *Insect Life*, Vol. v. No. 2, 121. Lintner, *Ibid.* Vol. vi. No. 2, 181.

remarkable that when it has once been observed it is readily distinguished in the future. The insect may be found upon pears and apples. "The moth is a very delicate and pretty steel-gray object. During the day it rests on a leaf with its heavily fringed wings folded closely over its abdomen, and its long, slender antennæ placed close together and projecting straight forward from its head. They may be seen on the leaves from about June 15 to July 15."[1] Eggs are soon laid upon the young leaves, and in the course of about two weeks the young caterpillars may be seen. During the first two or three weeks these mine within the leaf, eating out the green tissue and causing the formation of hollow brown areas. The larvæ then begin the construction from bits of the leaf of the peculiar cases, which are shaped like a cigar, but only about three-eighths of an inch long; in these they find protection. About the middle of September the worms migrate to the branches, where they remain throughout the winter. Early in spring, as soon as the first leaves appear, the larvæ return to the foliage and attack all green parts of the host-plant. As the case becomes too small for the growing insect, the old one is deserted and a new one made. The little worm continually carries the case on end, and it obtains its food by eating through the upper surface of the leaf and eating out the green portions which are within easy reach, causing the affected part to turn brown. During June the larvæ pupate, and soon the adult again appears.

Treatment. The case-bearer is serious in only a few localities, and its life history has but recently been carefully studied. Although no definite experiments have been made aiming at the destruction of the insect, yet the general opinion of all who have closely observed it is that the larvæ may be killed by spraying the affected trees with the arsenite early in the spring, making one application before the blossoms open, and two after they fall, as is done for the codlin-moth.

Codlin-moth (*Carpocapsa pomonella*, Linn.). — *Description.* This moth is about half an inch long, and when at rest has the wings folded close to its body. Its general color is grayish brown. "The fore wings are marked with alternate, irregular, transverse, wavy streaks of ash gray and brown, and have on the inner hind angle a large, tawny-brown spot, with streaks of

[1] Slingerland, *Cornell Agric. Exp. Sta.* 1895, May, Bull. 93, 219.

light bronze or copper color, nearly in the form of a horseshoe; at a little distance they resemble watered silk."[1] The hind wings are of a glossy light brown color (Fig. 44).

The moths first appear in spring, having passed the winter in cocoons. The first moths fly about the time that the blossoms fall from the apple trees, and they continue to appear for two or three weeks, or even longer. Very soon after leaving the cocoons the moths lay their eggs, generally at the blossom

Fig. 44. — **Codlin-moth**; all parts natural size.

ends of the little apples. The eggs soon hatch and the larvæ immediately begin to eat the fruit. The second generation of moths appears in about six weeks. Two or three broods are produced in a season, and this fact tends to increase the difficulty of treating the insect successfully.

Treatment. Formerly the principal remedy for the codlin-moth was to destroy all the windfalls, either gathering by hand, or having them eaten by stock which was allowed to run in the orchard. This practice was fairly successful. Since

[1] Saunders, "Insects Injurious to Fruit," 1889, 129.

the moth is a night-flying insect, it has been repeatedly tried to attract it by means of lights. Rarely is one caught, and it is useless to attempt to trap the moth in this manner.

Spraying with arsenites is rapidly taking the place of the many methods which were formerly employed to destroy this pest. The applications are safe, easily made, and are almost invariably followed by excellent results. The first application should be made as soon as the blossoms fall from the trees, earlier ones being unnecessary. But as soon as the blossoms have fallen, spray thoroughly, using either Paris green or London purple. The operation must not be delayed until the apples are as large as cherries, but should be immediately performed. It is well to spray a second time about ten days later, but if the weather is rainy, applications are advisable after heavy showers, since the poison is more or less washed away by a beating rain. Poison must be at the blossom end of the apple when the larva appears, for when the worm is once inside the fruit it can no longer be reached; the first thing that it eats should be poison.

Since the second brood comes from the first, if the first is killed there can be no second, therefore the necessity of doing the work well from the beginning. The appearance of the later broods is probably too irregular to allow of successful treatment, and it is not always advisable to make special applications for their destruction.

By applying a combination of an insecticide and a fungicide, we can treat both the codlin-moth and the apple scab, thus saving the labor of one treatment. The most reliable combination thus far made is that of the Bordeaux mixture and Paris green or London purple. This combination is as effective as when separate treatments are made[1] against the fungus and the insect. The use of the ammoniacal carbonate of copper applied in connection with the arsenites has also given good results, and as the mixture is more easily applied than Bordeaux, it may in some rare cases be given the preference (see page 140).

In Paris green we have a combined insecticide and fungicide, already prepared, but the fungicidal value is not so strong as might be wished. Its use during the past two years has, however, shown that it affords apples considerable protection

[1] *Cornell Agric. Exp. Sta.* Bull. 48, 274; 60, 274.

against fungi. The foliage of susceptible varieties may be rendered fairly perfect by the arsenite, and in consequence, the vigor of the tree itself will be considerably increased. Its additional value as an insecticide makes it one of the best remedies for destroying orchard pests.

Stock is frequently pastured in bearing orchards which are in permanent sod, and doubts are often expressed as to the advisability of removing the animals after the trees have been sprayed with arsenical poisons or other materials. Cook[1] has conducted some experiments to test this point, and in no case could he find that horses or sheep were in the least injured. He applied much larger amounts of the poisons than are generally used; and I have still to hear of the first case in which pasturing stock under sprayed trees, whatever the application may have been, has been followed by bad results. When one considers how small is the amount of poison used per tree, the small percentage of it that falls to the ground, and how little of this adheres to those parts of the herbage that are eaten, it will be seen that there is practically no danger to the stock.

Curculio (*Anthonomus quadrigibbus*, Say). — *Description.* As the name of this insect indicates, it possesses four projections, these being found on the back at the posterior end of the body. They are nearly conical in form and of a brownish-red color. The general appearance of the insect is brown, but a shade of red may also be noticed. Although it is closely related to the plum curculio, its body is slightly smaller and the snout longer; the entire length is about one-quarter of an inch. Its habits are also in some respects different. In laying its eggs no crescent-shaped mark is made, but a hole, somewhat enlarged at the bottom, is bored into the small apple, and the egg is there deposited.[2] The apple grows more slowly in the affected portions, which results in its becoming misshapen, and if the fruit is stung several times it will be worthless on account of its small size and irregular form. Fig. 45 represents apples which were injured by this insect and also by the plum curculio, another serious enemy of the apple.

Treatment. The apple curculio rarely does much damage in the North, but in some of the middle states it is occasionally very destructive. The most promising remedy is to spray the

[1] See page 233. [2] Gillette, *Iowa Exp. Sta. Bull.* 11, 493.

trees very thoroughly with the arsenites early in spring. It may be advisable to make the first application before the blossoms open, and another after their fall. The value of such applications is still a disputed point, and it is more fully discussed under "Spraying for the curculio," page 68. My own experience leads me to believe that apples in thoroughly sprayed orchards suffer comparatively little from this insect.

Jarring the trees has also been recommended, but this is not always practicable. Sheep and hogs may be of service in an

FIG. 45. — Apples distorted by curculio injuries.

affected orchard, but unfortunately apples which are stung by the curculio do not fall to the ground to such an extent as do those attacked by the codlin-moth, and only a small number would be destroyed by this means.

Fall Web-worm (*Hyphantria cunea*, Harris). — *Description.* The mature insect is a moth, pure white in color, with an expanse of wings of about one and one-fourth inches. The insect is widely distributed throughout the country, and when undisturbed, the larvæ may do considerable injury, not only to fruit trees, but to many other plants, since they are not very particular as to diet. The eggs are laid upon the foliage during early summer, and soon hatch. The full-grown larvæ are about an inch long, with varied markings. They are thickly covered with yellowish hair, of varying shades, it being longer at the extremities of the body. The head is black, and a dark stripe extends along the back. These caterpillars are most conspicuous in the fall after they have woven a web, inside which they work. The foliage to be eaten is first enclosed in this manner, and afterwards devoured. When full grown the caterpillars descend to the ground, and there spin cocoons in which they remain until the following year. There is but one brood of the insect in the North.

Treatment. Spray with the arsenites during summer, as soon as the presence of the insect is noticed. The foliage should be covered with the poison before it is surrounded by the web, and this can be done most effectively while the larvæ are small. If spraying is neglected, cut out the limb and burn it, or hold a burning torch to the nest until the caterpillars are destroyed.

Leaf-Skeletonizer (*Pempelia Hammondi*, Riley). — *Description.* The larva of this moth causes the curled and scorched appearance which is sometimes exhibited by apple leaves, especially when young. The worm, which is greenish-brown, causes the injury by eating the green portions of the leaves. Its length is about half an inch. A web is generally spun, and frequently several leaves are drawn together by it, making an unsightly object.

Treatment. The web spun by the larvæ affords them some protection against applications which are made; but if the arsenites are applied as soon as the worms are seen, their work should soon receive a check, for new material will soon be required for food, and this should bear the poison. Hand picking has also been recommended; it is a laborious but certain method of destroying them.

Maggot; Railroad-worm (*Trypeta pomonella*, Walsh). — *Description.* The many small burrows frequently seen extending in all directions throughout the flesh of an apple are caused by a greenish-white footless maggot about one-fourth of an inch in length. The mature form of the insect is a two-winged fly. It lays its eggs singly under the skin of the apple, early in summer; these hatch in a few days, and the maggot, after tunneling for about six weeks, leaves the fruit, and enters the ground, where it pupates. The mature flies appear the following summer.

Treatment. No effectual remedies are yet known. It is scarcely possible that arsenical sprays will lessen the trouble; but the destruction of the young affected fruit, if well done, would materially reduce the danger of injury.

Oyster-shell Bark-louse (*Mytilaspis pomorum*, Bouché). — *Description.* The small brownish scales which are commonly seen upon apple trees have been secreted by a little insect which may be found underneath them during the summer. The scale, or shell, protects the insect, and the latter can scarcely be reached by any application made at this time of the year. But in early spring the scales contain a number of light-colored eggs. These hatch in May, and during warm weather the young insects crawl about, and in a few days attach themselves to the bark. They then begin to secrete a shell which soon resembles that of the parent.

Treatment. Since the bark-louse is a sucking insect it cannot be destroyed by arsenites or similar poisons. Spray affected plants with some insecticide which kills by contact, such as kerosene emulsion, or tobacco water. These applications should be made before the young insect has attached itself to the bark. Before the eggs hatch it is well to scrape badly affected parts, and then to wash them thoroughly with some good insecticide, those of a soapy nature being preferable.

Tent Caterpillar (*Clisiocampa Americana*, Harris). — *Description.* The moths are three-fourths of an inch long, the spread of the wings being about one and three-fourths inches. The general color is brown, but there is a darker band near the outer margin of the fore wings. In July the moths lay their eggs closely in rows around the smaller twigs of trees, sometimes as many as three hundred being deposited. These eggs do not hatch until the following spring; then the caterpillars appear, and begin to feed upon the young leaves. After a few days they commence to spin their web, which soon grows to be large and unsightly. When full grown the caterpillars are about two inches long; they are somewhat hairy, and have a white streak running along the center of the back. The sides of the body are ornamented with yellowish markings, while underneath it is quite black. The worms mature in about six weeks from the time they are hatched. At this time they generally leave the tree and seek some sheltered corner in which they spin their cocoons. In three weeks moths issue, and eggs are again laid.

Treatment. This insect does considerable damage if it is left unchecked, but it is so easily destroyed that there is no need of having any trouble with it in an orchard. As soon as a nest is seen, the branch may be cut off and burned, or the insects crushed without the removal of the nest. But a much better remedy is to spray the foliage near the web with arsenites. The caterpillars always return to the web at night, and they may also be found there in bad weather; and if the tree has been sprayed they generally return there to die. In spraying for the codlin-moth sufficient poison is applied to rid the orchard of this enemy also.

Woolly Aphis (*Schizoneura lanigera*, Hausm.). — *Description.* This insect is a small yellow plant louse. It is found upon many kinds of trees, both on the branches and among the roots, and causes injury by sucking the juices. The insect is protected by a woolly or mealy covering, and from this it has received its common name. When the roots of nursery trees are attacked the stock is almost worthless, for the labor and expense of destroying the insects is generally greater than the value of the stock.

Treatment. Affected branches may be cleaned by throwing a strong stream of water upon them, thus dislodging the insects. Kerosene emulsion and tobacco water will also kill them, if the applications are made so thoroughly that the insecticide will penetrate the covering. It will probably be found necessary to repeat them. Roots of trees standing in the ground may be treated with scalding water. If the roots are to be dipped into the water, a temperature higher than 150 degrees F. should not be allowed, and 130–135° F. should kill the insects after a moment's immersion. Kerosene emulsion and tobacco water give good results. They may either be sprayed upon the roots, or these may be dipped into the liquid. In either case the roots must be well cleaned before the application is made, so that the insecticide will reach the insect. It is possible that the hydrocyanic gas treatment would be of value in treating young, dormant trees before setting. During summer these insects multiply very rapidly, and all treatments should be made early in the season, and very thoroughly. If this is not done, bisulphide of carbon may prove effective, although the remedy does not yet appear to have been used for this purpose.

APRICOT.

FUNGOUS DISEASES.

Leaf Rust. See under PLUM.

INSECT ENEMIES.

Curculio. See under PLUM.

ASPARAGUS.

Asparagus Beetle (*Crioceris Asparagi*, Linn.). — *Description.* In many localities asparagus is seriously injured by a small, dark, metallic-blue beetle, which is also marked with yellow and red. It passes the winter as a beetle, and lays its eggs on the young asparagus shoots in spring. There are two or three broods.

Treatment. The removal of affected parts and the destruction of the eggs will assist in suppressing the pest. Hellebore, mixed with flour, 1 part to 10, has been recommended as being effective against the first brood of larvæ, and it is probable that the arsenite would prove valuable if applied after marketing has ceased.

ASTER.

FUNGOUS DISEASES.

Leaf Rust (*Coleosporium Sonchi-arvensis*, Lév.). — *Description.* The fungus appears to attack the leaves mostly from the under side; here it produces orange-colored pustules and eventually causes the death of the diseased leaves.

Treatment. Spray the plants early in the season with a clear fungicide, repeating the applications at intervals of two to four weeks. Care should be exercised to reach the under surface of the leaves.

BALM OF GILEAD.

FUNGOUS DISEASES.

Leaf Rust. See under COTTONWOOD.

BARLEY.

FUNGOUS DISEASES.

"Barley is subject to two loose smuts, both somewhat like oat smut. They may be prevented by soaking the seed four hours in cold water, letting it stand four hours in a moist state in sacks, and finally treating in hot water as directed for oats and wheat (which see), but only for five minutes, and at a temperature of 126° to 128° F."[1]

BEAN.

FUNGOUS DISEASES.

Anthracnose; **Pod Rust** (*Colletotrichum Lindemuthianum*, Briosi and Cavara). — *Description.* This fungus attacks the stems, foliage, and fruit of bean plants, and is, perhaps, the most serious trouble against which bean growers have to contend. The seed may be affected even before it is sown; it is then wrinkled and pitted to a greater or less extent, the affected parts being sometimes only very slightly discolored, again, very markedly yellow or brown. The disease can be carried from season to season by affected seed, and in severe cases the young plants are so much injured by the fungus that they are not able to appear above ground. Young seedlings are also destroyed, as the stem is frequently cut off by the parasite, causing deep and blackened indentations. The large and the small veins are similarly attacked, while the green tissue of the leaf does not escape. The latter shows the trouble by the appearance of dark discolorations which conform in shape, to a certain extent, to the surrounding veins. The part first attacked soon becomes brittle and then breaks, leaving an irregular opening through the leaf. A black discoloration marks the progress of the disease. Upon the stems and veins, affected parts are considerably sunken and blackened, the edges being tinged with red.

[1] *U. S. Dept. of Agric. Div. of Veg. Path.* Farmers' Bull. No. 5.

This is particularly noticeable upon the sides of diseased pods (Fig. 46). Later, the central portion of the pits show minute,

Fig. 46. — Bean anthracnose.

light-colored dots, which are masses of spores or reproductive bodies. Spore formation appears to be particularly energetic upon the pods.

Treatment. The use of healthy seed is of the greatest importance. Diseased seed may be soaked in some good fungicide, but the value of the operation is open to doubt. Professor Beach has made a careful study of this disease, and his conclusion is as follows:[1] "Even when the treatment of the seed by the best fungicides is so severe that the stand is seriously injured, there remains enough of the disease to injure the crop under field conditions. At the time of harvesting the crop in the above noted experiments, not a sound plant or even a sound pod was found in the whole lot. These results certainly give little encouragement for hope that treatment of seed with fungicides will yield sufficiently good results to justify recommending its adoption."

The recommendations made by Professor Beach in regard to treating the disease are: "(1) Selection of sound seed; (2) immediate removal of infected seedlings from the field; (3) keeping the foliage covered with Bordeaux mixture." A weaker mixture, one containing about 1.5 per cent of copper sulphate, has given excellent results, and it is harmless to foliage. The disease is more severe in low, damp places, so these should be avoided as much as possible.

Rust (*Uromyces Phaseoli*, Winter). — *Description.* Diseased leaves first show small, brown dots which are nearly circular, and slightly elevated. They soon discharge a brown powder, this being the first crop of spores. Later, a second crop of spores is produced; these are black in color, and somewhat larger than the earlier form. The buds are similarly affected.

Treatment. The free use of Bordeaux mixture may afford full protection to exposed plants, but as yet no general use of the remedy has been made.

Insect Enemies.

Bean Weevil (*Bruchus obtectus*, Say). — This insect closely resembles the pea weevil in appearance, and their life histories are practically identical. See under Pea.

[1] *Some Bean Diseases.* A thesis in the Bot. Dept. of the Agric. Coll. Ames, Iowa, 1892, 323.

BEAN, LIMA.

Fungous Diseases.

Blight (*Phytophthora Phaseoli*, Thaxter). — *Description.* This fungus attacks the young leaves and stems, and also the pods. It generally appears during August and September, and covers the affected parts with a dense, white covering.

Treatment. Spray the plants with some clear copper compound before the season when the disease generally first appears. Two or three applications should protect the vines.

BEET.

Leaf Spot (*Cercospora beticola*, Sacc.). — *Description.* "The common name well describes the general appearance of the beet leaves infested with this *Cercospora*, for they are at first more or less covered with small light or ashy spots, which later often become holes by the disappearance of the tissue previously killed by the fungus. . . . Full-sized leaves often become mutilated, and sometimes scarcely more than the framework remains."[1] The spots are at first surrounded by a band of red or purple (Fig. 47). The disease is more or less prevalent throughout the summer months.

Treatment. The trouble may be controlled by the use of fungicides, but as beet foliage is easily injured, the safest one to use is the Bordeaux mixture. This may be used of the normal strength, or even more dilute. The first applications should be made about the middle of June or early in July, depending upon the latitude and the season. The foliage should thereafter be kept covered by the material.

Root Rot (*Phyllosticta*, sp.). — *Description.* The fungus causing root rot of beets is particularly serious after the roots are stored. The affected parts shrink slightly, turn black, yet remain quite firm. The leaves appear to be affected by the same fungus, its presence causing the formation of circular spots, sometimes half an inch in diameter. The diseased tissue dies and soon cracks.

Treatment. The foliage should be well protected by the Bor-

[1] Halsted, *N. J. Agric. Exp. Sta.* 1895, Bull. 107, 8.

deaux mixture during the growing season, and when the beets are stored all the leaves should be removed.

Rust (*Uromyces Betæ*, Pers.). — *Description.* This disease is at present most destructive in Europe and in California. It is easily recognized by the rusty-red powder that is abundantly produced upon the affected portions of the leaves. A similar disease attacks carnations and hollyhocks.

Fig. 47. — Beet leaf spot.

Treatment. Although it appears that no definite experiments have been made in this country for the control of beet rust, it is probable that the fungus may be held in check by continued applications of the Bordeaux mixture. The related forms found upon other plants yield to treatment, and applications made at the first appearance of the trouble should prevent it from becoming serious.

Scab (*Oospora scabies*, Thax.). — This disease also attacks potatoes, causing them to be scabby. The only known remedy for the trouble in beets is to avoid ground in which the fungus is known to exist.

BLACKBERRY.

The insect and fungous troubles of the blackberry are treated under RASPBERRY, which see.

CABBAGE.

FUNGOUS DISEASES.

Club-root; Club-foot; Finger-and-Toe (*Plasmidiophora Brassicæ*, Woronin). — *Description.* As its name indicates, this disease causes distinct and marked swellings or "clubs" at certain portions of the root system of the cabbage and related plants; when the attack is severe, the roots are apparently all united into one large swelling wholly distinct from the normal growth of the plant (Fig. 48). The fungus causing the disease may remain active in the soil for several years, and the young plants are frequently very seriously attacked even before they are set in their permanent quarters. Affected plants appear weak and sickly, they grow slowly or not at all, and are disinclined to form heads.

FIG. 48. — Cabbage club-root.

Treatment. Although club-root is one of the most serious of the diseases attacking cabbages, its treatment is not well understood. The successful use of fungicides appears to be hopeless, and until some means of destroying the fungus in the soil has been discovered, the best plan of overcoming the parasite is to starve it out by growing other crops upon the land. It has been recommended that cabbages and allied plants should not be grown upon infested land oftener than once in three years. All material which is capable of encouraging the growth of the fungus should be destroyed, and the spread of the disease should be checked whenever opportunity offers. Halsted has successfully treated club-foot by applications of air-slaked stone lime, used at the rate of 75 bushels per acre. This remedy should be given a thorough trial.[1]

INSECT ENEMIES.

Cabbage Aphis (*Aphis Brassicæ*). — *Description.* This insect is one of the many forms of plant lice with which gardeners have to contend. It is a small, greenish-blue insect which, if unchecked, increases at an astonishing rate. It is almost continually protected by a gray flour-like covering which renders treatment difficult. As with all other insects which propagate rapidly, it is essential that those found early in the season be as completely exterminated as possible.

Treatment. Poisons which penetrate the outer coverings of the insect are to be recommended. It is difficult to make materials adhere to either the foliage or to the insects, and for this reason they must be all the more carefully applied; kerosene emulsion, tobacco water, hot water, pyrethrum, etc., are all effective if properly used.

Cabbage Plusia (*Plusia Brassicæ*, R.). — *Description.* The adult insect is a dark-gray moth about an inch in length having a small silvery spot and **V**-shaped mark in the center of each fore wing. The moths appear in spring and lay their eggs generally on the upper side of the cabbage leaf. They hatch into green larvæ which feed upon the foliage of the plant, frequently burrowing through and through the cabbage head, practically ruining it for market. The worms also feed upon lettuce, endive, celery, and other garden plants, their treatment being the same as here described. These worms are span-worms; they progress by looping the body and then straightening it. When full grown they are about one and one-half inches in length. The larvæ then spin cocoons, pupate, and in a short time the adult moth appears. There is more than one brood each season.

Treatment. The remedies mentioned under CABBAGE-WORM may be used successfully against this pest also. But if possible, greater care should be exercised in destroying the plusia, since on account of its tunneling habits it inflicts more damage

[1] *N. J. Agric. Exp. Sta. 7th Ann. Rept.* 1894, 288.

on the crop. The first brood should be exterminated by repeated and thorough applications.

Cabbage Root-maggot (*Phorbia Brassicæ*, Bouché). — *Description.* The adult insect is a two-winged fly which bears much resemblance to that so commonly found in and about dwelling-houses. It is considerably smaller, however, and the wings fold more closely together.

The adult flies appear during April and early May. Eggs are laid about the base of the newly set plants, in some cases several hundred being found about a single plant. These appear to hatch in about a week, depending upon the condition of the weather. The young maggots generally first attack the young roots, burrowing along their surfaces, until finally the root is destroyed. The main roots are then attacked, and later the stem of the plant may be entered. In this manner a crop is soon rendered worthless. There appear to be two, and possibly three broods each year.

Treatment. The cabbage root-maggot has for years been causing serious losses to cabbage growers, and although about seventy methods of destroying the pest have been recommended, only few have much merit, showing that the enemy is a difficult one to deal with. Pieces of tar paper fitted closely about the young plants at the time of setting, or immediately after, are very effective in preventing the flies from laying their eggs. As the insect works upon many weeds, and also upon other cultivated plants, this method does not destroy the pest, but drives it to other quarters, from which future supplies may at all times come. Another and better plan is to inject about a teaspoonful of the bisulphide of carbon just underneath the plant, avoiding contact with the roots as much as possible. In severe cases a tablespoonful may be used to advantage. One application, if made when the maggots are first seen in May, should be sufficient. After applying the liquid, press the soil about the plant, to prevent, as far as possible, the escape of the fumes.[1]

Cabbage-worm.

Imported Cabbage-butterfly (*Pieris Rapæ*, Linn.). — *Description.* Our common cabbage-worm, although a species introduced from

[1] For an exhaustive account of this insect, see Slingerland, *Cornell Agric. Exp. Sta.* 1894, Bull. 78.

Europe, has become so widespread and serious that many cabbage crops are annually ruined by it. Gardeners are only too familiar with the mature and the larval forms to require complete descriptions for the identification of the insect. The adult is a white butterfly having the outer fore corner of the front wings marked with black. In addition to this the male has one black spot near the center of the front wings, while the female has two. The insects pass the winter in the chrysalis state, and in spring the mature forms appear. The female lays her eggs, which are small and of a yellow color, upon the leaves of cabbages and related plants; in a few days the eggs hatch, producing small green worms that feed upon the foliage of the plants upon which they were laid. These worms become full grown in about two weeks, when they seek some sheltered place in which they turn to pupæ. In from one to two weeks a new crop of butterflies may be seen, and these in turn continue to propagate the species. Several broods appear each year.

Treatment. This pest is most easily destroyed when it is in the larval stage. It may then be treated in two general ways. As the larvæ eat the foliage they may be poisoned very easily by applying hellebore or some form of arsenic. The latter, however, must be used only upon young plants, otherwise there is danger of poisoning the human consumer. Hellebore may be used quite freely at all times, since it loses its strength on exposure to air. The other method of destroying the insects is to apply poisons which penetrate the soft covering of their bodies. For this purpose kerosene emulsion may by successfully employed, but as in the case of the arsenites, only young plants should be treated in this manner. For heading cabbages, it is safer to use some form of pyrethrum. Some prefer the use of hot water to all other remedies; it is clean, does not injure the plants if properly applied, and it destroys the worms. It is unpleasant to handle, however, and its use has not generally been favored. Particular care should be taken to kill the first brood, whatever the remedy selected, for if this brood is exterminated, later ones will have small chances of appearing. All applications should be repeated as often as seems to be necessary.

Harlequin Cabbage-bug (*Murgantia histrionica*, Hahn). — *Description.* This southern insect is gradually extending north-ward along the Atlantic coast, and is showing itself to be perhaps the worst enemy of the cabbage grower. The adult bug is nearly half an inch in length. It is brightly marked with black and orange colors, and for this reason has received its popular name. The mature insect hibernates during the winter; in early spring, as soon as the cruciferous plants upon which it feeds make their appearance, the eggs are laid, commonly on the under side of the leaves, and closely cemented in a double row containing about a dozen eggs. These hatch within a week, and the young pests then begin to suck the sap from the leaves. So active are their operations in this direction that it is said a young cabbage plant will succumb in one day if attacked by half a dozen of the insects. The bugs are very shy, and if disturbed they try to hide. They mature in about twelve days from the time the egg is hatched, and this allows of the appearance of several broods each year.

Treatment. For several reasons this insect is very difficult to control. It cannot be destroyed by poisons which are taken internally, and on account of its active habits it is difficult to reach with external applications; again, the rapidity with which it can multiply renders very thorough work necessary from the start, else their number will soon increase to an extent sufficient to ruin the cabbage plants. Hand picking has been recommended, but it is of doubtful value when large areas are affected. One habit of the pest may prove of considerable service in its destruction. During the nights of spring and autumn, the adult insects collect under chips, boards, etc., and under small piles of leaves or some similar materials which afford them good hiding-places. If these are removed or burned in the morning after the insects have collected under them, large numbers may be disposed of. This practice is particularly valuable if the brood which hibernates during the winter can be so destroyed, since this largely reduces the abundance of the future generations. Another method of destroying this brood and of saving the cabbage plants has been suggested by Weed. The harlequin cabbage-bug is very fond of mustard, and if the latter is sown between the rows of cabbages almost all the insects will collect upon the mustard. This should then be sprayed with pure kerosene, and thus the hibernating bugs can practically all be destroyed.

CARNATION.

Fungous Diseases.[1]

Anthracnose (*Volutella* sp.). — *Description.* Although anthracnose is apparently an introduced disease, it has become so widespread that it is now one of the most serious of the many fungi attacking carnations. The fungus causes grayish-brown, sunken areas to appear at the bases of the leaves, these being marked with small black elevations covered with bristly points. The parasite also grows in the stems of flowering plants, causing the parts beyond the affected portion to suffer from want of nourishment, a symptom readily distinguished by an experienced florist. Cuttings very frequently contain the disease, and for this reason they cannot do well.

Treatment. Avoid spreading the disease when propagating the carnations; only healthy stock should be used. If there is danger from infection, the most promising method of preventing the spread of the disease is to keep the plants growing well, and to spray them with some good fungicide, as the Bordeaux mixture. To avoid staining the plants, the ammoniacal

Fig. 49. — Carnation rust.

[1] See, also, Atkinson, *Carnation Diseases.* A paper read before the American Carnation Society, 1893, *Am. Fl.* viii. 720.

solution of copper carbonate may be substituted, although it is perhaps not so efficient. The plants should at all times be protected in this manner.

Rust (*Uromyces caryophyllinus*, Schr.). — *Description.* This European disease was first noted in this country about the year 1891. It has been rapidly disseminated here by means of the stock sent out by propagators, and now it can be found in the house of nearly every extensive carnation grower. The first external appearance of the disease (Fig. 49) is the formation of gray, blister-like elevations on the leaves and stems, these being of various sizes and shapes. As the fungus develops, these parts rupture and a large amount of a reddish-brown powder is forced through the broken epidermis. This powder consists of spores which are capable of reproducing the parasite in other localities. Later another kind of spore is matured from the affected part, this being of service to carry the fungus through conditions which prove fatal to the body of the parasite and also to the spores first produced.

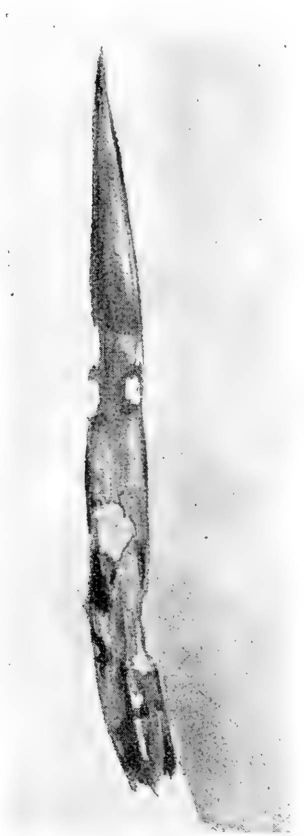

Fig. 50. — "Spot" of carnation.

Treatment. A plant that has become infested with the rust fungus cannot be cured; the only remedy is to cut out the affected parts and destroy them. The spread of the disease may, however, be checked by the proper use of fungicides. The disease appeared in the Cornell forcing houses during the winter of 1894–95, and was practically controlled by thorough applications of the Bordeaux mixture. Copper chloride appeared to be equally effective. Soap was used with the mixture in order to make the liquid adhere better. This, however, did not prove entirely satisfactory, and the greatest reliance was placed upon the production of an extremely fine spray, the particles being so small that they adhered without much difficulty. If thorough applications are made at intervals of one to three weeks, little trouble should be experienced from carnation rust. It is said that the disease may also be controlled by the use of the sulphide of potassium.

Spot; Blight (*Septoria Dianthi*, Desm.). — *Description.* The spot of carnations may be recognized by the presence of grayish-brown spots, more or less circular in outline, and surrounded by a conspicuous purple band which is well defined on the inner edge, but mingles with the healthy green tissue at the outer margin (Fig. 50). Both stems and leaves are attacked, and much damage is inflicted. The foliage cannot perform its functions properly, and the stems may be so severely attacked that all portions beyond the diseased areas die.

Treatment. It is probable that proper application of fungicides, as described under Rust, will prevent the malady from becoming serious.

CATALPA.

Fungous Diseases.

Leaf Spot (*Phyllosticta Catalpæ*, Ell. & Martin). — *Description.* During early summer the leaves of catalpa trees often become disfigured by circular brown spots which under favorable circumstances increase to such an extent that the trees may almost entirely lose their foliage before the middle of August. When the attack is less severe the affected portions frequently drop from the leaves, causing the latter to be more or less perforated.

Treatment. Spraying the trees early in the season with the Bordeaux mixture or some other good fungicide would probably largely prevent the trouble. Two or three applications made at intervals of two or three weeks should suffice.

CAULIFLOWER.

The enemies and diseases of cauliflowers have been considered under Cabbage, which see. Care should be taken in treating this crop, that the center or "flower" of the plant remains uninjured by the applications.

CELERY.

Fungous Diseases.

Celery Blight; Rust; Sun-scald (*Cercospora Apii*, Fries).—*Description.* The first indication of celery blight is the appearance of small, yellowish spots upon the leaves. They rapidly enlarge, run together, and finally cause the destruction of the leaf, which first turns yellow and then brown. The disease is more serious in dry locations, especially if the sun is allowed to shine freely upon the foliage.

Treatment. The crop should be grown only in moist localities, and there it naturally grows to its greatest perfection. If grown on high land, shade is desirable; if it can be obtained from a building so much the better, as trees and other growing plants rapidly dry out the ground in their immediate vicinity. In case the plants cannot be kept free from the disease by these means, the application of any standard fungicide will almost entirely prevent its appearance.

Leaf Blight (*Septoria Petroselini* var. *Apii*).—*Description.* All parts of the celery plant except the roots suffer from this fungous disease. Watery areas appear on the stems and leaves, and these soon show many small black dots which contain the spores or reproductive bodies of the fungus. The disease is very common in seed-beds, and may be carried over on the seed.

Treatment. The first precaution to take is to plant only clean seed. That which is speckled or spotted with the above-mentioned black dots should be avoided as much as possible. If, in addition, the young plants are sprayed with a good fungicide the disease should not become serious. Such applications should be repeated whenever the condition of the plants seems to demand it.

Insect Enemies.

Celery-caterpillar. See under Parsley.

CHERRY.

Fungous Diseases.

Brown Rot (*Monilia fructigena*, Pers.).—This disease and its treatment are fully discussed under Peach. The cherry does not require such repeated applications, since the fruit matures earlier in the season. It is also more unsafe to use the Bordeaux mixture, on account of the danger of staining the fruit; the ammoniacal solution of copper carbonate or some other clear fungicide will be found a better remedy after the cherries are one-half grown. The Bordeaux mixture may be safely applied as soon as the blossoms have fallen and the fruit has set.

Leaf Blight (*Cylindrosporium Padi*, Karst.). This disease is fully treated under PLUM, which see.

Powdery Mildew (*Podosphæra Oxycanthæ*, DeBary). See under APPLE.

Black Knot (*Plowrightia* [*Sphæria*] *morbosa*, Sacc.). See under PLUM.

INSECT ENEMIES.

Canker-worm (*Paleacrita vernata*, Peck). See under APPLE.

Plum Curculio (*Conotrachelus nenuphar*, Herbst). See under PLUM.

Slug (*Selandria Cerasi*, Peck). — *Description.* The mature insect is a black fly having four wings. The eggs are laid in small openings made in the leaf by the insect. They hatch in about two weeks. The larvæ mature in about four weeks. They bear a certain resemblance to a tadpole, being shiny, dark-green worms, about half an inch long (Fig. 75). They eat the soft tissues of the leaves, only the larger veins remaining. In severe cases the trees may be entirely defoliated. There are two broods each year.

Treatment. Fortunately this insect may be overcome very easily. Dry-slaked lime dusted over the leaves destroys the pest, and if air-slaked lime be freely used it will answer the same purpose. Pyrethrum, hellebore, or some form of arsenic, applied dry or with water, will also rid the tree of the insect. Dry road-dust has been recommended, but is not always satisfactory.

CHRYSANTHEMUM.

FUNGOUS DISEASES.

Leaf Spot (*Septoria Chrysanthemi*, E. & D.). — *Description.* The fungus causing leaf spot of chrysanthemums first causes the formation of small dark-brown spots upon the foliage. The affected areas increase in size until the leaves are so badly affected that they fall to the ground. It is only within the last few years that the disease has become serious. A leaf blight, caused by *Cylindrosporium Chrysanthemi*, E. & D., closely resembles the leaf spot and is with difficulty distinguished from it without the aid of a microscope.

New Leaf Spot (*Phyllosticta Chrysanthemi*, E. & D.). — *Description.* This is another recent disease affecting chrysanthemums. It forms upon the leaves rather large purplish-brown areas. These appear soft and velvety upon the surface. When a leaf is severely attacked the portions apparently unaffected turn yellow, and the value of the leaf to the plant is destroyed.

Treatment. Although these diseases have not been extensively treated, it seems very probable that they should be kept in check without much difficulty. Bordeaux mixture has in a few cases been used with apparent success; and if the applications are thoroughly made, and repeated at intervals of two or three weeks, there is every reason to believe that the plants may be kept comparatively free from disease. But these fungi have also proved to be troublesome in the cutting bench, and here their treatment is more difficult. Only healthy stock should be used for propagation, and if the plants have been well grown this should not be difficult to find. If the diseases do appear among the cuttings, the use of fungicides will undoubtedly be of value in checking the spread of the parasites.

CORN.

Fungous Diseases.

Smut (*Ustilago Maydis*, DC.). — *Description.* This fungus attacks all parts of the corn plant above ground. It forms large black swellings on the stalks, ears, and tassels, being especially common in the first two places named. It is less frequently found upon the leaves. It does the greatest damage in the ear, for it not only destroys much of the grain, but that which remains serves well as a source of infection to the crop grown the following year, provided any of it is used for seed.

Treatment. Effectual remedies for corn smut have not yet been found. Some claim that soaking the seed in a fungicide or in hot water may assist in preventing the trouble, but so many cases are on record in which such treatments were of practically no value that they cannot be recommended.

INSECT ENEMIES.

Corn is subject to the attacks of a great many forms of insects. As these cannot, however, be successfully treated by means of the remedies particularly treated of in this work, they will not be individually described. Those insects which attack the roots of corn, generally appear when the crop has been planted upon sod land, and as a rule the older the sod the more numerous are the insects. Those which work upon the parts of the growing plants above ground are perhaps best treated by collecting them by hand and then destroying them. No effective remedies are known for several of the pests. If the grain is to be stored it will also be exposed to the attacks of certain insects. These may be destroyed very easily by the use of the bisulphide of carbon; but the corn must first be placed in a tight receptacle.

COTTON.

FUNGOUS DISEASES.

Many fungous diseases of cotton have been described,[1] but apparently no good remedies have yet been discovered.

INSECT ENEMIES.

Leaf-worm; Cotton-worm; Cotton-caterpillar (*Aletia argillacea*, Hübn.). — *Description.* The adult insect is a grayish-brown moth whose wings expand nearly one and one-half inches. The slender green worms or caterpillars begin to appear in early spring, the eggs having been laid upon the under side of the young cotton leaves. The number of broods varies from three to six, so the transformations take place rapidly.

Treatment. The arsenites are probably the best insecticides to use in the destruction of this insect. They may be applied

[1] Atkinson, *Ala. Agric. Exp. Sta.* 1892, Dec. Bulls. 36 and 41.

either when mixed with water or when dry. The latter method is preferred by cotton planters, the undiluted poison being placed in osnaburg bags which are held over the plants. Machines which use the poisons diluted about ten times with flour or plaster are also made.

COTTONWOOD.

Fungous Diseases.

Leaf Rust (*Melampsora populina*, Lév.). — *Description.* Poplar and cottonwood trees are frequently attacked by a fungus which produces an orange-colored powder on the under side of the leaves. Such leaves may fall quite early in the year, and if the attack is severe, the trees will be partially or entirely defoliated. The winter stage of the fungus is found upon the under side of the leaves also; waxy pustules of a brown color mark its presence.

Treatment. This leaf rust may be checked by applications of the Bordeaux mixture made early in the season when the first leaves have unfolded; the treatments should be continued at intervals of two or three weeks until about the middle of July.

Insect Enemies.

Leaf-beetle (*Lina scripta*, Riley). — *Description.* This beetle is nearly three-eighths of an inch in length, of a deep, blue-black color, more or less freely marked with yellow, or the ground color may be yellow and the markings black. The adults hibernate during the winter, and lay their eggs upon the young foliage. The eggs soon hatch, and the young black grubs begin to feed voraciously, at the same time growing rapidly. As the larvæ grow older this color becomes of a lighter shade. They have the power of emitting from the spines found upon their bodies a milky liquid possessing a strong odor. There are several broods each year.

Treatment. The arsenites should be freely used for the destruction of the first broods, and if the insects appear again during the summer, the applications should be repeated.

Willow-worm. See under Willow.

CRANBERRY.

FUNGOUS DISEASES.

Gall Fungus; Red Rust (*Synchytrium Vaccinii*, Thomas). — *Description.* The presence of this fungus in the cranberry plant irritates the latter to such an extent that it forms the excrescences or galls which have given the popular names to the disease. These galls are of a red color, and in New Jersey they generally appear upon the young stems, leaves, flowers, and fruit, about the first of May. They are quite small, being no larger than one twenty-fifth of an inch, both in length and in thickness, but they are frequently so numerous that they give to the plant or even to a bog a decided red color. In such cases the affected portions are frequently dwarfed and misshapen. Some of the spores seem to ripen during the winter or early spring, and infection takes place during the early growing months of the year.

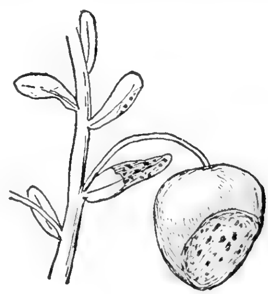

FIG. 51. — Cranberry scald.

Treatment. It has been recommended to burn affected parts; and the suggestion has also been made to keep the bog dry during winter and spring. As the disease apparently progresses by means of new infections, as do most of the fungous diseases which are under control, it seems reasonable to expect that application of such fungicides as the Bordeaux mixture or the ammoniacal carbonate of copper will prove beneficial if made as soon as growth begins in the spring. It would probably be necessary to make several such treatments, but the flowering time of the plants should be avoided if possible.

Scald; Rot. — *Description.* Scald of cranberries is produced by a fungus which attacks the fruit during July and August (Fig. 51). The first sign of the disease is the formation of a small, soft spot upon one side of the berry; or the disease may appear in different places at the same time. This affected part soon extends throughout the entire berry, giving the latter the appearance of having been cooked. It is soft and of a light brown color, but the skin remains unbroken. Later in the season the berry shrivels and may fall to the ground or remain hanging upon the plant. The foliage is also affected, distinct brown areas appearing upon the leaves. The disease is most troublesome during warm, moist seasons.

Treatment. It has been recommended to sand the bog to the depth of an inch as a partial remedy. Keeping the bog as dry as possible during the summer months is supposed to be of service. The use of properly applied fungicides appears promising, but the value of these cannot yet be told.

Insect Enemies.

Fire-worm; Cranberry-worm; Vine-worm; Blackhead (*Rhopobota vacciniana*, Packard). — *Description.* The moths lay eggs on the under side of the leaves during the fall. These do not hatch until the following spring, the young larvæ appearing during the latter part of April or in early May. The moths appear early in June, laying their eggs about the middle of the month. The grown larvæ have jet-black heads, the body being green and having fine hairs scattered over the surface. They feed upon the young leaves, and draw these together by means of silken threads. The moths are grayish-brown, lighter colored bands extending across the fore wings; the hind wings are dull brown. There are two broods.

Treatment. The bogs may be flooded after the eggs have hatched, in this manner drowning the larvæ. Some growers prefer to spray the bogs at this time with tobacco water. Kerosene emulsion might answer the same purpose.

Arsenites, if applied early and thoroughly, have been effectual in destroying these insects. Cranberry foliage appears to be susceptible to injury from these poisons, so that lime should be added. Two quarts of glucose or molasses are said to increase their effectiveness.

Fruit-worm (*Acrobasis Vaccinii*, Riley). — *Description.* The moths appear early in July and lay their eggs upon the small cranberries, generally at the blossom end. The eggs are small, flat, and light yellow in color. They hatch in about a week, producing a little greenish worm, which, when mature, is about half an inch in length. These larvæ first feed a day or two upon the outside of the berry, after which they enter the fruit, hollowing it out, and then another berry is attacked. The larvæ do not pupate till fall, passing the winter in this condition.

Treatment. The habits of this insect render it of easy destruction by the use of the arsenites. The bogs should be sprayed as soon as the fruit has set, and later applications be made at intervals of about ten days as frequently as appears to be necessary. Two treatments will probably prove to be sufficient in the majority of cases. No danger of poisoning the berries need be feared.

There are several other insects which feed upon the foliage and the fruit of cranberries; among them may be mentioned a weevil, the yellow-headed cranberry-worm, and the tip-worm. Proper applications of the arsenites, if made when the insects begin to cause trouble, will practically control the pests. Paris green is on the whole the safest insecticide, but it should be used with an equal volume of lime. Some farmers use tobacco water with satisfactory results. Proper flooding will also materially reduce the number of insects.

CUCUMBER.

Fungous Diseases.

Mildew (*Erysiphe Cichoracearum*, DC.).—*Description.* The cucumber mildew caused by this fungus is found almost entirely in greenhouses. All parts of the vines are affected, although upon the fruit the disease is not so serious. The parasite grows merely upon the surface of the plant, producing white, moldy areas, which appear as if they consisted of a white powder scattered thinly upon the affected part (Fig. 52). These may be so abundant that the entire upper surface of a leaf is covered, and the stems are frequently surrounded by the fungus for a considerable distance. These spots may be easily removed by rubbing the leaf, since the only portions of the parasite which enter the cucumber plant are small projecting threads that enter the cells, and from these the nourishment is drawn.

Treatment. Fungi growing upon the surface of the host-plants may be successfully treated whenever they are seen, and the cucumber mildew is no exception to the rule. It may be controlled by spraying with a solution of the liver of sulphur, the ammoniacal carbonate of copper, or the Bordeaux mixture. These should be used at about three-fourths their normal strength, as cucumber foliage is tender and the disease is not

FIG. 52. — Cucumber mildew.

difficult to overcome. The fumes of sulphur are also effective in destroying the fungus. This mildew also attacks verbenas, in which case applications of the sulphide of potassium have given good results.

Powdery Mildew (*Plasmopara Cubensis*, B. & C.) See under Muskmelon.

Insect Enemies.

Melon-louse (*Aphis Cucumeris*, Forbes). — *Description.* This louse attacks cucurbitaceous plants, especially cucumbers and muskmelon vines, about the middle of June. The affected leaves curl, the edges turning downward and inward, and thus affording protection to the insects, which propagate at a very rapid rate. Large quantities of honey-dew are excreted, and in this material a fungus grows which blackens the vines in a manner similar to that which occurs on pear trees attacked by the psylla. Badly infested plants die.

Treatment. The vines should be closely watched during the season, and the curling leaves should be removed and destroyed with the insects upon them. Applications of the Hubbard-Riley kerosene emulsion, diluted about fifteen times, made to the under side of the leaves will be of value; or whale-oil soap, used at the rate of one pound to six gallons of water and similarly applied, will also prove effective. The insect is a difficult one to keep under control.

Melon-worm (*Eudioptis hyalinata*, Linn.). — *Description.* The adult insect is a moth of bright, pearly-white color. A dark border extends along the front and outer edges of the fore wings, and along the lateral margin of the hind wings. The larvæ are a little over an inch in length, yellowish-green in color, a few hairs being scattered over the body. They feed upon the foliage and fruit of melons, cucumbers, squashes, etc., being particularly destructive in the southern states.

Treatment. Hellebore may be used successfully; but the arsenites offer perhaps the best means of destroying the insects.

Spotted Cucumber-beetle; Southern Corn Root-worm (*Diabrotica, 12-punctata*, Oliv.). — *Description.* The adult insect is a beetle about one-fourth of an inch in length. It is yellow in color, but has twelve black spots upon its back, as its name implies. The winter is passed in the mature stage. The eggs are laid in spring about the roots of cucumbers, squashes, etc., and in the South corn is very commonly selected. The eggs produce a slender, dirty-white worm, which is about half an inch in length when full grown. There are two broods each year. The beetles feed upon the plants mentioned above, and also upon other garden vegetables.

Treatment. See under STRIPED CUCUMBER-BEETLE.

Striped Cucumber-beetle (*Diabrotica vittata*, Fabr.).—*Description.* The beetle appears early in spring and attacks the leaves and stems of the cucumber and related plants. Eggs are laid, these being placed in the soil at the base of the plants. The eggs soon hatch and produce small whitish worms that are about half an inch long when full grown. They feed upon the roots of the plants, causing the latter to wilt and die. The larvæ mature in about two months, the insect passing the winter in the beetle form. It is then very handsome, the back being yellow but marked with three black stripes running nearly the length of the wing covers. The length of the insect is scarcely a quarter of an inch; but the pest is so abundant in spring that serious damage is inflicted if no steps are taken to prevent injury.

Treatment. The more difficult it is to destroy an insect, the more remedies are recommended, and the very number of these is good evidence that none are specifics. Powders have generally been recommended for the destruction or disposal of the two insects above described. Tobacco powder, or dust, is perhaps the best of these, especially if a little carbolic acid be added to it. The powder may be applied freely to the plants, and applications should be repeated at intervals of a few days, selecting a time when the plants are wet. In place of the above, it has been recommended to use lime, plaster, road-dust, etc., and kerosene may be substituted for carbolic acid. The arsenites, when used dry and mixed with some of the above, may also possess considerable value. All application should be made early, and, if possible, to the under side of the leaves. Spraying has not yet proved satisfactory.

Plants are frequently protected by means of a device consisting of a light frame, as two pieces of barrel-hoops crossing each other at right angles, covered by some fine mosquito netting. The frame is placed over the young plants, and over this is spread the netting. The edges of the latter must be well covered with earth, else the beetles will succeed in entering, and when once under the netting it appears to be impossible for them to get out again. When the plants have made a good growth the screens may be removed.

CURRANT.

Fungous Diseases.

Anthracnose; Leaf Blight (*Glœosporium Ribis*, M. & D.). — *Description.* During the latter part of June and early in July there occasionally appears upon the upper side of the foliage of cultivated currants small brownish-black spots, which are as yet still confined to the interior of the leaf tissue. As these spots enlarge, the epidermis on the upper side of the leaf becomes raised and loosened, and this gives a whitish appearance to the affected part, although the general color of the diseased tissue is dull brown. The entire leaf then changes to yellow, and finally it falls to the ground, this taking place early in August.

Treatment. Although the disease has apparently remained untreated, it is very probable that applications of fungicides, if made thoroughly and early in the season, will prove effective in controlling the trouble.

Rust; Leaf Spot (*Septoria Ribis*, Desm.; *Cercospora angulata*, Wint.). — *Description.* This disease attacks all varieties of currants, generally appearing a little before midsummer. It attacks the foliage of gooseberries as well. The first indication of the disease is the appearance of small brown spots upon various parts of the foliage (Fig. 53). These may be so abundant as to form considerable areas.

What is probably another disease causes the formation of whitish spots having black centers. These fungi are often present at the same time, and as their histories are not yet fully known and their treatment is the same, the two may here be considered together. They cause the leaves to fall from the bushes when the attack is severe, so that the plants may be entirely bare during the latter part of the summer, thus greatly weakening them.

Treatment. The plants should be sprayed with a clear fungicide, as the ammoniacal carbonate of copper, to avoid staining the fruit. After harvesting, the Bordeaux mixture may be used to advantage. The first application of the season should be made about two weeks before the spots may be expected. Since the Bordeaux mixture, if properly prepared, cannot injure the plants, it may be freely applied.

INSECT ENEMIES.

Borer; Imported Currant-borer (*Sesia* [*Ægeria*] *tipuliformis*, Linn.). — *Description.* The parent moth, which is about three-quarters of an inch across the expanded wings, is bluish-black in color, and has three yellow bars extending across the abdomen. The eggs are laid in the spring, and the small white larvæ which soon appear gnaw to the pith, upon which they feed. They pupate in the fall, but the moth does not appear

FIG. 53. — Currant leaf spot.

till the following spring. The presence of this borer materially reduces the vitality of the cane in which it feeds, to the injury of the crop. Gooseberry plants are also occasionally affected.

Treatment. The best way to overcome the pest is to watch for weak canes, and when these are found they should be cut off close to the ground and burned.

Currant-worm; Currant Saw-fly; Gooseberry Saw-fly; Imported Currant-worm (*Nematus ventricosus* Klug.). — *Description.* The currant-worm was imported from Europe probably some years before 1860. The adult insect is a four-winged fly which bears a certain resemblance to the common house-fly, except that it is somewhat larger and has a yellowish appearance. These flies may be seen in abundance in early spring hovering about the currant and gooseberry bushes, just as the first leaves are expanding. The small, white eggs are laid on the under side of these leaves, generally in rows along the larger veins. The eggs hatch in a week or ten days, and the worms immediately begin feeding. The presence of these insects is frequently not noticed until fully one-half or two-thirds of the leaves have been destroyed; this arises from the fact that the eggs are almost invariably laid upon the leaves which are near the ground, and also near the center of the plant. The upper foliage is therefore reserved till the last, and then when this also is gone the bushes appear as if suddenly defoliated. The young larvæ are at first whitish in color; they soon become green, and later they are spotted with black. Before pupating they again become green. There are from two to four broods a year.

Treatment. There is no insect which is more easily controlled than the currant-worm, yet there is scarcely one which is left so undisturbed in its destructive work. The principal trouble is that the pest is not noticed until the currants are about one-half grown, and at that time much damage has already been done, and eggs are being laid for a second brood. If the plants be thoroughly sprayed with an arsenite as soon as the first leaves are nearly grown, no injury will be done to the fruit, and practically all of the first brood will be killed, and with it the second one also. But this first treatment must be made early. If later ones are necessary, hellebore will be found an effectual remedy, whether applied dry or mixed with water. Such applications will also free the bushes from other leaf-eating insects.

Four-lined Leaf-bug; Black-lined Plant-bug; Four-striped Plant-bug; Yellow-lined Currant-bug (*Pœcilocapsus lineatus*, Fabr.). — *Description.* The mature insect (Fig. 54) is a bug about one-third of an inch long. Its back is yellow, but four black stripes extend nearly its entire length, and these have given rise to the many popular names of the insect. Eggs are laid near the tips of the soft growths about a week after the appearance of the adults. The eggs do not hatch until the following spring, the young insects appearing during the latter part of May. While young they are bright red in color, but later more black appears (Fig. 55). The adult insect may be found during June and July. The insects attack the leaves at the tips of the shoots, sucking out the juices. This causes the formation of small, brown, angular areas of dead tissue (Fig. 56), which at once indicate the presence of this bug by giving the leaves a characteristic spotted appearance.

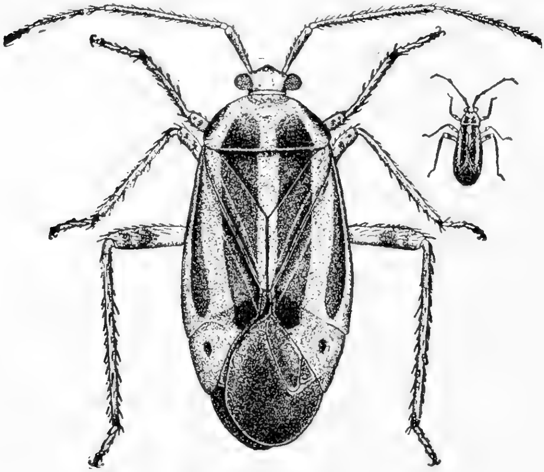

Fig. 54. — Four-lined leaf-bug of currants, adult.

Treatment. The insect is extremely active during the day, but in the early morning it may be jarred from the currant or gooseberry bushes and caught in pans containing kerosene. Kerosene emulsion, containing at least 9 per cent of the oil, will destroy the immature insects, but it must be made still stronger to kill the adults. The young insects should be destroyed if possible. A third way to overcome the pest, and perhaps the best one, is to cut off the tips of the shoots which carry eggs and then destroy them.

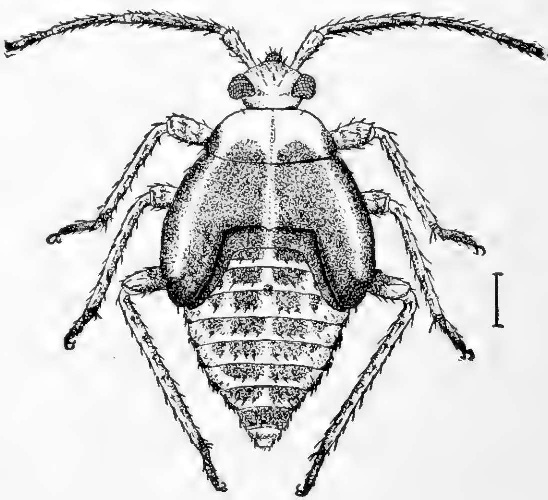

Fig. 55. — Four-lined leaf-bug, immature form.

Green Leaf-hopper; Currant Leaf-hopper (*Empoa albopicta*, Forbes). — *Description.* These insects are true bugs. They are rather slender, and about an eighth of an inch in length. The color is light green, almost white. The insects suck the juices from the under side of the foliage, and this causes the formation on the upper surface of white areas which invariably

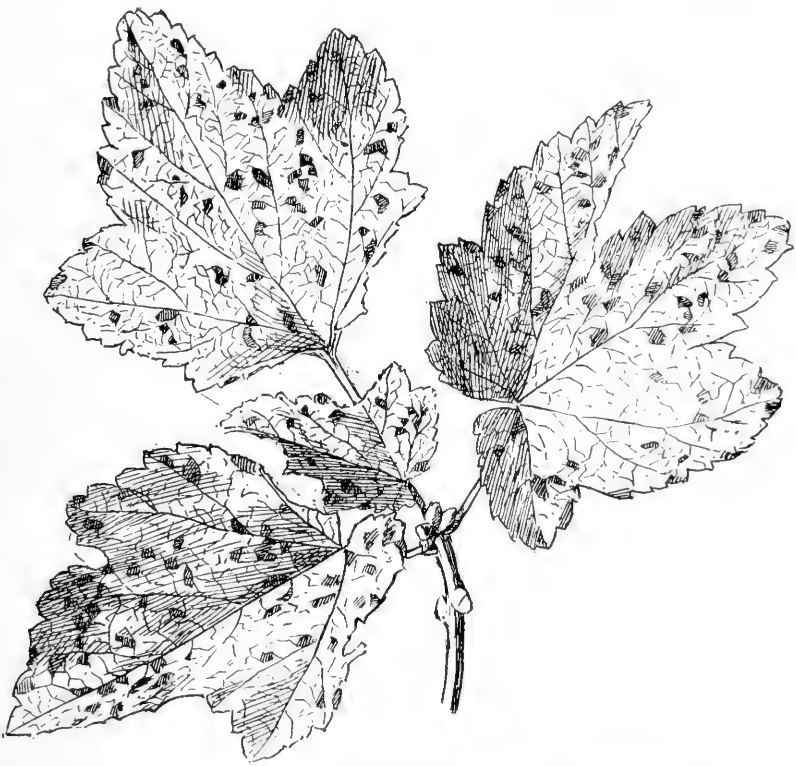

Fig. 56. — Currant foliage injured by the four-lined leaf-bug.

indicate the presence of the pest. Currants and gooseberries suffer most severely from the first brood, during May and June.

Treatment. Insecticides which kill by contact must be used. Kerosene emulsion, if directed towards the under surface of the leaves, will destroy great numbers. Pyrethrum may be used successfully, if the plants are first thoroughly wet, and the powder then freely dusted upon the foliage, from beneath if possible. Tobacco dust or liquor, or some of the many liquid commercial insecticides, will prove of value if properly applied. Whale-oil soap has also been recommended.

DAHLIA.

Four-lined Plant-bug. See under CURRANT.
Green Lettuce-worm. See under LETTUCE.

EGGPLANT.

FUNGOUS DISEASES.

Anthracnose (*Glœosporium Melongenea*, E. & Hals.). — *Description.* This fungus appears to attack the fruit more seriously than the other parts of eggplants. It causes the formation of shallow pits in which very small pink blotches appear. The disease has as yet not caused much loss, and no attempts directed towards its treatment appear to have been made. It is probable that the remedies recommended for the leaf spot will be sufficient for checking the anthracnose.

Leaf Spot (*Phyllosticta hortorum*, Speg.). — *Description.* When this fungus attacks the foliage of eggplants it causes the leaf tissue to turn brown, and later it becomes dry and brittle. These parts may in a short time fall from the leaf, forming openings of varying sizes. When several of such areas are situated near each other, large portions of the leaf may be affected, and it frequently happens that the plants lose nearly all their foliage in this manner. The fruit appears to be affected by the same fungus. Here it appears as a dark discoloration which causes the fruit to rot, and consequently renders it worthless for market.

Treatment. If the leaf-spot fungus is feared, the young plants should be sprayed with the Bordeaux mixture as soon as they have become established in the field. Applications should be repeated at intervals of two or three weeks. When the fruit is approaching maturity, a clear fungicide should be applied in place of the Bordeaux mixture, to avoid staining the fruit.

INSECT ENEMIES.

Potato-beetle. See under POTATO.

ELM.

INSECT ENEMIES.

Canker-worm. See under APPLE.

Elm Span-worm (*Eugonia subsignaria*, Hübn.). — *Description.* These insects hatch from eggs as soon as the buds break in the spring. The larvæ are commonly known as measuring, or span-worms. They are grayish-brown in color, having a large, red head, and the last segment of the body is of the same color. The larvæ pupate about the end of June, and during July and August the mature insect appears. It is a pure white moth, the wings expanding nearly one and one-half inches.

Treatment. When possible, the affected trees should be thoroughly sprayed with Paris green used at the rate of one pound to 150 gallons of water. This is the best remedy against all insects which work on the foliage of shade trees, but when the trees are large much difficulty is experienced in reaching all parts. See also page 195.

Gipsy Moth (*Ocneria dispar*, Linn.). — *Description.* The gipsy moth is found in America only in the immediate vicinity of Boston. It has there caused great damage, as the larvæ are voracious feeders and take kindly to nearly all foliage. The eggs of the moth are laid during July, August, and September, generally near the pupa case of the female. They are deposited in clusters, and covered with a thick layer of yellow hairs. The following spring the young caterpillars appear, and for about ten weeks they feed upon the foliage of most plants. When grown they are two inches or more in length, and greenish-brown in color. Each segment of the body bears upon either side a tuft of hairs, while along the back there is a double row of spots, those on the four anterior segments being purple in color; the remainder are brown. The insects pupate in some sheltered spot on the trees, or in neighboring fences, etc. In this state they remain about ten days, when the adults appear.

Treatment. The caterpillars are readily destroyed by the arsenites, Paris green and the arsenate of lead having been most extensively used. The latter is effective when used at the rate of two pounds to 150 gallons of water. It is not feasible in many cases to make such applications, so the insects are destroyed by collecting the eggs, and destroying them, and also by trapping the larvæ under bands of burlap, or some similar material, bound about the trunks of the trees.[1]

Imported Elm-leaf beetle; Elm Flea-beetle (*Galeruca xanthomelæna*, Schr.). — *Description.* The mature insect resembles the striped cucumber-beetle in size and markings. The larva is long, slender, and yellowish-black. It has a yellow band extending along the back and sides. The pest is most active from May till August, eating the soft tissues of the leaf, but not the veins. There are three or four broods. Serious eastward.

Treatment. The arsenites should be used when possible, spraying the tree thoroughly. When large trees are attacked, the insects may be destroyed by pouring hot water into all crevices and cracks about the base of the tree and in the immediate neighborhood. The insects pupate at the surface of the ground wherever a slight shelter can be found. Kerosene emulsion applied in the same manner would also probably prove effective in their destruction.

Willow-worm. See under WILLOW.

GOOSEBERRY.

FUNGOUS DISEASES.

Mildew (*Sphærotheca Mors-uvæ*, B. & C.). — *Description.* The fungus attacks the foliage and young fruits soon after the buds have broken. The first appearance is the formation of a cobweb-like covering which fits close to the plant. Later these areas become whitish, and apparently sprinkled with a fine white powder. Affected leaves and shoots are checked in their growth, and finally they become dry and brown; diseased shoots often branch freely (Fig. 57). The berries are checked in their growth, and generally drop from the bushes long before the time of maturity. They also show the powdery covering.

Treatment. The disease is caused by a surface fungus, and the white threads seen on the host-plants form the body of the parasite. This may be destroyed by applications of fungicides, especially some of the copper compounds, or of the sulphide of potassium. Weekly applications of the latter have given excellent results. To avoid staining the berries, clear fungicides

[1] See the reports of the Mass. State Bd. of Agric. on the "Extermination of the Gipsy Moth."

should be used, although the Bordeaux mixture may be applied once or twice early in the season. The first application should be made before the buds start in the spring.

INSECT ENEMIES.

Gooseberry Fruit-worm (*Dakruma convolutella*, Hübn.). — *Description.* A pale, gray moth lays its eggs upon the young

FIG. 57. — Gooseberry mildew. The shoot on the left was sprayed, the other not.

gooseberries in early spring, and the larvæ which appear enter the berries and feed within them. This causes the fruit to ripen prematurely. When the worm is full grown it is about three-fourths of an inch in length; its head is brown, but the body is light green. It leaves the berry and enters the ground, passing the winter in the pupa state.

Treatment. The affected berries should be destroyed when discovered. Poultry will aid in destroying the larvæ before they pupate. It has been recommended to spray with the sulphur and whale-oil soap wash just before the eggs are laid.

The other insects which work upon gooseberries have been mentioned under CURRANT, which see.

GRAPE.

FUNGOUS DISEASES.

Anthracnose; Scab; Bird's-eye Rot (*Sphaceloma Ampelinum*, DeBary). — *Description.* Anthracnose is perhaps the most formidable disease with which the vineyardist has to contend. It does not yield to the same treatment which checks the other fungous diseases of the grape, and even when applications are made which are especially designed for its control, the results are not invariably satisfactory. The vines should therefore be watched, that the first sign of the disease may lead to its timely treatment.

The fungus causing anthracnose attacks the fruit, the leaves, and the stems, in fact, all green parts of the vine. It may appear any time during the growing season of the plant, but most commonly affects the berries during the middle and latter part of summer. The name "anthracnose" is now generally used in this country and in Europe. It is formed from two Greek words meaning "coal" and "disease," the dark discoloration of the affected part suggesting the name.

The shoots of the grape are very subject to the attacks of the fungus. The first indication of the trouble is a darkening and sinking of small, oval areas which extend lengthwise of the stem. These may be very abundant, giving the shoots a speckled appearance. The spots gradually enlarge, and the center assumes a gray color, the edges still remaining dark, and having a more or less decided tinge of purple. After the disease has progressed some weeks, the stem is very seriously injured, and if there have been several points of attack, its growth may be entirely checked and the shoot destroyed. Upon the leaf the disease causes changes very similar to those of the stem, but there is a reddish-brown color in the affected areas, which renders it more difficult to distinguish this disease from some others. But one peculiarity of anthracnose is that it generally attacks the veins of the leaves, as well as the leaf-stems, and so its identification is not always difficult. The stems of the clusters are also injured, and it frequently occurs that a part is completely girdled, causing a "ring-around," as it is commonly called. The berries below the ring do not ripen, but remain green, and gradually shrivel.

The berries of some varieties of grapes are almost invariably affected to such an extent as to render them unfit for market. The Vergennes, Diamond, Salem, Agawam, and many others are very susceptible to its attacks. The first indication of the presence of the fungus on the berries is the formation of distinct brown spots which are practically circular in outline (Fig. 58). The discolored part is sunken, and may be bordered by a margin which has a tinge of red or purple. If a berry is attacked in several places, it becomes speckled in appearance, until the spots grow into each other, forming considerable areas of irregular outline. The portions first diseased may change to a lighter, or even to a gray color, on account of the rupturing of the epidermis or outer skin, forming a hardened "scab."

Treatment. In Europe, where the fungus has long been known, it is the custom to wash the vines and the stakes during winter or early spring with the sulphuric acid and sulphate of iron solution. The liquid is applied by means of swabs or brushes. It blackens the canes, and this is a test of the thoroughness of the work. See pages 45, 152.

If, after two or three days, there remain portions which are unchanged in color, the vineyard is treated a second time, particular attention being paid to the parts omitted at the first treatment. In addition to these winter treatments, the vines are sprayed during the summer months with the Bordeaux mixture. As these applications are made more particularly for other diseases, the downy mildew and the black rot, they will not be mentioned here in detail.

European vineyardists seem to have perfect control of anthracnose by following the above line of treatments, and the work done in America is also promising. The cost of washing vines and stakes in this country scarcely exceeds two dollars per acre, as shown by actual trials, and marked benefits appear to have followed the practice, even under adverse circumstances. Vine-

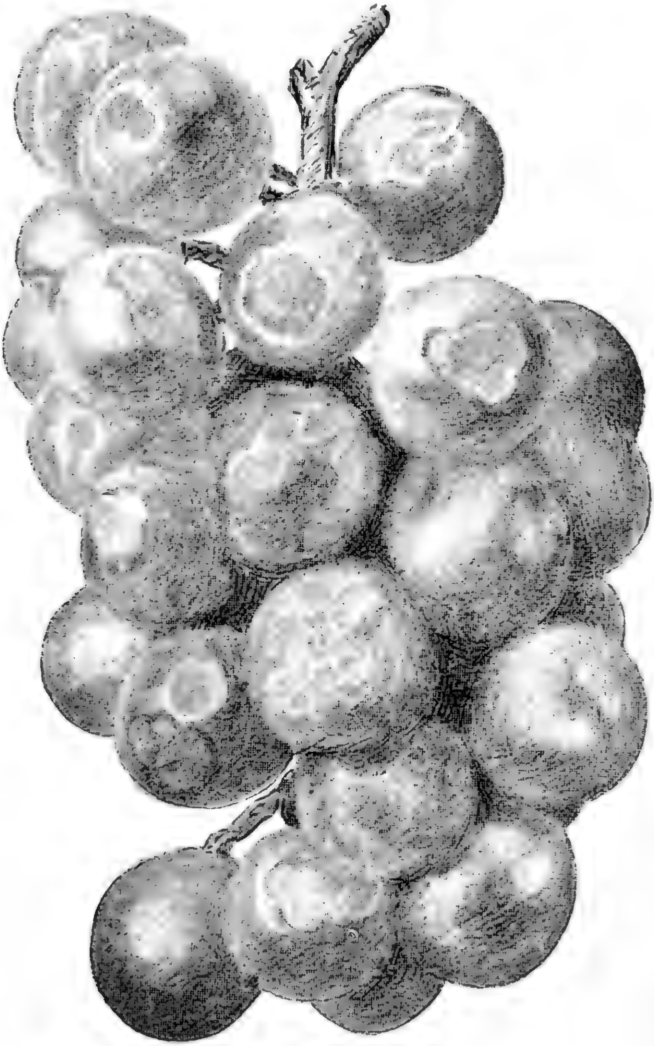

Fig. 58. — Brighton grapes affected with anthracnose.

yardists whose grapes are troubled with anthracnose are advised to give the above remedy a thorough trial, for it is the best as yet known.

Black Rot; Charbon (*Læstadia Bidwellii*, V. & R.; *Phoma uvicola*, B. & C.). — *Description.* The name "black rot" has been commonly applied to this disease on account of the appearance of the affected berries, these being of a deep black color. But the fungus causing the rotting of the fruit also attacks other parts of the plant. On the shoots it forms dark, oval areas, which are slightly sunken. The centers of such spots are more or less thickly studded with very small elevations or pimples, these being characteristic of the disease, and by their aid the trouble can in most cases be identified. Affected leaves turn to a dark, reddish-brown color at the injured part. These portions are generally found between the larger veins, and not centered upon them, as in the case of anthracnose. Their outlines are generally rounded.

To the vineyardist such attacks are, however, of slight importance as compared with those which injure the fruit. There is probably no fungous disease of the grape which annually causes greater losses than the black rot. Although each berry must be separately affected, since the disease does not spread from one to the other by means of the stems, yet the conditions are generally so favorable that a large percentage of the crop is annually lost. This applies particularly to southern vineyards, for in them the disease is much more virulent than at the North. In New York, the fungus is not generally serious, only those regions being visited in which the climate is ameliorated by bodies of water, or by other local conditions. Localities in which the Catawba ripens well may be considered as subject to the disease; colder climates are comparatively exempt.

Grapes which show the attacks of the black-rot fungus are generally nearly or quite full grown (Fig. 59). It is therefore during August and September that the disease is most to be feared. If the berries are still green when the fungus gains an entrance, the affected part turns a purplish brown, this color gradually extending to the entire berry, which still retains its form and firmness. The part first attacked gradually becomes blackened, and characteristic pimples appear. At the same time the berry shrivels and becomes strongly ridged, the seeds projecting prominently under the drawn skin; the entire berry is then black, and minute elevations may be seen scattered thickly over its surface. These changes may take place very rapidly, so that apparently in a few days a crop may be largely reduced. It seems to require about a week for the disease to become noticeable after infection takes place, the rapidity of the later changes depending very largely upon the condition of the weather. A warm, moist atmosphere is particularly favorable to the development of this fungus.

Treatment. Although the black rot appears late in the season, it is always safe to begin early in treating the vines. The copper compounds, especially the Bordeaux mixture, have shown themselves to be practically specifics against this disease. Applications should be made before the disease has appeared. In the South, where the rot is a regular visitor, the treatments may be commenced to advantage as soon as the first leaves have fully expanded. The second application may be made after the vines have blossomed, and the third from two to four weeks later, depending upon the season. The Bordeaux mixture may be used with safety up to the time when the berries are three-fourths grown, but if used later than this, there is danger of staining the clusters and reducing their market value. This may be partially avoided by reducing the strength of the normal mixture one-fourth or one-third; although not so effective as the stronger mixture, the dilute form still possesses much value as a fungicide, and it may be used to advantage. Or the ammoniacal carbonate of copper may be used in its place, and this is the fungicide very commonly employed when the later applications are made. If the weather is favorable to the disease, applications should be made about every ten days after the fruit is grown. Six or seven applications should practically prevent the appearance of the disease, even in badly infested districts.

In the North, where the attacks are not so severe, the treatments need not be begun so early. If the vines are thoroughly sprayed about the first of July, and two additional applications are made at intervals of two or three weeks, little trouble need be anticipated from black rot.

But everything depends upon the thoroughness with which the work is done. It was formerly supposed that to spray the clusters was injurious to them; but this is a fallacy. The clusters should be treated as well as the foliage, especially when they are young, and if the practice can be continued without

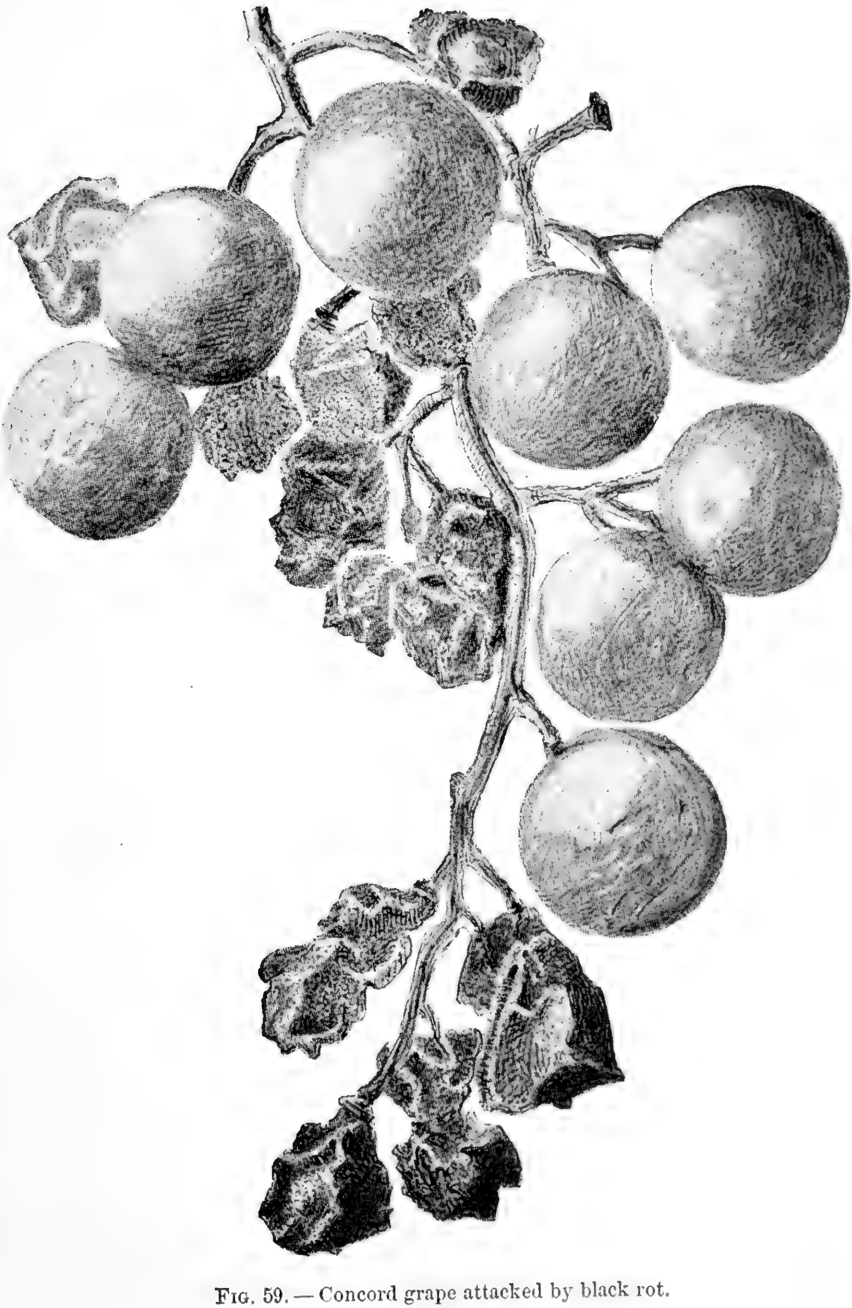

Fig. 59. — Concord grape attacked by black rot.

injury to the appearance of the fruit, so much the better. It is necessary that the growth from the spores which fall upon the berries should be stopped, and this can only be accomplished by treating the clusters, as well as the other parts of the vine.

The cost of spraying grape-vines depends upon a great many factors, all of which cannot here be discussed in detail. Good machinery is of the greatest importance, for upon this depends the quality of the spray. Reliable help will also increase the cost of the work, for such men will use more time and more material than shiftless workers. Yet only such labour should be employed. The time of the year also affects the cost of the work, since early in the year there is much less surface to be covered. The character of the season also influences the total outlay of the year, for in some seasons twice as many applications may be required as during others. A few data regarding the spraying of grapes may be mentioned, with the assurance that they will serve as guides to those beginning the work.

Taking an average of the applications made during the entire season, it may be said that each vine should receive approximately one quart of liquid at each application. The cost of material and labor should not much exceed one-half a cent per vine for each treatment, whether the Bordeaux mixture or the ammoniacal carbonate of copper is used, the latter being a little more expensive. When this small outlay is compared with the great benefits which so commonly result from the work, it is strange that the practice is not more generally followed. The above figures refer to vines of the Concord type, these making a very extensive growth. For less vigorous varieties the cost may be reduced, and the use of some of the machines now manufactured will still further lessen the expense. This is especially true in the North, where the black rot and other fungous diseases of the grape are not so serious as southward.

Downy Mildew; Brown Rot; Gray Rot (*Peronospora viticola*, DeBary). — *Description.* This fungus attacks the stems, foliage, and fruit of the grape-vine. While it is not generally so serious as the black rot, in the northern states it is more commonly seen, and probably causes the loss of more grapes than its southern neighbor.

The external characters of the downy mildew are very distinct. On the shoots it causes the formation of brown, slightly sunken areas; these may be easily distinguished from the deeper and more distinctly marked spots caused by anthracnose. But

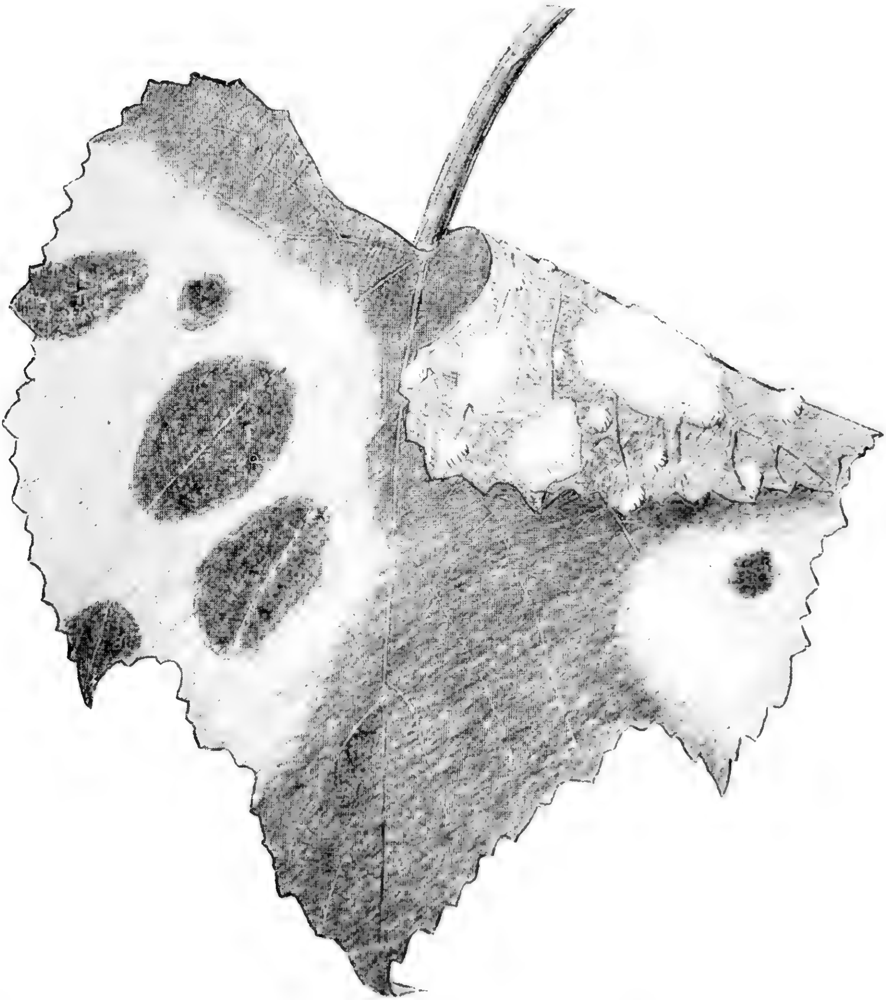

Fig. 60. — Downy mildew upon grape foliage.

it is only in very severe cases that the shoots are affected to an injurious extent. It is on the foliage and on the fruit that the greatest harm is done. The foliage (Fig. 60) first shows the presence of the parasite by portions of the leaf turning a lighter green than that of the normal tissue. Later, these parts turn yellow, and when the destruction of the tissue is complete, the parts affected are of a brown color. If the under surface of such leaves is examined, it will be found that there is a frost-like substance projecting from the discolored part of the leaf after the upper surface has begun to turn yellow. This appearance is due to the formation of fungous threads which project beyond the leaf surface and bear the summer spores of the parasite. This appearance assists materially in identifying the disease.

The fruit is also very susceptible to the attacks of the downy mildew; but when that is affected, the vine does not suffer so much as the grower does. In case of diseased foliage, the crop of the next year, as well as that of the present, is threatened; but with diseased fruit it is only a matter of the present year, which is all-sufficient to make the grower anxious to know what can be done.

In the southern states the mildew appears during June, but in the North it is not feared before July. The young berries suffer very extensively. They are generally attacked before they are one-half grown. The name "brown rot" has been applied to such fruit on account of the brown color which supplants the green. Later, as the fungus matures, the affected berries become covered with a whitish powder, — the fruiting threads and the spores of the parasite, — and this gives the berries a gray color, from which has come one of the popular names of the disease. Both forms of the rot are nevertheless caused by the same organism, although the external characters differ.

Treatment. The downy mildew of grapes may attack the vines throughout the growing season, and for this reason it is more essential that applications be made earlier in the year than those necessary for the control of the black rot. Where downy mildew is found, an application made when the shoots have grown from six to ten inches is a very important one. The second should be made after the vines have blossomed, and later ones should succeed each other at intervals of two to four weeks, taking the same precautions against staining the fruit as mentioned under BLACK ROT. The treatments should be preventive rather than curative.

Powdery Mildew (*Uncinula spiralis*, B. & C.).[1] — *Description.* The fungus causing the powdery mildew of the grape differs from the preceding diseases in the fact that it is a surface fungus, the body of the parasite not being found in the tissues of the host-plant, but upon the surface of the green parts. The vines are attacked throughout the growing season, but contrary to the general rule, the disease develops more abundantly during comparatively dry weather. It is therefore found over a wide territory, but fortunately it is not as a rule very serious.

Young shoots attacked by the powdery mildew are checked in their growth, and if the threads of the fungus are abundant, they impart to the affected portion a grayish-white color. This color is particularly noticeable upon the leaves (Fig. 61), for the fungus almost invariably grows upon their upper surface, and if allowed to develop unchecked, large patches soon become covered so thickly that the green parts underneath can no longer be seen. If these patches are firmly rubbed, the white covering may be removed, and the browning of the parts formerly covered will be seen. This is especially distinct when the mildew has made an energetic growth. The discoloration is due to the small suckers which the fungus has projected into the leaf cells for the purpose of obtaining nourishment, and the greater the number of these suckers, the more marked is the discoloration.

Affected berries show similar discolorations, and the whitish covering may be removed as well. As the berry grows, the injured parts assume a brown, scurfy covering which is composed of dried epidermis. This golden-brown film is very commonly seen upon green grapes; it is often cracked so that the green tissue is visible. Such disfigurements are, however, not always caused by the powdery mildew, since any cause which destroys portions of the epidermis will be followed by similar discolorations.

Treatment. The powdery mildew is not a serious disease, and as the body of the fungus is not within the host-plant, there is little occasion for treating the vines until the fungus

[1] The common surface mildew of European vines is Oïdium Tuckeri. B. In general appearance it resembles our powdery mildew. But it is more easily controlled, the flowers of sulphur having long proved to be a specific.

has put in an appearance. Sulphur has been very generally recommended for its destruction, the application being made either with the dry powder, or after the sulphur has been mixed with water. This remedy has not given uniformly good results out of doors, and a safer plan is to use some of the copper compounds. Carbonate of copper dissolved in ammonia

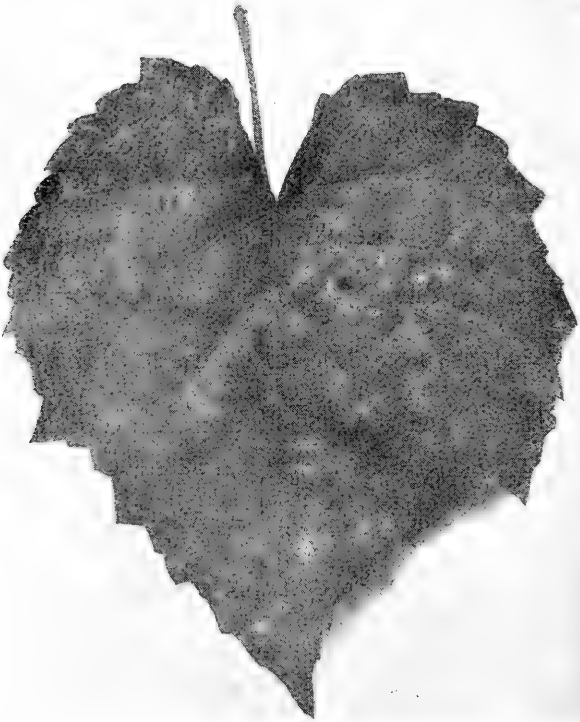

Fig. 61.—A fresh attack of powdery mildew upon grape foliage.

is an excellent remedy, and it is easily applied. All parts of the plants should be treated.

Rattles; Shelling.—*Description.* It frequently occurs that grape-vines drop their berries just as the latter are ripening. The outer extremities of the clusters are first affected. This trouble is primarily caused by defective nutrition of the berries, and, although to a certain extent influenced by the action of fungi and insects, the remedial measures should be directed towards strengthening the plant by means of proper fertilizers, potash being perhaps the most important element required. See *Cornell Bulletin*, 76, for a full account of the trouble.

Ripe Rot; Bitter Rot (*Glœosporium fructigenum*, Berk.). — *Description.* The names given this disease are suggestive of the time in which the berries are attacked, and what effect the fungus has upon the flavor of the fruit. The disease may attack the fruit stems, and cause the berries to wilt on account of the supply of nourishment being cut off. But more commonly the berries are directly attacked. Such fruit shows a reddish-brown discoloration at the affected point, and this color soon extends over the entire berry. The surface then becomes dotted with black pimples as in the case of black rot, but here they are not so numerous, and they are also larger but less elevated. The berry also shrivels, but the black color is wanting, since those affected with ripe rot remain dark purplish brown, although some assume a red tint. As a rule, they fall to the ground when this stage is reached, while berries destroyed by black rot remain upon the vine even until the following spring.

Ripe rot will spread after the grapes have been harvested, and care should therefore be exercised in selecting only sound fruit when it is to be stored. See under Apple, page 240.

Treatment. The same treatment which serves to check black rot will also control this disease, the later treatments being of special importance.

Insect Enemies.

Grape-slug; Grape-sawfly (*Selandria Vitis*, Harris). — *Description.* The adult, a small four-winged fly, lays its eggs in little clusters on the under side of the young leaves. These eggs produce small yellowish-green larvæ, which feed in groups, beginning at the margin of the leaf and eating inwards until the leaf is destroyed. Others are then attacked, and it frequently occurs that very serious injury to the vineyard is done by this insect. There are two broods, the first appearing in spring, and the second in July or August. The winter is passed in the pupal state.

Treatment. The larvæ are easily destroyed by spraying affected vines with an insecticide, such as an arsenite, hellebore, or kerosene emulsion.

Grape-vine Flea-beetle; Steely-bug (*Graptodera chalybea*, Illig.).—*Description.* This insect passes the winter in the adult form. As soon as the buds of the grape commence to swell in the spring the beetles begin feeding, the centers of the buds appearing to contain the most coveted portions. When a bud has been eaten in this manner it is of course useless, and in cases of severe attacks, which sometimes occur, the entire crop of the year may be ruined in a short time. The beetles feed for about a month, when eggs are laid in clusters on the under side of the leaves. Small, dark-brown larvæ soon appear, and these immediately feed upon the foliage. In about four weeks they leave the vines and pupate, the adult beetle appearing in about three weeks. It then continues feeding until fall.

Treatment. This insect is very easily controlled. The vines should be sprayed with Paris green when the beetles first attack the buds, and again when the young larvæ appear. One or two applications made during each of these two periods will practically clear a vineyard of the pest.

Leaf-hopper; Thrip (*Erythroneura Vitis*, Harris).—*Description.* This insect passes the winter in the adult form. It is about an eighth of an inch long, of a white color, but marked by three dark red bands. Eggs are laid in the leaves, the larvæ appearing in June. These miniature forms are without wings, but otherwise closely resemble the adult, except in being smaller. They moult several times, their white cast-off skins adhering to the under surfaces of the leaves for some time. They feed upon the juices of the plant. Grapes having thin foliage suffer more from these insects than do the heavier-leaved varieties. The affected leaves appear indistinctly spotted with white on the upper surface, and frequently much injury is done to the vine.

Treatment. The treatment of this pest is unsatisfactory. If the fallen foliage is gathered and destroyed so the insects cannot find proper shelter during the winter, their number will be materially reduced. The remedies suggested for the currant leaf-hopper may be of avail in the vineyard.

GREENHOUSE PESTS.

Fungi Infesting Plants.

There is such an enormous variety of plants grown under glass that each cannot here be treated individually. Nor is this necessary, for a few general directions may be made to cover almost all cases. Fungi as a rule prefer a warm, moist atmosphere for their growth, and this is generally found in a greenhouse, as it is essential to the proper development of many plants. But the general opinion of gardeners is that even when such conditions exist, mildews need not necessarily appear. It is said that extremes of temperature, of humidity, and draughts of air are conducive to disease, and common practice tends strongly to support the notion. Such conditions should therefore be avoided as far as possible.

Some of the surface fungi found on plants grown under glass, especially in houses improperly ventilated, are destroyed by spraying the foliage with clear water or with some prepared insecticide or fungicide, soapy mixtures being most commonly employed. Fungi which cannot be disposed of in this manner are reduced by removing diseased parts of the host-plant and destroying them. This tends to prevent new infections, and it is a process which well repays the outlay of time and labor.

Sulphur is probably the most valuable preventive of the fungous diseases which attack greenhouse plants. It may be used in various ways. An early method of making applications, and one still employed, is to dust the plants with the dry powder. This is effective in destroying several surface mildews. A preparation of sulphur formerly very generally employed is in liquid form. It is the *Eau Grison* of the French, and is very valuable in the treatment of diseases which may be controlled by the powder. But the most efficient method of using sulphur is to place it in a warm situation so that it will rapidly give off its fumes, and still not take fire. It may be mixed with equal parts of lime or some similar powder, and then by the aid of water, oil, or other liquid, it is wet until a thin paste is formed. This is then smeared upon the heating surfaces of the house. Or the sulphur may be evaporated in a sand bath over an oil stove, but in such cases extreme care must be exercised that the material does not take fire, for this means instant death to all plants reached by the fumes.

If, in spite of the above precautions, fungi are still present to an injurious extent, the next plan to follow is to apply some of the standard liquid fungicides to the threatened plants, preferring those remedies which are clear solutions, for these disfigure even the most delicate colors to only a very small extent. If this does not prove effectual, the plants should be thrown away, and the grower might do well to try some other business.

Insects Infesting Plants.

The number of different insects injurious to greenhouse plants is rather small, although the number of the individuals of each kind may be large enough. These creatures for the most part require different methods for their extermination, and each of the more important will be treated in detail.

Aphis; Green-fly; Plant Lice. — *Description.* These sucking insects are too well known to require description, for they attack nearly all greenhouse plants. They reproduce with extreme rapidity, and must therefore be continually watched. Affected leaves generally curl, the insects being found on the under side. When the stems are attacked, frequently no external sign of the insect's presence is visible except the insect itself.

Treatment. Insecticides which kill by contact must be employed for destroying the aphis. Kerosene emulsion, pyrethrum, tobacco water, etc., may be used with success. But the most common method of clearing a house of these creatures is to fumigate with tobacco stems. A common coal scuttle will answer the purpose well; when filled with the stems it will supply smoke sufficient for a house containing from three thousand to five thousand cubic feet. The amount to use will vary with the tightness of the house and the quality of the stems. The stems should be sufficiently moist to prevent them from blazing. They may be ignited very easily with some paper or shavings. If the house is a very tight one, it is well to admit air after the fumes have been in about an hour, but in the majority of establishments this point takes care of itself. If only few plants are to be treated, they may be placed singly under a paper flour-sack or in a box, and then smoked, care being taken not to use too much tobacco. Some commercial preparations of tobacco are excellent, for they are as efficient as the stems, and are almost free from smoke and leave no offensive odor. If powders are preferred for destroying aphis, pyrethrum will be found efficient, especially if the plants have been wet previous to the application; tobacco dust will also answer the same purpose.

Foliage-eating Insects, of which there are many kinds, should be treated by making applications of such insecticides as Paris green, hellebore, etc., but the foliage of many plants is easily injured by the arsenites, so these should be used cautiously. Picking the insects off by hand is another means of clearing the plants.

Mealy-bug (*Dactylopius adonidum,* Linn.). — *Description.* Mealy-bugs are familiar to all who have grown plants under glass. They are sucking insects, and are covered with a whitish powder from which they have received their common name. There is also a considerable quantity of a cotton-like material present where these insects have been allowed to multiply, and thus they may be easily recognized. All the green parts of affected plants are susceptible to their attacks.

Treatment. Although the mealy-bug is one of the oldest and best known of greenhouse pests, still no very satisfactory remedy for it has yet been discovered. The most practical plan is to throw forcible streams of water against them, so that they may be dislodged. If this practice is persisted in, it will prove very effective. But all plants will not bear such treatment, and it is not always possible to throw the water, so that the remedy has a somewhat limited application. Where it cannot be employed, the alcoholic decoction of pyrethrum will be found of great service. It should be applied by means of a small atomizer, and the insect should be treated until it is seen that the liquid has penetrated the woolly covering and has reached the body. The latter then turns yellowish-brown. Comparatively few plants are injured by this remedy, and its adoption is recommended. Kerosene emulsion, and commercial insecticides, as fir-tree oil, are also of value. Plants should be treated early, so that the insect may not obtain a foothold.

Mite; Verbena Mite (*Tetranychus bimaculatus,* Harvey). — *Description.* This mite is as yet not very well known in greenhouses. It is very similar to the red spider in size, shape, and habits, but it is not red, and it has two dark spots at the rear of the back.

Treatment. The mite is perhaps the most difficult to overcome of all insects found in the greenhouse. Unlike the red spider, it is but little affected by a moist atmosphere, or by moisture upon the infested parts. If water is forcibly sprayed upon the insects so that they will be dislodged, some good will result. But all plants cannot withstand this treatment. The best method of destroying the mite is probably to use kerosene emulsion containing from twenty to twenty-five parts of water to one of oil, or to apply Antipest, Fir-tree oil, or some other good commercial insecticide of this nature. The insects are most abundant on the under surface of the leaves, and all applications should be carefully and forcibly directed to these parts. The plants should be sprayed once or twice a week, and the foliage of some should be washed or syringed an hour or two after the treatment, to prevent injury from the insecticide.

Red Spider (*Tetranychus telarius*, Linn.). — *Description.* The red spider is a true mite, and not a spider. It has received the name from the fact that it spins a web, and covers the leaves and even whole plants with an envelope of irregularly but thickly scattered silken threads. It sucks the juices of the host-plants, preferring the more tender green parts for the scene of operations, although older foliage does not escape its ravages. The red spider causes the color of the leaf to change from green to a grayish-white, which shows very plainly upon most plants. This whitening of the upper surface of the foliage is a certain indication of the presence of a sucking insect, and generally this insect proves to be either the red spider, the mite, or thrips. The last, however, does not form a web. Such discoloration should be immediately investigated, and if either of the first are present, the careful gardener will remove the parts and take precautions to destroy any insects which may escape this process.

Treatment. The red spider flourishes in a dry atmosphere and in bright, sunny places; shade and moisture are unfavorable to its development. Here, then, lies the secret of its cheap and successful destruction. Copious spraying of the affected parts with clear water, and the maintenance of a moist atmosphere, will soon rid a house of this insect; in case such a course is injurious to the plants grown, an occasional wetting and the removal of infested leaves will be sufficient to subdue them.

Insecticides which kill by contact may also be used successfully, but they are not generally necessary. The fumes of sulphur, produced as described on page 175, are also said to have a beneficial action in the destruction of the red spider, as well as of the mite.

Snail; Slug.—*Description.* The foliage of plants grown in moist situations under glass is frequently riddled or entirely devoured by snails. In dryer places so much harm is not done. These animals feed mostly in the night, concealing themselves under boards or other objects, or in crevices which are dark. They feed upon tender vegetation of nearly all kinds, and may cause irreparable damage to young seedlings or cuttings in a single night.

Treatment. Large numbers of snails may be caught by examining the houses with a light after dark. They may also be trapped by placing pieces of turnip, cabbage, or other vegetable matter about the houses in such a manner that hiding-places may be formed. The creatures congregate under the bait, and often large numbers are caught in this manner. Salt, and also lime, are said to be distasteful to them.

HOLLYHOCK.

Fungous Diseases.

Rust (*Puccinia Malvacearum*, Mont.).—*Description.* During May and June the stems and leaves of the hollyhock may become discolored by small spots which at first are yellow, but later they become brown. These diseased parts are due to the presence of the rust fungus, a parasite which may develop so vigorously and abundantly that the leaves of the host-plant become dry and dead, as if scorched. The plants may be entirely prevented from blossoming, and unless measures are taken to check the disease, hollyhocks may be forced from cultivation, as has occurred in some parts of Europe.

Treatment. Hollyhock rust may be practically prevented by spraying the foliage with some good fungicide as soon as the leaves appear in the spring. The applications should be repeated frequently enough to keep the young growths covered.

INSECT ENEMIES.

Hollyhock-bug (*Orthotylus delicatus*, Uhl.).—*Description.* These bugs, which are bright green in color, sometimes attack hollyhocks early in the season so vigorously that the plants wilt, and occasionally die. The insects suck the juices of the plants, and are undoubtedly their worst insect enemy.

Treatment. Kerosene emulsion has been successfully used against the pest, and if the applications are commenced as soon as the bugs are seen, no serious damage should result.

MAPLE.

FUNGOUS DISEASES.

Leaf Spot (*Phyllosticta Acericola*, C. & E.). — *Description.* The fungus attacks the foliage of both large and small trees, destroying the green coloring matter. It appears in spring, causing the formation of dark brown areas which enlarge very rapidly. Later the parts first affected assume a lighter, or even a gray color, although there is much variation in the appearance of the disease upon different species of maples. The patches may finally extend over the entire leaf.

Treatment. Large trees are treated with difficulty, but nursery stock may be easily reached. Plants should be sprayed thoroughly with the Bordeaux mixture as soon as the leaves appear in spring, and new treatments should be made so that the young growths shall at all times be protected. Destroying affected leaves may assist in checking the disease upon the shade trees, but spraying them by means of proper machinery will prove most satisfactory.

INSECT ENEMIES.

Green-striped Maple-worm (*Anisota rubicunda*, Fabr.). — *Description.* The adult insect is a moth of a yellowish-white color, the shade varying in different parts of the country. The spread of the wings is about two and one-fourth inches. The insect passes the winter in the pupal state, and in spring, when the adult moths appear, large numbers of eggs are laid, generally in clusters on the under side of the leaves. The larvæ are striped longitudinally with alternating bands of light and dark green, while at the posterior extremity there project two black horns, each about a quarter of an inch in length. The larvæ feed upon the foliage of the trees, being particularly injurious in the western states, where shade trees are in certain years entirely defoliated. There are two or three broods, depending upon the latitude.

Treatment. The best and most effective remedy is to spray the trees with Paris green or some similar poison, whenever such a course is practicable. In other cases, the larvæ may be caught in trenches about a foot deep that are dug in concentric circles about the bases of the trees. The larvæ wander from the tree to pupate, and they will collect in the trenches, where they may be easily destroyed.

Tussock Moths (*Orgyia*, sp.).—*Description.* There are several species of tussock moths which resemble each other very closely. The caterpillars when grown are about an inch in length; the body is yellow in color, and generally is marked by a narrow, dark band extending along the back. The sides of the body may be similarly marked. Upon the back, just forward of the center, may be found four thick tufts of yellowish hair, while from the second segment of the body there extend two long black plumes. A single plume extends backward from the rear of the body. The larvæ hatch during May from eggs which were laid upon the silken cocoons by the female during the preceding fall. In about five weeks the larvæ begin to pupate, the adults appearing a week later. Only the males possess wings; these expand nearly an inch and a half. The ground color is ashy gray, but several dark lines cross the fore wings. As a rule there are two broods.

Treatment. These insects cause much injury to shade trees, and if unchecked they gradually increase in numbers so that the trees are each year defoliated. The most practical remedy appears to be to collect the cocoons while the trees are dormant. As the eggs are laid upon the surface of the cocoons they may be easily discovered. The cocoons may be found upon the branches and trunks of infested trees, and also upon fences and in sheltered spots in the neighborhood. The larvæ are also easily killed by the arsenites, although the application of the latter is not always practicable.

MIGNONETTE.

Fungous Diseases.

Leaf Blight; Mignonette Disease (*Cercospora Resedæ*, Feckl.). — *Description.* "The disease first appears either as minute pale spots with brownish or yellowish borders, — little sunken areas in the succulent tissue of the leaf, — or as reddish discolorations which spread over the leaf and finally develop into these pale spots or patches. The spots when young are simply dead portions, uniformly brown throughout; but as they become older and larger, little black specks appear in their centers, giving a somewhat granular cast. The disease spreads very rapidly over the leaves, the dead areas grow larger and more irregular in shape, the leaves commence to curl, wither, and hang limply against the stems."[1]

Treatment. Early and repeated sprayings of the young plants with the Bordeaux mixture or ammoniacal carbonate of copper will almost entirely prevent the disease.

MOSSES AND LICHENS.

It is very rare that these growths injure the cultivated plants upon which they are found. But they often lend an unkempt air to a plantation, and for this reason, if for no other, their removal appears desirable. Bordeaux mixture has frequently cleaned fruit trees of these plants, and its general use for this purpose may be recommended. Alkaline washes have a similar action. Spanish moss, which in the Southern States appears to have an injurious action upon certain trees, may be destroyed by spraying the tree with a wash composed of eight cans of concentrated lye dissolved in fifty gallons of water. It is possible that strong fungicides would exert a similar influence.

MUSKMELON.

Fungous Diseases.

Powdery Mildew; Cucumber Mildew (*Plasmopara Cubensis*, B. & C.). — *Description.* This disease has been reported as having

[1] Fairchild, *Ann. Rept. U. S. Com. of Agric.* 1889, 429.

been found upon squashes, melons, cucumbers, and pumpkins, in some cases inflicting serious damage. It bears a certain resemblance to the downy mildew of grapes in its external characters. Affected parts of the leaves turn yellow, then brown, while underneath these parts may be found the frost-like patches so characteristic of the downy mildews. But with the cucumber mildew the growth changes to a color closely approaching violet. The dead leaf tissue soon becomes broken, and the leaf is often entirely destroyed.

Treatment. The application of a good fungicide, as already described under downy mildew of the grape, should protect the vines from the fungus.

Insect Enemies.

See under Cucumber.

OATS.

Fungous Diseases.

Loose Smut (*Ustilago Avenæ*, Jensen). — *Description.* This fungus causes the grains, and generally the husks as well, to be transformed into a black mass in which all the normal tissue of the oat plant has disappeared. This powdery mass consists of spores. These appear when the crop is heading, and they mature at blossoming time. When the crop is harvested the spores have nearly all been blown away, leaving a naked stalk.

Treatment.[1] "It has been found that the infection of the plant takes place when the seed is germinating and from spores adhering to the seed when planted. If these adhering spores can be killed, a crop wholly free from smut can be obtained.[2]

"*The Jensen or hot-water treatment for oat and wheat smut.* — This method, discovered by J. L. Jensen, of Denmark, in 1887, consists in immersing the seed which is supposed to be infected with smut for a few minutes in scalding water. The temperature must be such as to kill the smut spores, and the immersion

[1] The remedies here mentioned have been taken from *Farmers' Bull. No. 5, of the U. S. Dept. of Agric. Div. of Veg. Path.*

[2] "There is some good evidence to show that fresh manure of herbivorous animals containing smut spores may, if applied at the time of planting, infect the young plants. It is hardly necessary to mention this manner of infection, since almost no American farmers manure grain fields in this manner. There is no danger in using well-rotted manure."

must not be prolonged so that the heat would injure the germinative power of the seed. If the water is at a temperature of 132½° F., the spores will be killed, and yet the immersion, if not continued beyond fifteen minutes, will not in the least injure the seed. The temperature must be allowed to vary but little from 132½°, in no case rising higher than 135°, or falling below 130°. To insure these conditions when treating large quantities of seed, the following suggestions are offered:

"Provide two large vessels — as two kettles over a fire, or boilers on a cook-stove, the first containing warm water (say 110° to 130°), the second containing scalding water (132½°).

"The first is for the purpose of warming the seed preparatory to dipping it into the second. Unless this precaution is taken it will be difficult to keep the water in the second vessel at a proper temperature.

"The seed which is to be treated must be placed, a half-bushel or more at a time, in a closed vessel that will allow free entrance and exit of water on all sides. For this purpose a bushel basket made of heavy wire could be used, within which spread wire netting, say twelve meshes to the inch, or an iron frame could be made at a trifling cost, over which the wire netting could be stretched. This would allow the water to pass freely and yet prevent the passage of the seed. A sack made of loosely woven material (as gunny sack) could perhaps be used instead of the wire basket. A perforated tin vessel is in some respects preferable to any of the above.

"Now dip the basket of seed in the first vessel; after a moment lift it; and, when the water has for the most part escaped, plunge it into the water again, repeating the operation several times. The object of the lifting and plunging, to which should be added also a rotary motion, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment, after which plunge the basket of seed into the second vessel. If the thermometer indicates that the temperature of the water is falling, pour in hot water until it is elevated to 132½°. If it should rise higher than 132°, add small quantities of cold water. This will doubtless be the most simple method of keeping the proper temperature and requires only the addition of two small vessels, one for cold and one for boiling water.

"Steam, conducted into the second vessel by a pipe provided with a stopcock, answers even better, both for heating the water and elevating the temperature from time to time.

"The basket of seed should, very shortly after its immersion, be lifted and then plunged and agitated in the manner described above; and the operation should be repeated eight or ten times during the immersion, which should be continued fifteen minutes. In this way every portion of the seed will be subjected to the action of the scalding water. Immediately after its removal dash cold water over it or plunge it into a vessel of cold water and then spread out to dry. Another portion can be treated similarly, and so on until all the seed has been disinfected. Before thoroughly dry the seed can be sown; but it may be thoroughly dried and stored if desired.

"The important precautions to be taken are as follows: (1) *Maintain the proper temperature* of the water (132½° F.), in no case allowing it to rise higher than 135° or to fall below 130°. This will not be difficult to do if a *reliable thermometer* is used and hot or cold water be dipped into the vessel as the falling or rising temperature demands. Immersion fifteen minutes will not then injure the seed. (2) See that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time. (3) Never fill the basket or sack containing the seed entirely full, but always leave room for the grain to move about freely. (4) Leave the seed in the second vessel of water *fifteen minutes.*

"*The hot-water treatment for oats.*—The foregoing method is applicable to both wheat and oats. With oats the following slight modifications are probably advantageous: (1) Have the water in the second vessel 143½° F. and immerse the seed five minutes, cooling with cold water afterwards. Where large amounts of seed are to be treated this will prove the most speedy form of the treatment, but great care must be taken to see that every grain is thoroughly wetted. (2) Have the water in the second vessel at 132½° F.; immerse the seed ten minutes and do not cool with cold water, but spread out at once to dry. This last is no doubt the best form of the Jensen treatment for oats, since it requires a shorter time than the regular method and the warmth of the grain aids it materially in drying. Moreover, experiments have shown that seed treated in this way yields the most grain and straw. Neither of these modifications can be recommended for wheat without more data than we now possess.

"*Potassium sulphide treatment for oats.*— In this treatment the seed is left twenty-four hours in a one-half per cent solution of potassium sulphide. The published experiments seem to show that a weak solution of potassium sulphide is nearly as good as the hot water. The potassium sulphide is cheapest in the 'fused' condition, in which form it costs about twenty-five cents a pound. One pound of the sulphide should be dissolved in twenty-four gallons of water. Place the seed in a *wooden vessel* and pour on the solution till the seed is covered several inches deep. Stir the solution before pouring it on the grain and thoroughly mix the seed several times before taking it out of the solution. The oats should stand in the solution twenty-four hours, after which they may be spread out to dry. The solution gradually loses its strength and hence cannot be used more than three or four times without being renewed.

"It will probably be best to sow the seed as soon as possible and before it becomes thoroughly dry.

"Soaking the seed twelve hours in a solution of twice the strength will no doubt prove effectual.

"*Copper sulphate treatment for wheat.*— This consists in immersing the seed in a solution made by dissolving one pound of commercial copper sulphate in twenty-four gallons of water for twelve hours and then putting the seed for five or ten minutes into lime water made by slaking one pound of good lime in ten gallons of water.

"These treatments have all been tried and have proved effective. Probably the hot water is the best for general use. In some parts of the country, seed wheat is treated in strong solutions of copper sulphate and no lime is used. This practice is much inferior, since it injures the seed, while those given here prevent the smut completely and at the same time do not injure the seed if carefully followed. In all forms of seed treatment care should be taken to spread the grain out to dry at once, and by frequent stirring prevent its spoiling. The treated seed should be handled only with clean tools and should be put in sacks disinfected by boiling fifteen minutes. If these precautions are not taken the seed may be infected again after treatment, especially in case of stinking smut of wheat. If the seed is to be sown broadcast it will not have to be so dry as if it is to be drilled. The seed may be treated with hot water a considerable time before planting if dried carefully, but it is probably better to treat just before planting."

Rusts. — The various rusts which attack oats, wheat, and barley have not been successfully treated by the use of fungicides.

ONION.

Fungous Diseases.

Mildew; Rust (*Peronospora Schleideniana,* Unger). — *Description.* Seed onions, especially when grown on low ground, appear to be particularly affected by this disease. The first appearance of the trouble is the formation upon the onion tops of a grayish velvety coating. The leaf wilts, and turns yellow. This occurs about the time that the onions begin to bottom. The fungus passes the winter by means of spores which are developed within the tissue of the host-plant.

Treatment. Proper applications of the Bordeaux mixture, or of some other fungicide, if made early in the season and repeated at intervals of two weeks, should keep the disease in check. All affected onions should be destroyed.

Smut (*Urocystis Cepulæ,* Frost). — *Description.* The disease is more severe upon dry land, as the onions appear to be less able to outgrow it. The first leaves of the seedlings are attacked, dark spots scattered along their surfaces showing the presence of the fungus. Such plants generally die before the third leaf is formed. When the disease appears upon older plants the bulbs show dark ridges extending up and down their sides, even to the leaves. These ridges are mainly composed of a sooty powder consisting of the spores of the fungus. It has been estimated that a single large onion may mature a cubic inch of smut in a single season. The soil soon becomes filled with the germs of the disease, and it is almost impossible to grow a sound crop.

Treatment. Affected soil should not be planted to seed onions. It appears probable that by transplanting onions the disease may be largely avoided, since it enters the young onions before they appear above ground. One ounce of a mixture of equal parts of sulphur and lime to every fifty feet of drill has been recommended as a preventive.

INSECT ENEMIES.

Maggot (*Phorbia Ceparum*, Meigen). — *Description.* This insect closely resembles the Cabbage Root-maggot in appearance, and the methods of treatment are practically the same for the two insects. See under CABBAGE.

FIG. 62. — Orange scab.

ORANGE.

FUNGOUS DISEASES.

Scab (*Cladosporium* sp.). — *Description.* Orange leaves affected with the scab first show warty-like elevations, mostly on the under surface of the leaves (Fig.62). These excrescences also appear upon the young shoots. They are at first light-colored, but later the tops turn nearly black. Growing leaves and shoots are distorted by the parasite, and they finally become yellow and worthless.

Leaf Spot (*Colletotrichum adustum*, Ellis). — *Description.* Leaf spot attacks both wild and sweet oranges. It first produces on the leaves light green spots which are about an eighth of an inch in diameter. These enlarge till they are fully an inch across, the older portions becoming brown and studded with small black dots. This disease is not as yet very serious.

Treatment. The two diseases here mentioned have apparently not been thoroughly treated, so that all recommendations must be founded upon the experiences gained in treating other plants. The copper compounds will probably prove most efficient in controlling the diseases, the applications being commenced a week or two before the troubles first appear.

INSECT ENEMIES.

Leaf Notcher (*Artipus Floridanus*, Horn). — *Description.* The adult is a small insect about a quarter of an inch long; it is of a metallic greenish-blue color. It feeds upon the foliage of the trees, beginning at the edges of the leaves.

Treatment. Jarring the trees has been recommended, and it seems probable that applications of the arsenites would prove effectual in destroying the pests.

Mealy-wing (*Aleyrodes Citri*). — *Description.* These minute white flies frequently appear in such numbers upon orange foliage that the tree may be considerably weakened by them. Related forms are common in northern greenhouses, and plants are often seriously injured by their work. In the South the insects generally pass the winter in the larval stage. In early spring they pupate, and the adults appear during March and April. Eggs are laid in abundance on the under side of the leaves. They soon hatch, and the larvæ, on account of their transparency, may be present in swarms, and still pass unnoticed. They suck the juices from the leaves, and secrete a honey-dew upon which a dark fungus soon grows. There are three generations each year in the South.

Treatment. The insects do not yield readily to treatments of kerosene emulsion, but the resin wash smothers the immature forms. Under glass, other species are easily destroyed by tobacco smoke.

Mite; Leaf-mite; Spider; California Spider; Red-spotted Mite; Red Spider (*Tetranychus 6-maculatus*, Riley). — *Descrip-*

tion. The insect is pale green in color, and is marked above by six small dark spots. It feeds upon the juices of the plant, and increases with such rapidity that, unless checked, the foliage soon becomes ruined. Ten days is the estimated time for maturing the insect from the egg when conditions are favorable. The name "spider" has been applied to the mite on account of its habit of spinning a fine thread which often entirely covers the infested parts.

Treatment. The pest is held in check by abundant rains, showing that it does not relish water any more than its relative, the red spider of greenhouses. It is also easily destroyed by kerosene emulsion, whale-oil soap, and if the trees are thoroughly and forcibly sprayed with clear water, it will have a decided effect in clearing the foliage of the insect.

Rust-mite. — The rusty appearance of oranges is caused by the work of a minute yellow animal, a true mite. It lives upon the essential oil which is found in all parts of the orange tree, sucking it out by means of a beak. On the fruit this causes the familiar browning of the orange.

Treatment. As the eggs, molting young, and adults are found upon the trees at all seasons of the year, no definite direction can be given which will apply to every district. All applications should be repeated at intervals of a week or ten days, so that the young may be destroyed before they mature. Spraying the trees with sulphur suspended in water is one of the best remedies, as the fumes are deadly to the insects. Whale-oil soap solution, made by dissolving one pound of the soap in ten gallons of water, is also effectual.[1]

Glover's Scale; Long Scale; Oystershell Scale (*Mytilaspis Gloverii*, Packard). — *Description.* The eggs of this insect hatch early in spring, the young larvæ being yellowish purple in color. These almost immediately begin to secrete a cotton-like covering which extends over the entire body in about a week. The first molt takes place about three weeks after the eggs hatch, and the covering of the insects from that time on is penetrated with difficulty by insecticides. There are three periods when the newly hatched scales are most abundant; in March, in June and July, and in September or October, and each generation soon

[1] For detailed experiments, made by H. G. Hubbard, see *Ann. Rep. U. S. Com. of Agric.* 1884, 361.

covers itself with the long, yellowish or dark brown scale which may be found upon the leaves and branches of the orange.

Treatment. The trees should be sprayed with resin washes, kerosene emulsion, or whale-oil soap whenever the young insects are seen. It is especially important that this should occur during the three periods above mentioned, for then the greatest numbers can be destroyed. The old scales cannot be penetrated by any insecticide which does not injure the foliage.

San José Scale (*Aspidiotus perniciosus*, Comstock). — *Description.* This scale insect is undoubtedly the most serious to fruit trees of any with which the horticulturist has to deal. It is probably a native of Chili, but was imported into California, and from there it has spread to the eastern states. It is now very irregularly scattered throughout the East and has already shown that it is capable of destroying not only the orange, but also most of our other fruit trees.

During the winter the San José scale is only about one-half grown, the scale being less than a sixteenth of an inch in diameter. It is nearly circular, quite flat, but the center has a slight elevation. This is of a dark color, while the remainder of the scale is gray. These immature forms begin sucking the juice of the plant as soon as growth commences in the spring. They complete their growth in about four weeks, and then lay their eggs under the scale. Early in June, in the latitude of New York, the young insects begin to crawl out from under the old scale. In two or three days they settle down, and begin the secretion of a scale which resembles that of the parent form. Before fixing themselves they are active, and so minute that their small yellow bodies can scarcely be seen without the aid of a glass.

From the time of the appearance of the first generation in spring, the young insects can be seen almost continually throughout the summer months, and until the arrival of cold weather in the fall. The number of generations which appear in a season has not yet been ascertained.

Treatment. The most effectual method of ridding plants of this pest is by treating them, while dormant, with hydrocyanic-acid gas. With grown trees, the operation of covering an entire plant with an air-tight tent is a difficult process, although it has been done successfully in the orange groves of

California. Nursery stock may, however, be treated very easily in this manner, and when the operation is finished there need be no doubt that all the insects are destroyed. In California the resin washes have been used with success, care being taken that all parts of the tree are reached by the material. In the eastern states these washes have not proved to be equally effective, a solution of two pounds of whale-oil soap to a gallon of water having given the best results. Kerosene emulsion may probably be successfully used if made according to the Hubbard-Riley formula, and diluted five times. Caustic soda and caustic potash should also give good results if applied during the winter months.

During the summer, if kerosene emulsion is persistently used, so that at least the majority of the young are killed, the insects may be gradually reduced in numbers, although the fight will prove a hard one. Continued watching and thorough spraying must in time exterminate the scale in an orchard.

PANSY.

Fungous Diseases.

Mildew; Rust (*Peronospora Violæ*, DeBary). — *Description.* Diseased leaves show the presence of this fungus by turning brown at the affected places. The disease as yet does not appear to be well understood.

Treatment. Proper culture and the application of fungicides are to be recommended.

PARSLEY.

Insect Enemies.

Parsley-worm; Celery-caterpillar (*Papilio Asterias*, Cramer). — *Description.* The mature butterfly is black, but it has rows of yellow and blue spots upon the wings. These expand nearly four inches, and the adult is one of the most handsome of our summer butterflies. The eggs are laid upon the leaves of parsley, parsnip, celery, carrot, and many related plants. The young caterpillar, appearing in June, is at first black, but as it increases in size the color becomes greenish. About the middle of July, when full grown, the larva is about an inch and a half long, the ground color being pale green, but the sides of the body are marked with a series of yellow and black markings. When disturbed it projects two yellow horns from the back of the head; these emit a disagreeable odor, and doubtless serve as organs of defense. It soon seeks a sheltered spot, and there spins its cocoon. In about two weeks the adult insect again appears. Eggs are laid, and the larvæ become full grown and pupate late in September or early in October. The winter is passed in this condition, the mature insect appearing the following spring.

Treatment. These insects are rarely present in sufficient numbers to cause much injury. If their destruction is attempted, the arsenites will be found very efficient, but they should be applied only to those plants whose foliage is not used. Hellebore, or pyrethrum, is safer and almost as effective, and these materials should be applied to celery, parsley, and other plants whose treated parts are used as food.

PARSNIP.

INSECT ENEMIES.

Parsley-worm. See under PARSLEY.

Web-worm (*Depressaria heracliana*, De Geer.) — *Description.* The moths probably hibernate during the winter, laying their eggs early in spring. The larvæ appear in June. They feed upon the green parts of the parsnip, and protect themselves by means of a web. The flower cluster is particularly affected. This insect is comparatively rare.

Treatment. One or two applications of an arsenite should be sufficient to protect the plants, since the insect appears to have but one brood each year. The treatments should be made as soon as the larvæ are seen in the spring. The insects pupate in the stems of the parsnip, and the destruction of these stems late in July would materially reduce the number of the insects.

PEA.

FUNGOUS DISEASES.

Mildew (*Erysiphe Martii*, Lév.). — *Description.* This disease generally appears late in summer, or during the autumn months.

It covers the foliage with a white, downy layer, which almost entirely obscures the green color of the leaves and stems. Later, small black dots appear, these being the fruiting bodies of the fungus.

Treatment. The disease could undoubtedly be easily checked by means of the copper sprays; but the foliage of these plants is of such a character that liquids do not readily adhere. Soap will assist in overcoming this difficulty if it is added to the liquids. Another line of treatment which might be followed by good results is to apply powders to the vines while they are wet with dew. Fostite should prove of value for this purpose.

Rust. — This is the same disease which has been discussed under BEAN. It is rarely serious.

INSECT ENEMIES.

Weevil; **Pea-bug** (*Bruchus Pisi*, Linn.). — *Description.* The adult is a dirty-black beetle having white markings on the wing covers, and a T-shaped mark of the same color at the extremity of the abdomen. The insect is scarcely three-sixteenths of an inch long. The winter is generally passed in the adult stage, the beetles mostly appearing in the spring. Eggs are laid while the young pods are forming, and the larvæ enter the growing peas, upon which they feed, rarely injuring the germ, however, although the seed is considerably weakened. The insects pupate within the peas, and soon afterward the adult appears, although it does not leave the peas, as a rule, until the following spring.

Treatment. No practicable method has yet been found by means of which the beetle can be prevented from laying its eggs in the young pods. The practice commonly followed is to treat the peas, after harvesting, with the bisulphide of carbon. Two or three treatments at intervals of three or four weeks will be found sufficient to exterminate the pest. Another method of destroying the insects is to subject the peas to a temperature of 145° F. for about an hour. If this is done as soon as the peas are ripe, the larvæ, which are then practically grown, will succumb, and the germinating qualities of the seed will not be injured. The bean-weevil may be successfully treated in the same manner.

PEACH.

Fungous Diseases.

Black Spot (*Cladosporium carpophilum*, Thm.). — *Description.* This surface fungus is generally more severe upon late varieties, Hill's Chili being especially susceptible to its attack. It forms small dusky-brown or black spots upon the side of the fruit (Fig. 63), and although the spots scarcely exceed one-

Fig. 63. — Black spot of peach.

eighth of an inch in diameter, when several run together, large areas of the peach may be affected (Figs. 64, 65). In such cases, all growth of the diseased portion is stopped, and frequently the flesh cracks down to the pit. As a rule, the disease is not very troublesome.

Treatment. Spray the trees with the Bordeaux mixture, beginning the treatments early in July. The mixture should not be made stronger than one pound copper sulphate to ten gallons of the liquid, and an abundance of lime should be added, otherwise the foliage may be seriously injured. Two applications may be required after the first of August. For these, a clear fungicide, such as the ammoniacal carbonate of copper, should be used, but there is again danger of burning the foliage. For this reason, the solution should not be made stronger than an ounce to twelve gallons of water. Some injury may result even from this dilute preparation, but it will be so slight that no serious loss need be feared. Powders have proved unsatisfactory in the treatment of peaches, as the leaves are so smooth that but little of the material adheres to them.[1]

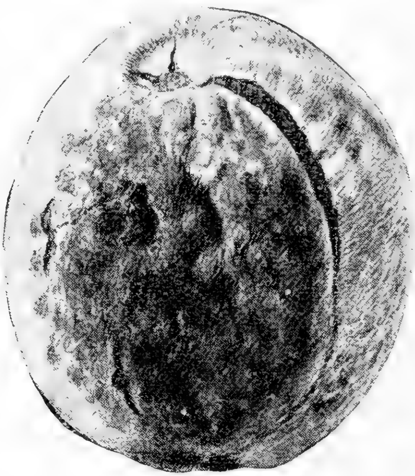

FIG. 64. — Fruit severely attacked by black spot.

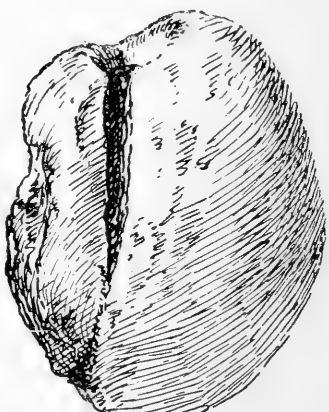

FIG. 65. — Same as Fig. 64, another view.

Brown Rot; Fruit Rot; Twig Blight (*Monilia fructigena*, Pers.). — *Description.* Brown rot is probably the most serious fungous disease with which peach growers are obliged to con-

[1] Peach trees should at all times be treated cautiously. At a meeting of the A. A. A. S. held at Springfield, Mass., Aug. 27, 1895, "P. H. Rolfs read a paper upon 'Some unexpected results from spraying peach orchards.' He said: In spraying peach orchards with the resin wash advised by the division of entomology, it was found that the insecticide was excellent when used during dry weather. When the wash was used late in the year and early in the spring, it was liable to destroy the fruit buds. In no case did the insecticide affect the leaf buds. The experiments show that the insecticide advised for winter use should not be used in winter in Florida, but may be used in September and October." — *Springfield Republican*, Aug. 28, 1895, 4. See, also, Bull. xviii., *Cornell Exp. Sta.*

tend. The disease is more severe upon early varieties, and in the middle Atlantic states the fungus is extremely prevalent and serious. It causes the rotting of the fruit about the time the period of ripening begins. It increases rapidly in warm, moist weather, and peaches which touch each other are among the first to suffer from the disease. This is mainly due to the fact that a certain amount of moisture is retained at the point of contact, and with such favorable conditions the fungus easily succeeds in gaining an entrance. Cherries and plums also suffer from the disease, and in the same manner; the sweet, soft-fleshed varieties of cherries are especially susceptible. The affected fruit turns brown and appears as if decayed; it then becomes covered with an ash-colored coating which consists of myriads of spores, each one capable of spreading the disease. The fungus also attacks the small twigs, causing their death (Fig. 66). It is no uncommon sight to see dried peaches, plums, or cherries attached to the branches upon which they grew, the latter having been destroyed by the disease as well as the fruit. It also appears certain that the blossoms may be affected and ruined, so that no fruit will set. This disease, therefore, should be closely watched and thoroughly controlled.

Treatment. The treatment here described applies practically also to plums; but cherries cannot be treated so often, as the fruit matures earlier. (1) The first application should be made, in badly infested districts, just before the buds begin to swell; at this time spray with a simple solution of copper sulphate, using one pound to twenty-five gallons of water. (2) While the buds are swelling, spray with the Bordeaux mixture. (3) Repeat the second when the fruit has set. (4) When the fruit is grown, spray with the ammoniacal carbonate of copper, using one ounce of copper carbonate to twelve gallons of water. (5) Repeat the fourth application at intervals of six or eight days until the fruit is harvested. It is only in very few localities that such measures need be adopted; in the majority of cases the third and the fifth recommendations will suffice.

Curl; Leaf Curl; Frenching (*Exoascus deformans*, Fuckl.). — *Description.* The name "curl" has been given to this disease on account of the appearance of the affected leaves. As soon as the first leaves have become grown, they frequently show a curled or puckered appearance (Fig. 67); the ridges may

Fig. 66. — Brown rot of peaches.

extend across the leaves or in a longitudinal direction. They appear as if puffed up, and the normal green color is replaced by shades of yellow or red. Such foliage generally falls from the trees before July, when another set of leaves is produced. The mycelium of the fungus appears to live through the winter upon the buds and twigs, for when buds are taken from diseased trees and inserted in nursery stock the resulting shoots generally show the disease, although there was no apparent infection when the budding was performed.

FIG. 67. — Peach curl.

Treatment. Some think to have controlled the disease by spraying thoroughly with the copper sulphate solution before the buds break, and following this, after the trees have blossomed, with applications of the Bordeaux mixture at intervals of about two weeks until July first. Burning affected leaves and giving good cultivation may also decrease the severity of the trouble.

Leaf Rust. See under PLUM.

FIG. 68. — Peach mildew.

Mildew (*Podosphæra Oxycanthæ*, De-Bary). — *Description.* Early in the season, before the peaches are one-half grown, they are occasionally attacked by a mildew which produces white, powdery patches upon their surface (Fig. 68). These may be very small, or they may enlarge until they are fully half an inch in diameter. As the season advances these parts become brown and hard, sometimes causing the peach to crack. The foliage is also attacked by this fungus; here it produces a thick covering of white mycelium which entirely obscures the green color underneath.

Treatment. It is probable that the disease can be checked by spraying the trees with the Bordeaux mixture as soon as the fruit has set, and following this at intervals of two weeks by two treatments of one ounce of the carbonate of copper dissolved in ammonia and diluted with twelve gallons of water.

Rosette. — This disease causes the growth of affected trees to become compressed and bunched in the form of a rosette. The causes as well as the remedies are unknown. The disease is found only in the southern states. It is contagious, and affected trees should be destroyed.

Yellows. — Peach yellows is a disease which has so far baffled all researches as to its cause or the methods of curing affected trees. The trees first ripen their fruit prematurely, the peaches possessing distinct red streaks extending from the surface towards the pit. The following years the new growth is generally tufted, and branched shoots are produced from wood that is more than two years old. Such growths have narrow, horizontal leaves, which are yellowish in color. The disease is contagious, and affected trees should be burned as soon as the disease is discovered. No cure is known.

Insect Enemies.

Black Peach-aphis (*Aphis Persicæ-niger*, Smith). — *Description.* These plant lice are shining black in color, one form having wings, the other possessing none. They feed upon the juices of the trees, and may be found upon the leaves, stems, and roots. They reproduce in the characteristic manner of plant lice.

Treatment. The insects found above ground may be destroyed by kerosene emulsion diluted fifteen or twenty times, or by tobacco water. Those found upon the roots are more difficult to destroy. Tobacco stems or dust may be dug about the affected parts; or the roots may be exposed, and water having a temperature of 130° F. poured upon them. Another remedy which should give excellent results is to inject bisulphide of carbon about the roots, using about a teaspoonful to every square foot of soil. The roots of young trees may be dipped in hot water or in kerosene emulsion before setting them in their permanent positions.

Borers. See under Apple.

Plum Curculio. See under Plum.

PEAR.

Fungous Diseases.

Leaf Blight; Fruit Spot (*Entomosporium maculatum*, Lév.). — *Description.* The leaves, stems, and fruit of the pear are sub-

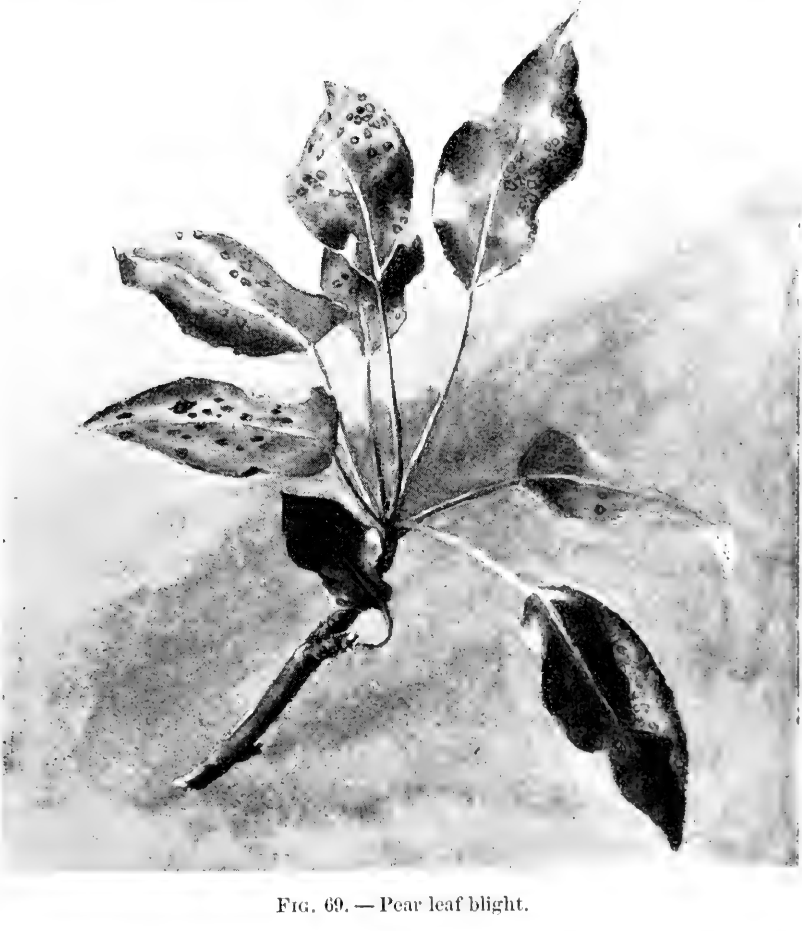

Fig. 69. — Pear leaf blight.

ject to the attacks of the leaf blight fungus. Quince trees suffer in the same manner. The disease appears as soon as the first leaves are developed, or, if the weather is dry, it may not cause any injury until midsummer. The leaves become dotted with reddish-brown spots which gradually increase in size, coalesce, and eventually destroy large areas (Fig. 69). The leaves finally fall to the ground, and if the fungus is very prevalent the trees may be entirely defoliated. Upon the stems the affected parts appear black and dead. The fruit first shows reddish spots which later turn dark (Fig. 70). If the pears are attacked while small, the diseased parts grow but slowly, the tissues become hard and corky, and the result is an irregular fruit, generally cracked upon the dwarfed side, and more or less marked by isolated spots which appeared after the first serious infection. Quinces suffer in the same manner, but the

FIG. 70. — The fruit spot of pears.

foliage frequently turns yellow before falling to the ground, and the affected fruit is mottled with black spots less than an eighth of an inch in diameter, when late infections have taken place. This fungus is probably the most serious of those which work upon these fruits, but fortunately it may be controlled with comparative ease.

There is a bacterial disease which is frequently mistaken for the leaf blight, but it is entirely distinct. It is commonly known as "fire blight" or "twig blight." It is very serious upon pears and quinces, and also frequently attacks some varieties of apples. It causes the foliage to turn to a uniform brown, the change taking place sometimes in two or three days. The leaves do not fall from the trees but remain upon the branches, giving the parts the appearance of having been scorched by fire. The bark of affected stems becomes brown and sunken. The bacterium enters the tree through the blossoms and also through the growing tips. There is no known remedy, the only method of checking the malady being to cut out affected parts and to burn them as fast as they appear.

Treatment. The leaf spot of pear and quince may be prevented by spraying the trees with the Bordeaux mixture as soon as the first leaves have developed. The application should be repeated at intervals of two to four weeks, more treatments being made during moist weather, until the first of August. Later treatments will rarely be required. In case they should appear to be necessary, the ammoniacal carbonate of copper, diluted as for peaches, should be applied. Other clear fungicides will answer the same purpose for the late treatments.

Rust. See under APPLE.

Scab. See under APPLE.

INSECT ENEMIES.

Borers. See under APPLE.

Bud-moth. See under APPLE.

Cigar-case Bearer. See under APPLE.

Codlin-moth. See under APPLE.

Curculio. See under PLUM.

Midge (*Diplosis pyrivora*, Riley). — *Description.* The mature insect is a small two-winged fly or gnat. It appears in early spring, the winter having been passed in the pupal stage, and lays its eggs in the young pear blossoms even before these are fully opened. The eggs hatch quickly, and the larvæ immediately bore into the young fruit, which they pierce in all directions. The fruit becomes swollen and misshapen, and eventually drops from the trees. Before this takes place the pears crack open in wet weather, and thus allow the escape of the midge larvæ. The larvæ are less than three-sixteenths of an inch in length; they are pale yellow in color, and have a very smooth skin. They enter the ground early in June and there pupate; the mature insect appears the following spring.

Treatment. The pear-midge is exceedingly difficult to control. It cannot be reached by insecticides while in the pears, and after it has pupated it is also well protected. If the pears are not allowed to set, the larvæ will be unable to develop, and the recommendation has therefore been made that the trees be sprayed while in blossom and all the fruit prevented from setting. This might be accomplished by using an arsenical spray, as white arsenic, but no experiments appear to have been made to settle the point. Picking the affected fruit before the larvæ enter the ground has also been suggested, as well as thorough cultivation to destroy the pupæ. Thorough application of kerosene upon the surface of the soil would also destroy many of the larvæ before they pupate. Professor Smith has

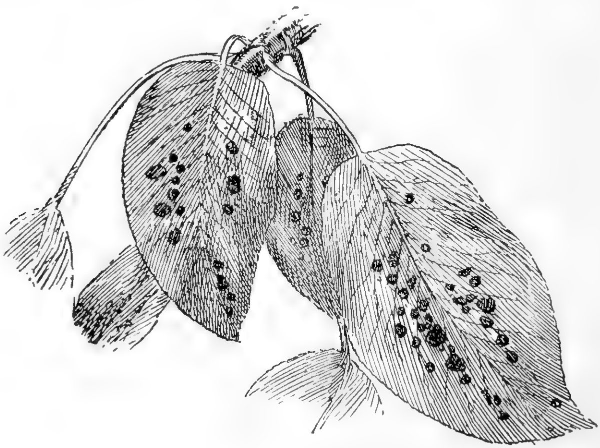

Fig. 71. — Pear leaf blister.

said that heavy fertilizing applications of kainite, if made early in July, will materially reduce the numbers of this insect.

Pear Leaf Blister (*Phytoptus Pyri*, Scheuten). — *Description.* The animal causing the reddish blisters so commonly seen upon pear leaves early in the season (Fig. 71) is a true mite (Fig. 72). It passes the winter under the outer scales of the buds, and as soon as warm weather starts the trees into growth it abandons its winter quarters and begins to feed upon the juices of the young foliage. The insect enters the leaves, where it is entirely protected from all applications of insecticides. The presence of this pest causes the formation of small swellings which are dull red early in the season, but later they turn green, and about the middle of June they appear as irregular brown patches, of varying sizes. The leaves become distorted and unsightly, and redden up early in the fall.

Treatment. Spray the trees in spring before the buds swell with the Hubbard-Riley kerosene emulsion, diluting with five to seven parts of water. One thorough application will practically exterminate the insect.

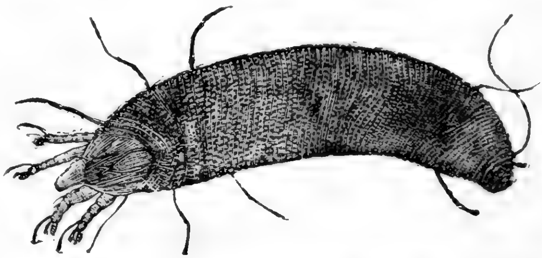

Fig. 72. — Mite causing pear leaf blister, greatly enlarged.

Psylla (*Psylla pyricola*, Forst.). — *Description.*[1] The eggs of this insect are laid early in spring, during warm days of April, by adults which hibernated during the winter. The eggs are laid in small crevices of the twigs; they hatch in about two weeks, and produce small flattened nymphs (Fig. 73), which suck the juices of the tree. They occasionally appear before the buds have opened, in which case they hide under the bud-scales or under the bark, and wait for the coming of the leaves. They then seek the axils of the leaves and move but little. They secrete large quantities of honey-dew, often being entirely covered with it. It runs down the stems of the tree, and is a favorable medium for the growth of a dark fungus which causes the tree to appear as if covered with soot. The absence of this color is a good indication that the psylla is not present. The adult insect (Fig. 74) appears about a month after the egg hatches. It closely resembles a cicada or harvest-

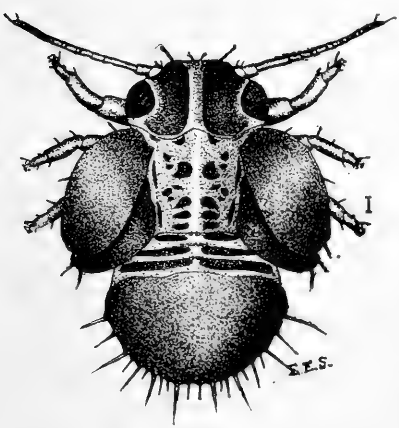

Fig. 73. — Immature form of psylla.

[1] See Slingerland, *Cornell Agric. Exp. Sta.* 1892, Oct. Bull. 44.

fly, but is only about a sixteenth of an inch in length. This winged form is extremely active and difficult to capture. Affected trees become much weakened; the foliage is light green or yellowish, and if the tree is badly infested both the fruit and the foliage drop prematurely to the ground.

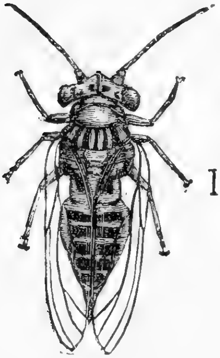

FIG. 74.—Adult psylla.

Treatment. The best method of overcoming this destructive insect is to spray the trees with kerosene emulsion, containing from 4 to 5 per cent of kerosene, as soon as the first leaves have unfolded in spring. The application should be made very thoroughly, and it should be repeated once or twice at intervals of ten days or two weeks, if there is reason to fear that many insects have survived. Treatments made during the summer are also of value, but the spray must be copious, and it must be thrown with great force to destroy the adults. All applications should also be made soon after a rain, for then the honey-dew is mostly washed away, and the immature insects, or nymphs, may be reached

FIG. 75. — Cherry slug upon pear leaf.

more easily by the emulsion. Winter applications of kerosene emulsion as applied for plum scales have been recommended.

Slug. — The shiny dark-colored slug, which is so frequently seen upon pear foliage (Fig. 75), is identical with the one found upon cherry foliage. A description of the insect will be found under CHERRY, but it will be well here to emphasize the necessity of treating the pest before much damage is done. Application should be made seasonably and thoroughly.

PLANE-TREE.

See SYCAMORE.

PLUM.

FUNGOUS DISEASES.

Brown Rot. See under PEACH.

Leaf Blight; Shot-hole Fungus (*Cylindrosporium Padi; Septoria cerasina*, Peck). — *Description.* The foliage of plums and

FIG. 76. — Shot-hole fungus of plum.

cherries is often disfigured in early summer by small circular spots about an eighth of an inch in diameter. The spots are at first of a purple color, but later, as the tissue dries, the color changes to brown, and the affected areas become loosened and drop out. This causes the leaves to appear as if pierced by shot, as they are frequently full of these small, round holes (Fig. 76). In such cases the foliage turns yellow, drops during the summer, and the trees are unable to mature their fruit. If unchecked, the fungus may cause serious losses, but fortunately the disease is easily controlled.

Treatment. The trees should be sprayed with the Bordeaux mixture as soon as the leaves appear, the application being repeated at intervals of two or three weeks until about the middle of July. Clear fungicides should be applied to cherries early in the season to avoid staining the fruit, and the same precaution should be observed with plums, although the Bordeaux mixture may be continued longer with this crop. Four applications should be sufficient even in very bad seasons; and two or three will generally be found sufficient.

Fig. 77. — Black knot of plum.

Leaf Rust (*Puccinia Pruni-spinosæ*, Pers.). — *Description.* In general appearance this disease is very similar to the preceding. The affected areas are dull red upon the upper surface of the leaf and yellowish-brown on the lower surface, but the spots are small, and frequently cause the foliage to drop prematurely.

Treatment. Give the same treatment as for the plum leaf blight.

Plum Knot; Black Knot; Plum Wart (*Plowrightia* [*Sphæria*] *morbosa*, Sacc.). — *Description.* It is a common opinion that the black knots (Fig. 77) found so generally upon plum and sour cherry trees are caused by insects, but such is not the case.

These swellings are caused by a fungus, and the insects find them to be good breeding-places, which explains their presence in many old knots. Although the fungus has long been known to mycologists, its life history has not yet been entirely determined; enough is known, however, to serve as a safe guide in the treatment of the disease. Early in spring, when growth starts, these swellings begin to appear. At first they are yellowish in color, but later this changes to a darker shade. During May and June a crop of spores is produced upon the surface of the knots, causing them to appear as if coated with a thin layer of velvet. This soon disappears, and then the knot becomes darker until winter, when it is jet black. In November and December the surface of the knot may be seen to be thickly covered with minute black elevations, in which the winter spores are borne. These are distributed during the latter part of winter. The spores generally gain entrance into the trees at the crotches of small limbs and at the junction of annual growths. They cause swellings which extend along the younger branches to a distance of four or five inches the first year. All the mycelium does not die during the winter, so the following spring the formation of new swellings may be seen at the edges of the old knot. In this manner the disease may live from year to year, or until the limb dies.

Treatment. The general recommendation has been to cut out the knots and destroy them as soon as they are discovered. It should be done before a crop of spores is matured. If in addition to this the trees are thoroughly sprayed with the Bordeaux mixture during the warm days of early spring before growth starts, and again when the buds are about to burst, it is probable that the winter spores may be rendered harmless. If the crop of spores produced during May and June is similarly disposed of, no infection need be feared. Consequently the trees should be sprayed for the third time with the Bordeaux mixture during the latter part of May, and again about the middle of June. These applications must be thoroughly made, and if this is done the black knot fungus may be practically controlled. In case a knot appears upon a large limb, or upon the trunk of a tree where it cannot be easily removed, it should be painted with pure kerosene oil. This will destroy the knot and also the living tissue surrounding it; care should therefore be exercised in the application of the oil that it is not too freely distributed. By mixing some coloring matter with the kerosene the treated parts may easily be distinguished.

Plum Pockets; Plum Bladders (*Exoascus* [*Taphrina*] *Pruni*, Fuckl.). — *Description.* Plums are frequently attacked by this

Fig. 78. — Plum pockets.

fungus soon after they blossom. The affected fruit begins to swell (Fig. 78) until it is from one to two inches in length. At first the plums are very smooth, but they are yellow in color. Later this changes to gray, the appearance being caused by a thick coating of the spores of the parasite. This color is then replaced by dark brown or black, and towards the end of June the fruit falls to the ground. It is then nearly hollow, and rattles like inflated bladders. The walls of the plum are fairly thick, but no stone or pit exists. Wild cherries and plums are also attacked by other closely related fungi. The mycelium of these fungi is perennial, so that the disease generally appears year after year on the same tree. It attacks the leaves and stems as well as the fruit, and causes the affected parts to become swollen and distorted.

Treatment. No careful work appears to have been done in controlling the fungi that cause plum pockets. From the fact that the mycelium has been found growing upon the twigs and extending to the young leaves and fruits, it seems probable that the copper compounds would prove valuable in controlling the disease. The trees should be sprayed when the buds begin to swell, and again just before the blossoms open. The disease may also spread by means of spores, and this would probably necessitate applications at the time when the affected fruit is of a gray color.

Powdery Mildew. See under Apple.

Rot. See under Peach.

Insect Enemies.

Borers. See under Apple.

Bud-moth. See under Apple.

Canker-worm. See under Apple.

Curculio (*Conotrachelus nenuphar*, Herbst). — *Description.* The plum curculio, or "little Turk," as the beetle is occasionally called, is the worst enemy of plum growers. The adult insect is scarcely a fourth of an inch in length. It is grayish-brown in color, and has a black hump on the center of each wing cover. The long snout is generally curved underneath the body. The eggs are laid in the young plums as soon as the blossoms fall, and beetles may still be present even six weeks later. By means of the snout a hole is bored in the plum and the egg is laid within it; a crescent-shaped cut is then made about the part containing the egg in such a manner that a small lip of the green flesh is formed. Within this lip the egg is secure. It hatches in a few days, the grub immediately beginning to eat its way towards the center of the fruit. It feeds for about four weeks, being then over three-eighths of an inch in length. It is of a yellowish-white color, the head being pale brown. When full grown, the larva leaves the plum and descends several inches into the ground. It there pupates, and the mature insect appears in the fall, or sometimes not until the following spring. There is but one brood each year.

Treatment. Spraying the trees with arsenites has been recommended as an effective method of destroying the curculio, but many growers doubt the efficiency of the practice (see pp. 68, 73). The beetles feed some time before laying their eggs, and such applications are designed to kill the adults before the eggs are laid. The first treatment should be made as soon as the first leaves unfold, and before the blossoms open; the second, when the blossoms have fallen; the third, about two weeks later. Paris green and lime should be used, each at the rate of one pound to about two hundred gallons of water.

Another method of destroying the curculio, and a more certain one, is to jar the trees early in the morning before the beetles are active. The insects fall readily from the trees, and may be caught on sheets, or in some of the machines now used for the purpose. When the insects are ordinarily abundant, the trees should be jarred every other morning, beginning the work as soon as the blossoms have fallen. In severe cases the trees must be treated daily, and some growers have repeated the operation again in the evening, as the insects were so numerous. Jarring the trees should be continued until the beetles are no longer caught upon the sheets; in this manner the fruit will be well protected.

Plum gouger (*Coccotorus scutellaris*, Lec.). — *Description.* This insect is found mostly west of the Mississippi River. It is a snout-beetle, and resembles the plum curculio in many respects. It is, however, yellowish-brown in color, and when the egg is laid no crescent mark is made about the point of insertion. The larva burrows into the pit; here it pupates, and late in summer or early fall the adult appears. The winter is passed in this stage, the eggs being laid the following spring at the same time as are those of the plum curculio.

Treatment. The plum gouger is controlled in the same manner as the plum curculio.

Plum-scale (*Lecanium* sp.). — *Description.* This scale insect passes the winter in an immature form. The scales are about one-twenty-fifth of an inch in length; they are very narrow, flat, and of a brown color. About the first of April these minute scales move about and soon fasten themselves, generally to the under side of the small branches. They increase rapidly in size, so that in two months they are from two to three-sixteenths of an inch in length, and nearly circular in outline. At this time eggs are abundantly produced under the large brown scales, and by the first of July the young insects may be seen crawling over the branches. They pass on to the under side of the leaves, where they establish themselves near the larger veins. Here they remain until the latter part of August, when they return to the branches. The affected leaves make little growth and look unhealthy; and although the scales have increased but little in size, so much sap has been removed that the trees make but little growth and the fruit is dwarfed. When the insects return to the branches in the fall they are of a rich brown color, and but one-twenty-fifth of an inch in length; in this form they hibernate, and the following spring they again become active.

Treatment. In the fall, as soon as the foliage has fallen, spray the trees with the Hubbard-Riley kerosene emulsion diluted with four parts of water. A weaker emulsion will not be effective, and a stronger one may injure the trees. If this work is thoroughly done, the pest can be practically exterminated. The application may be made any time from November to April. During the summer months the foliage interferes with the proper application of the spray, and the emulsion cannot be applied to the leaves with safety.

Slug. See under CHERRY.

POPLAR.

See COTTONWOOD.

POTATO.

FUNGOUS DISEASES.

Early Blight (*Macrosporium Solani*, E. & M.).— *Description.* The early blight of potatoes is not yet fully understood, but much of the early dying of the leaves is no doubt caused by the fungus mentioned. Observations tend to show that the injuries caused by the flea-beetle frequently serve as starting-points for the disease (Fig. 79). Around the little holes made by these insects,

Fig. 79. — Early blight (*Macrosporium Solani*) on potato foliage.

there may be seen the characteristic browning and drying of the leaf-tissue, rings of a darker color being visible in the affected areas. The edges of the leaves are more generally affected, and as the small, circular spots increase in size they run together and destroy the entire outer portions of the leaf. These then turn yellow and later brown, the edges curl up, and finally all the leaflets and the petiole are destroyed. The injury also extends to the stems, and eventually the plant dies. The potatoes do not rot, but they remain small. The browning of the tissue often begins during July, the trouble being much more severe upon mature plants, and if the weather is moist the trouble appears to increase less rapidly than during a drought. Whether the early blight fungus is capable of entering uninjured tissue, or whether its entrance is entirely dependent upon the work of the flea-beetle, has not yet been definitely determined, but it is undoubtedly true that the abundance of this insect has considerable influence upon the prevalence of the disease. In some cases the tissue dies apparently without the assistance of insects.

Treatment. Spraying the vines with the Bordeaux mixture has given fairly good results. The fungicide should be used at least of normal strength, and it appears probable that a stronger mixture is still more beneficial. For very early potatoes the first application should be made, in New York, in June; for medium varieties from the first to the middle of July; while late varieties may not require treatment before the first of August, although this period is rather late, the third week in July being perhaps an average date. Applications should be repeated at intervals of two to four weeks, three treatments being sufficient in seasons favorable to the fungus. If power sprayers are used, each row should receive as much liquid as is thrown by two Vermorel nozzles while the horse is walking across the field. The vines should be very thoroughly treated.

Rot; Blight; Late Blight; Downy Mildew (*Phytophthora infestans*, De Bary). — *Description.* Potato blight, or rot, has long been known as the most serious and destructive of all potato troubles. When the weather is warm and moist the disease spreads with great rapidity, so that an entire field may be destroyed in the course of a few days. The first symptom of the malady is the browning of distinct areas upon the potato leaves (Fig. 80); the affected portions may be small, or they may extend over the entire leaflet. In this respect it differs

Fig. 80.—Potato foliage attacked by *Phytophthora infestans*, a fungus which causes rotting of the tubers.

plainly from the early blight, which progresses slowly, and causes distinct, circular spots, while those produced by the rot are at first small and irregular but they rapidly extend under favorable circumstances over large portions of the foliage. There is also soon formed on the under side of the discolored parts a frost-like coating, which is composed of the summer spores and of the threads bearing them. Such a condition is not present when the plants are attacked by the early blight. The tubers of plants attacked by the phytophthora almost invariably rot, and it is on this account that the losses occasioned by the disease are often so great. It is supposed that the tubers are infested by spores which fall to the ground from the diseased leaves above, and not by the mycelium of the fungus growing downward within the stem to the potatoes. The spores are carried through the soil by descending water, and upon reaching the potatoes they gain an entrance into the tubers and cause the dry rot which is so destructive. It is possible, however, that the tubers may be reached by both methods.

As its name implies, the late blight does not appear early in the season. It rarely attacks plants before the middle of July, and frequently not before the first of September. Consequently there is abundant time for treating the vines, and the losses from this disease need not be heavy.

Treatment. The potato rot caused by this fungus can be almost entirely prevented by the application of proper fungicides. The work of Professor Jones of Vermont has clearly shown that the disease can be controlled, and experiments made in Europe have emphasized the same fact. Bordeaux mixture is the best fungicide to use, as there is no danger of disfiguring the crop, nor of injuring the foliage. It should be made at least of "normal" strength, and when made according to the "standard" formula, it has been still more effective. But the latter mixture is applied with considerable difficulty, so that thorough applications of the former are to be advised. Treatments may be begun any time during July, depending upon the time of planting and the lateness of the variety. July 15th is generally early enough for the first application in New York. It should be followed by one or two others made at intervals of one to three weeks, depending upon the weather. If the potato foliage is thoroughly covered with the mixture, little trouble need be anticipated from this disease.

Bacterial Blight. — Potatoes also appear to suffer from a bacterial disease which causes the death of the parts above ground and also a rotting of the tubers. No distinct discolorations appear upon the leaves, as is the case with fungous diseases, but the entire plant is unhealthy and dies prematurely. Tubers frequently show discolored patches on their surface before decaying; a soft rot results. No remedy is known, except rotation.

Scab (*Oospora scabies*, Thax.). — *Description.* Potatoes very commonly suffer from the attacks of a fungus which causes the skin of the tubers to become rough or scurfy (Fig. 81), the injury often penetrating to a considerable depth. The life history of the fungus is not yet well understood, but it is

Fig. 81. — Potato scab.

known that the disease may be communicated to new tubers by unclean seed, and that barnyard manure, lime, or ashes may have a tendency to increase the disease. Soil in which scabby potatoes have been produced also appears capable of infecting later crops. One kind of scab is caused by an insect.

Treatment. Land in which the scab fungus is found should not be planted to potatoes, and only clean fertilizers or uninfected manure should be applied. Scabby seed may be cleaned by soaking it for an hour and a half in a solution of corrosive sublimate, using one ounce of the poison in eight or nine gallons of water. This may be done either before or after the potatoes are cut, but the tubers must not again be brought in contact with the disease. It is safer to treat the seed before it is cut; and if care is taken not to transfer the organism to the cleaned potatoes, no scab should develop upon clean land. Halsted has been successful in preventing the development of the disease by rolling the seed in sulphur. He used the sulphur at the rate of three hundred pounds to the acre, that which did not adhere to the potatoes being sprinkled in the open row.

INSECT ENEMIES.

Colorado Potato-beetle; Potato-bug (*Doryphora* 10-*lineata*, Say). — *Description.* This insect is too well known to require a detailed description. It hibernates during the winter as a mature insect, and in the spring it begins to feed upon the foliage of eggplants or potatoes as soon as these are at hand. The eggs are laid on the under side of the leaves. They are bright yellow in color, and easily seen. The larvæ appear in about a week, and the plant is soon stripped of its foliage. In a short time the grubs become full grown; they then leave the plant and pupate in the surface soil. Here they remain about ten days, when the mature insect again appears. There are three or four broods each year.

Treatment. Potato-beetles are easily destroyed by spraying the young plants with an arsenical poison. This should be done early in the season so that the first beetles, or at least the first brood of larvæ, may be exterminated. The poison should be made about one-fourth or one-third stronger than for fruits, as these insects seem to require more poison than most others. There is no danger of injuring potato foliage in this manner.

Flea-beetle (*Phyllotreta vittata*, Fabr.; *Haltica striolata*, Harris). — *Description.* This species of flea-beetle, as well as several others, makes the growing of many garden plants a difficult matter. The mature beetles are, as a rule, not more than one-tenth of an inch in length. They are very active, and move so quickly that their popular name is very appropriate. The beetles appear early in spring and eat out little cavities in the tender foliage of young plants, often to such an extent that the plants are ruined. If the work of the beetles does not destroy the crop, the injured parts afford conditions suitable to the growth of certain fungi, and these two parasites may succeed in accomplishing that which each alone could not have done. There appear to be several broods of the beetles each season.

Treatment. No uniformly effective remedies are known. Good results have been obtained by dusting the young plants, while wet, very freely with tobacco dust. Arsenites have also been recommended, as well as lime, ashes, plaster, and kerosene emulsion. Bordeaux mixture and soap has given good results in certain cases when thoroughly applied.

PRIVET.

FUNGOUS DISEASES.

The privet is comparatively free from fungous diseases, one form of blight which occasionally appears rather suddenly being the most serious. It is probably due to *Phyllosticta Ligustri*, Sacc. Little attention has been given it, but the use of Bordeaux mixture is the most promising line of treatment.

INSECT ENEMIES.

Privet Web-worm (*Margarodes quadristigmalis*, Gn.). — *Description.* The adult moth is almost entirely white, a narrow brown line marking the anterior edge of the front wings; there are also a few brown dots and markings at the outer edges of both pairs of wings. The body is almost entirely white. It is nearly five-eighths of an inch in length, the wings expanding about one and one-fourth inches. Eggs are laid in spring, near the mid-vein of the leaves; they hatch in less than a week, and the larvæ immediately begin to feed upon the foliage. They vary in color from yellowish-green to a very dark green, while along the back are situated two rows of small black warts. The head is yellowish-green. The caterpillars feed for about three weeks; they then pupate, the moth appearing about eight days later. There are at least four broods of this insect each year in the latitude of Washington.

Treatment. The free use of arsenites or of kerosene emulsion will undoubtedly exterminate the insect if the work is begun when the first larvæ are seen in spring.

PUMPKIN.

FUNGOUS DISEASES.

Powdery Mildew. See under MUSKMELON.

INSECT ENEMIES. See under CUCUMBER.

QUINCE.

Fungous Diseases.

Black Rot (*Sphæropsis Malorum*, Peck). — *Description.* Apples and pears, as well as quinces, suffer from the fungus which causes black rot. The fruit is generally not attacked until it is at least one-half grown. Infection takes place, as a rule, at the blossom end. A small brown spot appears upon the surface, and as it increases in size dark pimples appear upon the part first affected. Later the fruit cracks, and spores are freely distributed. The diseased quinces frequently remain hanging on the trees throughout the winter, and serve as excellent sources of infection.

Fig. 82. — Quince foliage affected with leaf blight.

Treatment. As the malady appears late in the season, the application of the Bordeaux mixture can scarcely be recommended. Clear fungicides should be used, and, if thoroughly applied, the disease, which, as a rule, is not serious, can probably be held in check by two or three treatments.

Blight. See under Pear.

Leaf Blight; Fruit Spot; Leaf Spot (*Entomosporium maculatum*, Lév.). — *Description.* Quince foliage is generally affected by the leaf-blight fungus during early summer. Fig. 82 represents quince foliage dotted with the small circular spots which are produced by the fungus. These are of a reddish-brown color, and although at first circular in form, when several are united, the diseased part assumes an irregular outline. Badly infested leaves turn yellow and fall to the ground during the latter part of summer, or early in the fall. Trees very commonly lose all their leaves in this manner. Upon the fruit, if the attack takes place after the quince is nearly grown, dark brown or nearly black sunken areas are formed, these being more or less thickly scattered over the surface, as shown in Fig. 83. If the quince is affected while it is small, its shape may be much altered, for the flesh becomes cracked and corky in the diseased places. Such fruit is only too familiar to quince growers. The fungus also attacks pears.

Fig. 83. — Quince attacked during the latter part of the season by fruit spot.

Treatment. The method of treating this disease has already been mentioned under leaf blight of the pear. The two fruits are treated in a similar manner, but the applications made upon the quince during the latter part of June and in July are the most important ones.

Ripe Rot. See under Apple.

Rust (*Rœstelia aurantiaca*, Pk.). — *Description.* This disease (Fig. 84) "is very conspicuous upon the fruit, as it covers the injured portion of the quince with an orange, fringe-like growth. The tube-like projections of the fungus contain numerous spores, and when this stage is apparent, the fruit is already irrevocably ruined. Sometimes the entire young fruit is involved, and it may die and fall; but more often the fruit hangs upon the tree, and the diseased portion becomes dry, hard, black, and sunken. . . . This rust fungus also penetrates the twigs, and often causes knots to appear, resembling the black knot of the plum."[1] The life history of this fungus is similar to that causing the rust of apples, which see.

Treatment. See under Apple.

Insect Enemies.

Borers. See under Apple.

Slug. See under Cherry.

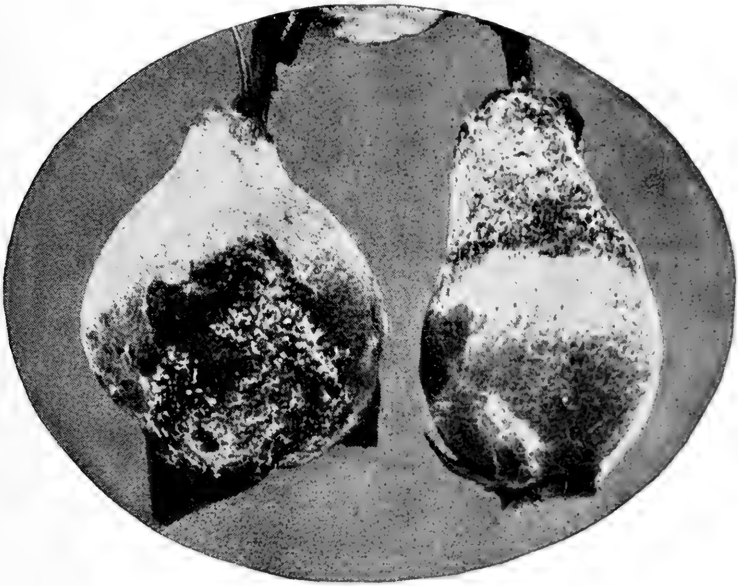

Fig. 84. — Young quinces attacked by rust.

RADISH.

Insect Enemies.

Maggot. See under Cabbage.

RASPBERRY.

Anthracnose; Cane Rust (*Glœosporium necator*, E. & E.). — *Description.* This fungus attacks the young canes of raspberries, blackberries, and dewberries. It appears during the latter part of June and during July, attacking the lower parts of the

[1] Bailey, *Cornell Agric. Exp. Sta.* 1894, Dec. Bull. 80, 625, 626.

canes first. The affected parts are circular but later oval in outline (Fig. 85), the central part is gray in color, and this is surrounded by a distinct purple rim. These areas are sunken, and when several run together they may cause the cracking of the cane, or even its death. The leaves are also attacked to a limited extent, but with no such serious results. When the fruit stems are diseased, the berries are frequently prevented from ripening, and consequently they dry up on the bushes.

FIG. 85. — Raspberry anthracnose, or cane rust.

Treatment. Anthracnose has not yet been very successfully treated. The best recommendations which can now be given are to spray the bushes thoroughly with the copper sulphate solution before the buds swell in the spring, and to follow this by repeated and copious applications of the Bordeaux mixture at intervals of two weeks until midsummer. A clear fungicide may be necessary to avoid staining the fruit. Even this treatment may not hold the disease in check. In that case perhaps the best method to follow is to cut off all growth close to the ground during the fall or spring, and then burn the canes. This means the loss of one year's crop, but the source of infection would no doubt be so reduced that but little disease should appear during the next few years, especially if the bushes are also sprayed as above described. Or the entire plantation may be pulled up and a new one, composed of less susceptible varieties, may be set upon other land.

Orange-rust; Red-rust (*Cæoma luminatum*, Link). — *Description.* This fungus is found upon blackberries and raspberries.

It possesses a perennial mycelium, so that when a plant is once infested it cannot be cured. The fungus has two forms which were formerly supposed to be distinct plants. One form is known as *Puccinia Peckiana;* it attacks the foliage, and produces spores which germinate in the fall or spring. The mycelium enters the canes of the host-plant, probably by means of the underground parts, and from there it spreads to the various branches. The copious production of orange-colored spores on the under side of the foliage of diseased plants is the result of such infection. This condition is preceded by an appearance which is easily recognized: the leaves are smaller, and they have a pale green color which distinguishes them from the healthy tissues.

Treatment. The only practical remedy yet known is to dig out and destroy affected plants as soon as they are discovered. Spraying the foliage with a fungicide to prevent the entrance of the fungus into the leaves might be followed by good results.

Insect Enemies.

Cane-borer (*Oberea bimaculata,* Oliv.). — *Description.* The mature insect is a slender, black beetle about half an inch in length. During June it lays its eggs in the young shoots which grow from the base of the plant. A row of punctures is made above and below the place in which the egg is inserted. The egg soon hatches and the grub begins to burrow downward. By autumn it has reached the roots of the plant. The following spring the adults again appear.

Treatment. The puncturing of the young canes when the eggs are laid causes the tips to wilt and on this account the affected shoots are readily seen. They should be cut off below the injured part, and destroyed. The canes should also be watched during late summer, and any which are found wilting should be cut out close to the ground and burned.

Sawfly ; Raspberry-slug (*Selandria Rubi,* Harris). — *Description.* During May and early in June the raspberry sawfly may be seen among the canes of these plants. It is a black, four-winged fly, the abdomen being tinged with red. The eggs are laid within the leaf, generally near the veins. The larvæ are at first nearly white, but later they become dark green and are thickly covered with soft spines of the same color. When grown, the larvæ are about half an inch in length. They feed upon the foliage of the plants, and, if present in considerable numbers, the foliage may be almost entirely devoured. During June the insect pupates, but the adult does not appear until the following spring.

Treatment. The slugs are readily destroyed by the arsenites, hellebore, or pyrethrum. But some applications must necessarily be made while the plants are in blossom; this exposes bees to the action of the poisons, and large numbers of these insects are destroyed whenever enough poison to kill the slugs is applied. Under such circumstances it is a question of killing the bees or tearing out the plants. Hand picking might be practiced, and if carried on for a year or two would greatly reduce the numbers of the pest. Kerosene emulsion might also be tried, the blossoms being touched as little as possible.

ROSE.

Black Spot; Leaf Blight (*Actinonema Rosæ*, Fries). — *Description.* During early summer the foliage of roses suffers from the attacks of a fungus which causes the formation of irregular, black spots upon the upper surface of the leaves (Fig. 86). The spots eventually become nearly circular; their edges are apparently fringed with delicate white, and later in the season the affected leaves turn yellow, and fall to the ground; at this time the spots may be fully half an inch in diameter. Roses grown indoors or in the open appear to be equally affected.

Treatment. Fungicides containing copper will check the disease if the treatments are begun as soon as the buds open in spring. Clear solutions are to be preferred. Removing and destroying the affected leaves will also tend to lessen the trouble.

Leaf Spot (*Cercospora rosæcola*, Pass.). — *Description.* The spots formed by this fungus are dark red or nearly black, the edges of the well-defined areas being mostly of a red color. The center changes to a grayish-brown color as the season advances. Only those plants which grow out of doors are affected, the foliage being the part generally attacked.

Treatment. The treatment described under Black Spot, above, is also recommended for this disease.

Mildew (*Sphærotheca pannosa*, Lév.). — *Description.* This fungus attacks roses which are grown under glass and also those out of doors. It checks the growth of the young shoots, and causes the leaves to remain dwarfed and curled, the edges

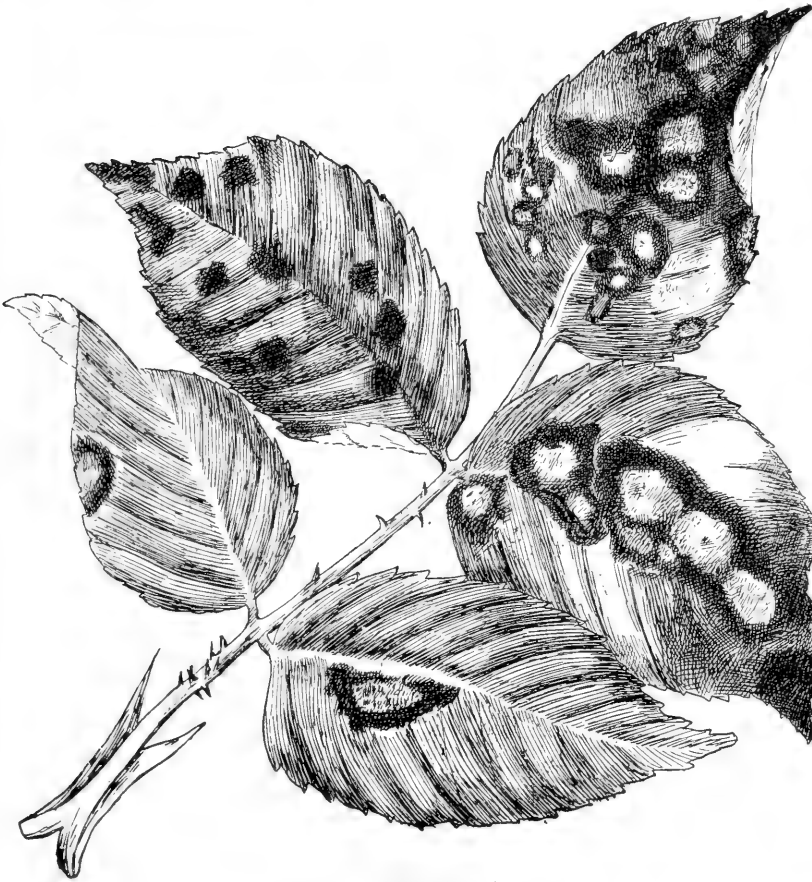

FIG. 86. — Black spot of roses.

being generally rolled downward. At the same time, a white powdery growth entirely covers the affected areas, and the plants soon become so weakened that they possess no practical value. Fig. 87 represents a leaf partially affected.

Treatment. The treatment of mildews affecting plants grown under glass has already been discussed under GREENHOUSE

PESTS. Many of the same remedies will also prove of value with plants grown in the border, sulphur and the copper compounds being particularly recommended.

FIG. 87. — Rose leaf attacked by mildew.

Rose Phragmidium (*Phragmidium speciosum*, Fries). — *Description.* The stems of roses suffer severely from this fungus. The mycelium is perennial, and the affected places show irregular elevated areas on the stem (Fig. 88). They are black in color, and consist of innumerable spores borne upon slender filaments. In severe cases the diseased stems die.

Treatment. The treatment recommended against the rust will also apply to this disease. In addition, however, the affected stems should be removed as soon as discovered.

Rust (*Phragmidium mucronatum*, Winter). — *Description.* All the young green parts of the rose are subject to the attacks of

FIG. 88. — Rose Phragmidium.

the rust fungus. It causes the formation, in early summer, of small reddish-yellow spots which gradually increase in size as the season advances. The stems frequently become bent and twisted by the growth of the mycelium. During August, the color of the spots changes to dark red. In the fall, small dark bodies are produced on the under side of the leaves; they contain the spores which preserve the fungus through the winter.

Treatment. The plants, and the soil about them, should be sprayed in early spring before growth has commenced with the copper sulphate solution. After the buds have burst the Bordeaux mixture should be used, or some clear fungicide which will not stain the leaves. These applications should be continued until midsummer at intervals of two or three weeks. Raking and burning the leaves in the fall will also diminish the trouble.

INSECT ENEMIES.

Mealy-bug. See under GREENHOUSE PESTS.

Rose-chafer; Rose-beetle; Rose-bug (*Macrodactylus subspinosus*, Fabr.). — *Description.* The beetles appear, as a rule, early in June. They are about half an inch in length and of a yellowish-brown color, the legs being pale red. The beetles feed for about a month after the time of their first appearance. They devour nearly all kinds of foliage, and in some localities fruit plantations are annually almost ruined by these insects. Shortly before the disappearance of the adults, the eggs are laid in the ground near the surface. The grubs feed upon the roots of various plants and in the fall they descend below the frost line and there pass the winter. In the spring they ascend to the surface and pupate, the adult emerging as above stated. There is but one brood each year.

Treatment. No satisfactory remedies for the destruction of the rose-beetle are known. The insect can persist only on sandy land, for heavier soil prevents the grubs from descending to a proper depth. It is, therefore, only on sandy land that the pest is to be feared. The following methods of exterminating the insect have been recommended, but none are entirely satisfactory: "Hand picking. Knocking off on sheets early in the morning. Bagging. Pyrethrum. Kerosene emulsion. Pyrethro-kerosene emulsion. Eau céleste. It is said to prefer Clinton grapes, spireas, rose-bushes, and magnolias, and it has been suggested that these plants be used as a decoy. Open vials of bisulphide of carbon hung in bushes and vines are recommended by some. Sludge-oil soap, a manufactured material. Spraying with dilute lime whitewash. Hot water, at a temperature of 125° to 130° F. To prevent the insects from breeding, keep the light lands — in which they breed — under thorough cultivation, and especially never seed them down."[1]

Rose Leaf-hopper (*Typhlocyba Rosæ,* Harris). — *Description.* These insects are generally found upon the under side of the leaves, but when disturbed they move or fly rapidly from place to place. They live upon the juices of the plants, and are frequently serious. The mature insect is less than a fourth of an inch in length; its wing covers are nearly transparent, and the body is yellowish-white. There are several broods. The affected leaves show irregular, white markings on their upper surface, and in this manner the presence of the pest may easily be observed.

Treatment. The same remedies mentioned under CURRANT GREEN-LEAF-HOPPER may also be employed against this insect.

SHADE TREES; SHRUBS.

There are many fungi and insects attacking other plants than those mentioned individually in this work, but it is scarcely practicable to describe each in detail. The reader is referred to Chapter VI., in which general directions will be found; it is hoped these will serve as guides in the treatment of any trouble which it is desired to overcome.

SPINACH.

Anthracnose (*Colletotrichum Spinaceæ,* E. & H.). — *Description.* The affected parts are generally circular in form; they soon produce brown pustules, and the color of the spot gradually changes to gray. The fungus spreads with great rapidity, attacking the old and the young leaves indiscriminately.

Mildew (*Peronospora effusa,* Rabenh.). — *Description.* Spinach grown under glass is frequently attacked by this fungus. The diseased foliage shows "gray, slightly violet patches of a velvety texture upon the under side of the leaves, while from the upper side they have a pale yellow shade due to the loss of the green color."[2] Dr. Halsted has also described three other fungous diseases of spinach, viz. black mold, leaf blight, and

[1] Bailey, *Horticulturist's Rule-Book*, 1895, 42.
[2] Halsted, *N. J. Agric. Exp. Sta.* 1890, July, Bull. 70, 5.

white smut, and the reader is referred to the bulletin mentioned below for detailed descriptions.

Treatment. All spinach diseases are controlled with difficulty, since the parts attacked by the fungi grow quickly, and they are then used as food. Fungicides would undoubtedly prevent the entrance of the parasites, but the market value of the crop would be lessened to such an extent that the applications can scarcely be advised. The plants might be sprayed with dilute solutions of clear fungicides, but comparatively little has as yet been done in this direction. The destruction of all infested leaves or plants appears to be the most advisable procedure.

SQUASH.

Fungous Diseases.

Powdery Mildew. See under Muskmelon.

Insect Enemies.

See under Cucumber.

STRAWBERRY.

Leaf Blight; Rust; Sunburn (*Sphærella Fragariæ.*, Sacc.). — *Description.* The foliage of strawberries is subject to the attacks of a fungus which may appear at any time during the growing season. The first symptom of the disease is the formation of small purple spots which gradually increase in size until they are from an eighth to a quarter of an inch in diameter (Fig. 89). The purple color is early replaced by a clear, reddish-brown, which becomes of a still lighter shade as the season advances; the edges of the spots, however, generally remain purple. Badly infested leaves turn dark and are of no value. The fungus passes the winter by means of spores, and by mycelium contained within the leaves. This disease is frequently very serious, especially upon certain varieties.

Treatment. Spraying the plants with the Bordeaux mixture will check the trouble. Applications should be begun as soon as growth starts in spring, and non-bearing plants may be treated throughout the summer, the treatments being made at intervals of three or four weeks. Bearing plantations will derive benefit from a treatment made when growth starts in the spring, and from another made when the first blossoms open. After harvesting the fruit, it is a good plan to mow off the old foliage, then to remove and destroy it. Burning the strawberry patch over is frequently followed by bad results. The new growth should then be sprayed at intervals of three or four weeks until two or three applications have been made.

Mildew (*Sphærotheca Castagnei*, Lév.).—*Description.* This fungus grows on the berries, and also on the surface of the

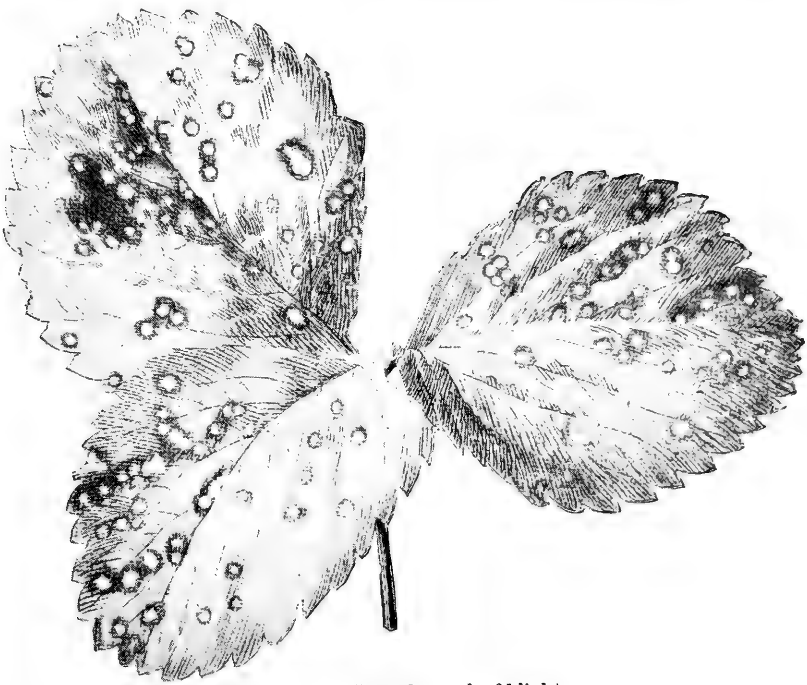

Fig. 89.—Strawberry leaf blight.

strawberry leaves, during the summer. It covers them with a thin net of mycelium which resembles delicate cobweb. Affected leaves curl and appear as if suffering from want of water (Fig. 90). The disease is rarely serious.

Treatment. When the malady is first seen, spray the plants with a fungicide containing copper. Sulphur, if scattered upon the leaves and between the plants, is also said to check the disease, since the heat of the sun at this season of the year is sufficiently great to cause fumes to be given off freely.

INSECT ENEMIES.

Leaf-roller (*Phoxopteris comptana*, Fröl.). — *Description.* The adult insect is a small, brown moth measuring about half an inch across the wings. It appears in early spring and lays its eggs upon the leaves of the strawberry, although the raspberry and blackberry are rarely affected. The larvæ are greenish brown, and when full grown, nearly half an inch in length, but rather slender. They mature in June after having spun a web which causes the familiar rolling upward of the leaflets. The soft tissue of the leaf is eaten, and what remains turns reddish brown, giving the plant a burned appearance. There are two broods in the North, the winter being passed in the pupal stage.

Treatment. Spray the plants during August, when the second brood of larvæ appears, with an insecticide such as Paris green or London purple. Two applications may be required. Or the foliage may be cut and burned, for the first brood pupates in the rolled leaf, and in this manner it may be practically exterminated.

Sawfly; Slug (*Emphytus maculatus*, Norton). — *Description.* "The four-winged fly appears in spring, and deposits its eggs within the tissues of the leaf or stem. The larvæ hatch in a short time and feed upon the leaf, gnawing small, circular holes at first like those eaten out of currant and gooseberry leaves by young currant-worms. They develop in five or six weeks into pale green worms about three-fourths of an inch long. The larvæ now go slightly beneath the surface, where they form cocoons within which they change to the pupa state, and later emerge as flies. In the southern states there are two broods each season, while at the North there appears to be but one."[1]

Treatment. Burn the foliage as soon as the crop is harvested, or spray with hellebore or Paris green before there is danger of poisoning the fruit. Plants which are not bearing may be sprayed with an arsenite when the worms first appear, and again later if necessary.

Tarnished Plant-bug (*Lygus pratensis*, Linn.). — *Description.* This bug is about one-fourth of an inch in length. It is very variable in color, some being dark yellow, and others nearly

[1] Weed, "Insects and Insecticides," 1891, 92.

black. The adult hibernates during the winter, but in the spring it sucks the juice of the growing plants, preferring to obtain it from the young fruits, which are in consequence dwarfed. Eggs are laid early in spring, and soon both adult

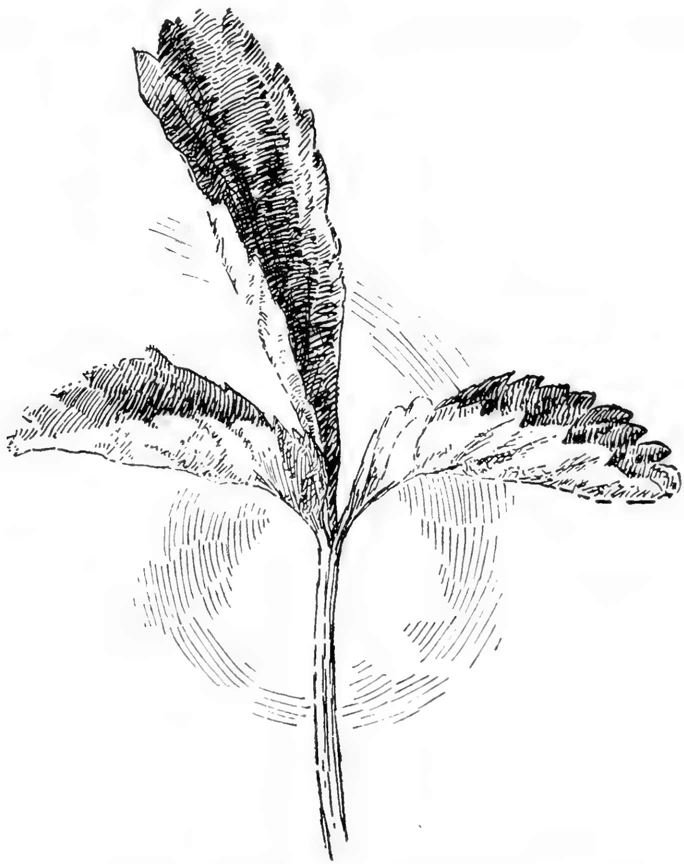

FIG. 90. — Strawberry leaf curled by the mildew.

and immature forms may be found. A great many species of plants suffer later in the season, and as there are from two to four broods each year, much injury may be done.

Treatment. Pyrethrum powder dusted freely upon affected plants will destroy the insects; this is probably the best remedy. Kerosene emulsion is also effective, but there is danger of tainting the fruit.

SWEET POTATO.

Fungous Diseases.

Black Rot (*Ceratocystis fimbriata*, E. & H.).—*Description.* The fungus causes large, greenish-black patches to appear upon the tubers; the dark color eventually extends deeply into the potato, entirely ruining it. The disease may attack the young plants in the seed beds, the infection coming either from the soil or from unhealthy tubers. When the young sprouts are affected, the stems near the ground become discolored by dark lines or blotches, and the lower leaves frequently suffer in the same manner. The shoots frequently die beyond the point of attack.

Treatment. The use of unaffected potatoes for producing the sets is essential. No diseased sprouts should be planted, and, if possible, land that is free from the fungus should be used for the crop. Spraying with copper compounds may materially assist in checking the trouble in the field, and soaking the tubers a short time in the ammoniacal carbonate of copper before storing them may prevent its spread in the bins.

Leaf Spot (*Phyllosticta bataticola*, E. and M.).—*Description.* Sweet-potato foliage attacked by this disease dies at the points of infection, the dead portions turning nearly white. The plants may suffer severely from the disease, the yield being correspondingly reduced.

Treatment. Spray with the Bordeaux mixture at the first appearance of the fungus.

White Mold; **Leaf Mold** (*Cystopus Ipomœæ-panduranæ*, Farl.). —*Description.* This fungus causes the leaves to turn brown, the older ones being particularly affected. Small white patches also appear on the under side of the discolored areas.

Treatment. Spraying the vines with a good fungicide will probably prove valuable in checking the disease.

Insect Enemies.

Sawfly (*Schizocerus ebenus*, Norton; *S. privatus*, Norton).—*Description.* These two sawflies are not, as a rule, very serious, but occasionally they develop in sufficient numbers to do considerable damage. The larvæ appear during the summer, and feed upon the foliage.

Treatment. The same treatment recommended for the destruction of the currant sawfly will also destroy these insects. The applications, however, need not begin until the young larvæ are noticed, but they should be repeated as required during the summer.

Tortoise Beetles; Golden Bugs (*Cassidæ*). — *Description.* The insects hibernate in the adult state. They attack the young potato vines during May and June, eating irregular holes in the foliage. Eggs are laid, and during June and July the larvæ appear. At this time the vines are growing so fast that the insects do comparatively little injury. The adults appear again during July and August, but no eggs seem to be laid until the following spring.

Treatment. Professor J. B. Smith recommends the use of Paris green or London purple at the rate of 1 pound to 175 gallons of water. The application should be made as soon as injury is noticed, both sides of the leaves receiving treatment. The vines should be treated again if the first application does not prove effective.

SYCAMORE.

Leaf Blight (*Glœosporium nerviseqimm*, Sacc.). — *Description.* Both the native and the foreign species of plane trees are subject to the attacks of a fungus which causes the leaves to appear as if scorched. The disease develops so early in the season that the injury caused by it is often ascribed to frost. Entire trees are frequently discolored by the abundance of brown leaf surface, and although this form of the disease is present only about two months, still trees have been killed by the repeated attacks of the fungus. Diseased leaves often fall.

Treatment. The severity of the attacks can undoubtedly be diminished by spraying with fungicides as soon as the leaves unfold in spring, repeating the operation so that all new growths may be protected. But such applications can only be made to smaller trees, and when they are impracticable a probable help in checking the malady is to burn all affected leaves that fall from the trees.

TOBACCO.

Insect Enemies.

Tobacco worm (*Phlegethontius Carolina*, Linn.). — *Description.* The moth closely resembles the tomato worm as regards color and habits. There are two broods in the South, and it is here that much injury is done to the tobacco plantations through the ravenous appetite of the worms.

Treatment. The destruction of the insect by means of the arsenites appears to be the most feasible method. The following practice appears to be safe and efficient:[1] "To those who wish to use poison I would advise the use of (*a*) Paris green, ¼ pound in a forty-gallon barrel of water, with a little whitewash well stirred in. (*b*) That the mixture be kept well stirred in the barrel and sprayer. (*c*) That applications should begin by the tenth of June and be repeated every two weeks by topping, and *that no applications should be made after that time.*" Hand picking may also be resorted to.

TOMATO.

Fungous Diseases.

Blight (*Cladosporium fulvum*, Cooke). — *Description.* Affected leaves first show dark-brown spots on the under side. The upper surface at the same time turns yellow and the edges of the leaves curl downward, as a rule. As the disease progresses, the foliage shrivels and eventually dies, leaving the naked stems. The fungus is found both in greenhouses and out of doors.

Treatment. For the treatment of the blight when found upon plants grown under glass, see Greenhouse Pests. When the fungus appears out of doors, the plants should immediately be thoroughly sprayed with the Bordeaux mixture, or modified eau céleste, repeating the treatment at intervals of ten days or two weeks, until no further infection is feared.

Rot (*Macrosporium Tomato*, Cooke). — *Description.* This fungus generally attacks the tomatoes when they are over one-half grown. The blossom end is attacked, the appearance of a small black spot being the first indication of the disease. This

[1] Peter, *Ky. Agric. Exp. Sta. Bull.* 53, 139.

spot increases in size until fully half of the tomato is destroyed. The diseased part is black and sunken, and generally extends squarely across the tomato from side to side (Fig. 91). The warm moist weather of summer appears to be particularly favorable to the development of this parasite.

Treatment. Very thorough spraying with the Bordeaux mixture, or other copper compound, is perhaps the best preventive. If possible, a dry location should be selected for growing the plants, and the stems should be kept free from the ground.

Fig. 91. — Tomato rot.

Two other serious diseases of the tomato are also known, but as they are probably caused by bacteria, no remedies can as yet be named. It is probable that one of these organisms is the first cause of the rotting of tomatoes above described.

Insect Enemies.

Tomato Worm (*Phlegethontius celeus*, Hbn.). — *Description.* The larvæ of this moth are fully three inches in length when grown. They are of a green color, but have a few nearly white markings on each side of the body. They devour an enormous amount of foliage, and can be discovered by the bare places among the plants. Early in September the larvæ enter the ground to pupate, and here they remain until the following summer, when the moths appear. These belong to the Sphinx family, and they are beautifully and delicately marked. They fly mostly in the evening. The ground color is a soft gray, but there are various markings of a darker color, some red or reddish-brown parts being present.

Treatment. Hand picking is the most common method of destroying the larvæ, but any of the poisons in use against chewing insects would answer the purpose as well.

TURNIP.

INSECT ENEMIES.

Maggot. See under CABBAGE.

VERBENA.

FUNGOUS DISEASES.

Mildew; Rust (*Erysiphe Cichoracearum*, DC., or *Oidium erysiphoides*, Fr.). See under CUCUMBER.

VIOLET.

FUNGOUS DISEASES.

Mildew. See under PANSY.

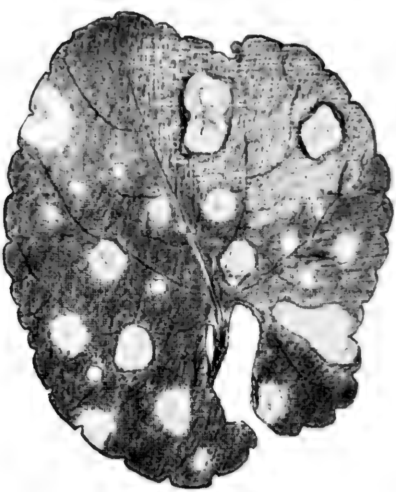

FIG. 92. — Violet disease.

Rust; Spot; Violet Disease (*Cercospora Violæ*, Sacc.).—All violet growers are familiar with this disease (Fig. 92), which causes the formation upon violet foliage of small, circular, grayish-white spots having a dark center. The first appearance of the disease may occur during summer, while the plants are in the open ground. Or it may not be visible until late in winter. Surrounding conditions appear to have a strong influence in the development of the fungus. Too much heat, carelessness in watering, fresh stable manure, and improper ventilation have all been advanced as immediate causes of the appearance of the disease. Much truth undoubtedly lies in these statements, and the requirements of the plants should be thoroughly understood by all who attempt to grow the crop.

Treatment. Give good culture. If the disease persists, spray the plants with a good fungicide, as the Bordeaux mixture, making the first application as soon as the disease appears, and repeating it at intervals of two to four weeks. Destroy affected leaves and plants.

WATERMELON.

FUNGOUS DISEASES.

Anthracnose. — This disease may be identical with the anthracnose of the BEAN, which see.

Powdery Mildew. See under MUSKMELON.

WEIGELIA.

INSECT ENEMIES.

Four-lined Leaf-bug. See under CURRANT.

WHEAT.

FUNGOUS DISEASES.

Stinking Smut (*Tilletia fœteus,* Schroet.; and *T. Tritici* Wint.). — *Description.* This disease causes the wheat kernels to become swollen as they approach maturity. They are at first green in color, but later turn grayish-brown. If a kernel is crushed, it will be found to be filled with a brown powder possessing a very disagreeable odor: this has been the cause of the popular name of the disease.

Treatment. See under OATS.

Loose Smut (*Ustilago Tritici,* Jensen). — *Description.* This disease closely resembles the loose smut of oats. Unfortunately, no practical remedies are as yet known.

WILLOW.

INSECT ENEMIES.

Willow-worm; Antiopa Butterfly (*Vanessa Antiopa,* Linn.). — *Description.* The adult insect hibernates during the winter.

It is a butterfly whose wings are "purplish brown above, with a broad buff-yellow margin, near the inner edge of which there is a row of pale blue spots. Expands from three to three and a quarter inches."[1] The eggs are laid early in spring upon willow, poplar, and elm trees, the young larvæ appearing early in June. When full grown the larvæ are nearly two inches in length; the ground color is black, but it is relieved by spots of white and red. During June the larvæ pupate, the adult appearing early in July. There are two broods each year, the larvæ of the second appearing in August.

Treatment. The caterpillars are voracious feeders, and they may be destroyed by arsenical poisons.

[1] Harris, "Insects of Mass. Injurious to Vegetation," 1841, 218.

APPENDIX.

A. LAWS REGARDING THE SPRAYING OF PLANTS.

Many of the organisms which attack cultivated plants have become so abundant and serious in certain localities that communities have taken measures to check the spread of existing parasites, and also to prevent the introductions of different ones which occur in other localities. A few States have passed quarantine laws with this end in view, all nursery stock being rigidly examined, and treated if necessary, before its passage into the State is allowed. The exportation of trees, etc., from very restricted areas within certain States has also been forbidden. The suppression of insect and fungous diseases is thus rapidly increasing in importance, and laws aiming at their extermination are being more and more frequently passed. Several of these consider the spraying of plants, and below will be found the leading points concerning these acts.

CALIFORNIA has been a pioneer in legislating against plant diseases. On March 14, 1881, there was approved "An Act to Protect and Promote the Horticultural Interests of the State." It was amended by an act approved March 19, 1889, and by an act approved March 31, 1891. Section 1 states: "Whenever a petition is presented to the Board of Supervisors of any county, and signed by twenty-five or more persons who are resident freeholders and possessors of an orchard, or both, stating that certain or all orchards or nurseries, or trees of any variety are infested with scale insects of any kind injurious to fruit, fruit trees, and vines, codlin-moth, or other insects that are destructive to trees, and praying that a commission be appointed by them, whose duty it shall be to supervise their destruction as herein provided, the Board of Supervisors shall, within twenty days thereafter, select three commissioners for the county to be known as a 'County Board of Horticultural Commissioners.' . . ." [Statutes of California, 1889, 413.]

It is the duty of the County Board to cause the inspection of all plantations and buildings in which the presence of injurious insects or fungi is feared. If such are found, a notice is served upon the proper individuals, and it then becomes incumbent upon the latter to destroy the pest. In case this is not done within a certain period, the Board is compelled to assume the work, the expenses being ultimately drawn from the owners of the property. An excellent feature of the above law is that all officials are *required* to enforce its provisions, as is distinctly stated. The mere granting of power to act in a certain manner has been fatal to the enforcement of other laws of this nature.

Several counties have availed themselves of the benefits to be derived from the above acts, and have passed ordinances suited to their needs. In 1894, thirty-four counties possessed "Horticultural Quarantine Guardians."

Canada possesses a law which prohibits spraying fruit trees while in bloom with any substance injurious to bees. The act was passed in April, 1892, and reads as follows:

"1. No person in spraying or sprinkling fruit trees during the period within which such trees are in full bloom shall use, or cause to be used, any mixture containing Paris green or any other poisonous substance injurious to bees.

"2. Any person contravening the provisions of this Act, shall on summary conviction thereof before a justice of the peace, be subject to a penalty of not less than $1.00 or more than $5.00 with or without costs of prosecution, and in case of a fine or a fine and costs being awarded, and of the same not being upon conviction forthwith paid, the justice may commit the offender to the common gaol, there to be imprisoned for any term not exceeding thirty days unless the fine and costs are sooner paid.

"3. This Act shall not come into force until the first day of January, 1893."

This law scarcely appears necessary, as all our fruits may be amply protected without treating them during the blossoming period; and, bees unquestionably suffer if such applications are made.

The MASSACHUSETTS legislature, on March 14, 1890, approved an act whereby the Governor was "authorized to appoint a commission to provide and carry into execution all possible and reasonable measures to prevent the spreading, and secure the extermination of the *Ocneria dispar* or gypsy moth, in this Commonwealth." Three commissioners were appointed, and work was begun April 1st.

In 1891, by an act approved April 17th, the entire work came under the control of the State Board of Agriculture. Spraying with Paris green was one of the methods adopted for the extermination of the insect. "When the caterpillars appeared, spraying was commenced with a large force of men and teams equipped with hogsheads of Paris green and water, pumps, hose, ladders, oil suits, etc. — an extensive and expensive outfit."[1] The remedy proved to be only partially successful, however, as it was expensive, and it met the opposition of property owners. The large size of many of the plants also prevented proper applications from being made, so that the treatments have since met with little favor.

MICHIGAN passed a compulsory spraying law early in 1895. It is entitled, "An Act to Prevent the Spreading of Bush, Vine, and Fruit Tree Pests, such as Canker Worms and Other Insects, and Fungous and Contagious Diseases, and to Provide for their Extirpation."

The more important features of the law are here outlined:

"Section 1. The people of the state of Michigan enact that it shall be the duty of every owner, possessor, or occupier of an orchard, nursery, or vineyard, or of land where fruit trees or vines are grown, within this state, to spray with a poisonous solution or disinfectant of sufficient strength to destroy such injurious insects or contagious diseases, all fruit trees or vines grown on such lands which may be infested with any injurious insects or worms, or infected with any contagious disease known

[1] *Special Report of the Mass. State Bd. of Agric.* Jan. 1892, 7.

to be injurious to fruit or fruit trees or vines: *Provided*, That no such spraying shall be done while said fruit trees or vines are in blossom, except in case of canker-worms.

"Section 2. In any township in this state where such injurious insects or contagious diseases are known to exist, or in which there is good reason to believe they exist, or danger may be justly apprehended of their introduction, it shall be the duty of the township board, upon the petition of at least ten freeholders of such township, to appoint forthwith three competent freeholders of said township, as commissioners, who shall hold office during the pleasure of the board, and such order of appointment and of revocation shall be entered at large upon the township record. *Provided*, That in townships having a board of yellows commissioners, such commissioners shall be ex officio commissioners under this act."

It is the duty of the commissioners to notify owners of plantations of the presence of any injurious parasite, it being unnecessary that a complaint be first made by any one.

"Section 5. Whenever any person shall refuse or neglect to comply with the order to spray or disinfect the orchards or vineyard designated by the commissioners, as aforesaid, it shall become the duty of the commissioners to cause said trees or vines to be effectually sprayed with a poisonous solution, or disinfected, as occasion should require, forthwith, employing all necessary aid for that purpose, and the expenses for the same shall be a charge against the township; and for said spraying or disinfecting, the said commissioners, their agents or workmen, shall have the right and power to enter upon any and all premises within their township.

"Section 6. If any owner, township officer, or commissioner, neglects or refuses to comply with the requirements of this law as set forth in the preceding sections, and within the time therein specified, such persons shall be deemed guilty of a misdemeanor, and punished by fine not exceeding fifty dollars or imprisonment in the county jail not exceeding sixty days, or by both such fine and imprisonment, in the discretion of the court; and any justice of the peace of the township where such trees or vines may be growing shall have jurisdiction thereof."

The act was ordered to take immediate effect.

OREGON has followed the example of California, for on February 25, 1889, the legislature approved "An Act to Create a State Board of Horticulture and Appropriate Money Therefor." It was amended February 21, 1891, and again in February, 1895. After dwelling upon the formation of a "Board of Horticulture," and other details of organization, etc., some of the powers of the board are stated as follows:

"Section VI. For the purpose of preventing the introduction into the State, or spread of contagious diseases, insect pests, or fungous growth among fruit or fruit trees, and for the prevention, treatment, cure, and extirpation of fruit pests, and diseases of fruit and fruit trees, and for the disinfection of grafts, cions, orchard débris, fruit boxes and packages, and other material or transportable articles dangerous to orchards, fruit or fruit trees, said Board may make regulations for the quarantining, inspection, and disinfection thereof, which said regulations shall be circulated by the Board in printed form among the fruit growers and fruit dealers of the State, shall be published at least four successive times in some daily or weekly paper in each county in the State, before the same shall be in force therein, and shall be posted in three conspicuous places in each county in the State, one of which shall be at the County Court House. Such regulations, when so promulgated, shall be held to import notice of their contents to all persons within the State and shall be binding upon all persons therein. A wilful violation of any quarantine or other regulation of said Board necessary to prevent the introduction into the State, or the shipment sale or distribution of any articles so infected as to be dangerous to the fruit growing interest of the State, or the spread of dangerous diseases among fruit trees or orchards shall be deemed a misdemeanor, and on conviction thereof shall be punished by a fine of not less than five, nor more than one hundred dollars, for each offense, or by fine and imprisonment for not less than five nor more than thirty days."

When the Board becomes aware of the presence of injurious insects or fungi upon certain premises, the owner is to be notified.

"Such notice shall contain directions for the application of some treatment approved by the Commissioners for the eradication or destruction of said pests, or the eggs or larvæ thereof, o the treatment of contagious diseases or fungous growths. Any and all such places, orchards, nurseries, trees, plants, shrubs, vegetables, vines, fruit, or articles thus infested are hereby declared to be a public nuisance. And whenever any such nuisance shall exist at any place in the State, on the property of any owner or owners, upon whom or upon the person in charge or possession of whose property, notice has been served as aforesaid, and who shall have failed or refused to abate the same within the time specified in such notice, or on the property of any non-resident or any property not in the possession of any person and the owner or owners of which cannot be found by the resident member of the Board or the Secretary, after diligent search within the district, it shall be the duty of the Board, or the members thereof in whose district said nuisance shall exist, or the Secretary under his or their direction, to cause such nuisance to be at once abated, by eradicating or destroying said insects or pests, or their eggs or larvae, or by treating or disinfecting the infested or diseased articles. The expense thereof shall be a County charge, and the County court shall allow and pay the same out of the general fund of the County."

UTAH possesses a law which might be of considerable value. It was approved March 8, 1894, and is known as

"An Act Authorizing the County Courts to Appoint Fruit Tree Inspectors and to Provide for the Destruction of Fruit Destroying Insects."

Its directions are specific, and so complete that if the county probate judges perform their duty properly, the plants should remain very free from parasites. The following extract shows to what extent details are mentioned:

"Section 1. It shall be the duty of the county court of any county in the Territory of Utah where fruit is grown, to appoint one or more fruit tree inspectors for such county.

"Sec. 2. The duty of the fruit tree inspector of each county shall be to inspect every orchard, vineyard or nursery in such county at such time and under such regulations as the county court shall prescribe. He shall annually report to the county court every item of interest and the result of his labors pertaining to the duties of his office.

"Sec. 3. It shall be the duty of the Probate Judge of any county wherein fruit trees are growing, to annually issue hi proclamation, stating the time or times when it is prudent an proper to spray fruit trees and to otherwise disinfect orchard that are infested with any kind of fruit-destroying insects, i which he shall name two or more formulas that have been use and approved for such purposes."

And further:

"Sec. 5. The county court is hereby authorized and require to provide for the publication of the proclamation required b section 3, and to formulate such rules and regulations as it ma deem proper, to govern the actions of the fruit tree inspector i his duties, and to give such public notice as it may deem prope in relation to the disinfecting of storerooms, warehouses an salesrooms where fruits in either a green or dried state may b stored, handled or offered for sale."

On March 8, 1895, a proclamation issued by the probat judge of Sanpete County contained directions for sprayin apple, pear, peach, and plum trees, the time for making th applications as well as the materials to be used being stated

An inquiry was made to learn of the success attending th enforcement of the terms of the proclamation, and of the gen eral effectiveness of the act as passed by the legislature. Mr Joseph Judd, the probate judge of Sanpete County, replied a follows:

"In answer to your favor on the subject of our spraying laws, will say we hav the law on our statute book, and it was enforced in 1894. It has been carried ou thoroughly this year again, and we have found good results of the spraying. Ther is no doubt that spraying is absolutely necessary in these dry climates, and I con sider it a very necessary law. But I have always doubted its constitutionality, a it hardly looks reasonable that the law can tell a person just how and when he sha spray or otherwise treat his orchard, and inflict a penalty if the law is not complie with.

"Some of our people have refused to comply in full, or as to when they sha spray, and we have just had a ruling on the law by our chief justice Merritt. H declares the law unconstitutional, and from this time on I think that spraying wi not be done so generally."

With such a precedent, it appears doubtful if laws designe to control spraying will ever become popular.

B. METRIC SYSTEM.

The meter is the primary unit of length. It is equal to $\frac{1}{10000000}$th part of the distance measured on a meridian of the earth from the equator to the pole, and equals about 39.37 inches.

Measures of Length.		Equivalents.
Myriameter	10,000 meters	6.2137 miles
Kilometer	1,000 "	0.62137 mile, or 3280 ft. 10 in.
Hectometer	100 "	328 ft. 1 in.
Dekameter	10 "	393.7 in.
Meter	1 meter	39.37 in.
Decimeter	.1 "	3.937 in.
Centimeter	.01 "	.3937 in.
Millimeter	.001 "	.03937 in.

Measures of Surface.		Equivalents.
Hectare	10,000 sq. meters	2.471 acres
Are	100 " "	119.6 sq. yards
Centare	1 " meter	1550. sq. inches.

Measures of Capacity.			Equivalents.	
	No. of Liters.	Cubic Measure.	Dry Measure.	Liquid or Wine Measure.
Kiloliter, or Stere	1000	1 cu. meter	1.308 cu. yards	264.17 gal.
Hectoliter	100	.1 " "	2 bu. 3.35 pks.	26.417 gal.
Dekaliter	10	10 cu. decimeters	9.08 quarts	2.6417 gal.
Liter	1	1 cu. decimeter	.909 quart	1.0567 qts.
Deciliter	.1	.1 " "	6.1022 cu. inches	.845 gill
Centiliter	.01	10 cu. centimeters	.6102 cu. inch	.338 fl. oz.
Milliliter	.001	.1 cu. centimeter	.061 " "	.27 fl. dram

System of Weights.		Equivalents.	
	No. of Grams.	Weight of Water Maximum Density.	Avoirdupois Weight.
Millier, or Tonneau	1,000,000	1 cu. meter	2204.6 pounds
Quintal	100,000	1 hectoliter	220.46 "
Myriagram	10,000	1 dekaliter	22.046 "
Kilogram, or Kilo	1,000	1 liter	2.2046 "
Hectogram	100	1 deciliter	3.5274 oz.
Dekagram	10	10 cu. centimeters	.3527 "
Gram	1	1 cu. centimeter	15.432 grains
Decigram	.1	.1 " "	1.5432 "
Centigram	.01	10 cu. millimeters	.1543 grain
Milligram	.001	1 " millimeter	.0154 "

Common Measure.	Equivalents.	Common Measure.	Equivalents.
An inch	2.54 centimeters	A cu. yard	.7646 cu. meter
A foot	.3048 meter	A cord	3.624 steres
A yard	.9144 "	A liquid qt.	.9465 liter
A rod	5.029 meters	A gallon	3.786 liters
A mile	1.6093 kilometers	A dry qt.	1.101 "
A sq. inch	6.452 sq. centimeters	A peck	8.811 "
A " foot	.0929 sq. meter	A bushel	35.24 "
A " yard	.8361 " "	An oz. avoirdupois	28.35 grams
A " rod	25.29 sq. meters	A pound "	.4536 kilogram
An acre	.4047 hectare	A ton	.9072 tonneau
A sq. mile	259 hectares.	A grain troy	.0648 gram
A cu. inch	16.39 cu. centimeters	An oz. "	31.104 grams
A " foot	.02832 cu. meter	A pound "	.3732 kilogram

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