UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
BERKELEY, CALIFORNIA

AGRICULTURAL EXPERIMENT STATION
E. W. HILGARD, DIRECTOR

CIRCULAR No. 7.

(JUNE, 1903.)

REMEDIES FOR INSECTS.

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[The demand for information relative to the destruction of injurious insects has been an important part of the correspondence of the Experiment Station. To assist in answering these letters of inquiry, there was issued, in 1893, a circular giving the formulæ of the standard remedies. The edition was soon exhausted, and a more elaborate treatment of the subject was prepared and issued as Bulletin No. 115. This likewise did not last long, and was reprinted in the report for 1895–97, and a considerable edition of the article was printed separately. The formulæ were also again printed in circular form. The present circular is a second revision of Bulletin No. 115, omitting the parts relative to fungous troubles.]

It is very important that every one who has the care of crops, whether of garden, orchard, or field, should have a clear idea of the remedies available for preventing the injuries due to insects. Not only must one know how to make and apply the remedies, but it is equally essential that he should fully understand *when* to apply and *when not* to apply.

This will involve a certain knowledge of insects and fungi, but not necessarily the knowledge of species nor of structure which is generally designated by the term entomology. What is needed is a clear appreciation of the nature, time, and extent of the injuries produced by the various forms of organisms attacking the plants, and of the degree of immunity which may be afforded by the use of the remedies at our disposal.

The farmer should clearly understand that the use of remedies is purely a matter of dollars and cents. Money or time should only be invested in this work when there is good prospect of an ample return.

It is safe to say that, even in California, where this matter has been agitated for so many years, in only a very small fraction of the cases where injury might be prevented is the proper treatment made. It is very difficult to estimate the amount of preventable loss that occurs in this State every year, but it is an entirely conservative estimate to say that it amounts to hundreds of thousands of dollars. On the other hand, it may also be said that when a treatment is made it is often of

no effect, and is a waste of time and money. Careful observation of the practices in this State in reference to treating insects makes it appear that fully half of what it now costs to treat our crops is wasted.

The remedy for this condition of affairs is only to be found in the farmers of this State becoming better informed in regard to these things. Heretofore, too many have blindly followed receipts or prescriptions which may have applied only to a particular case; and often when the results were not satisfactory they have given up hope of doing anything and, pocketing their losses, have blamed the weather. Most of the knowledge necessary to enable the farmer to do this work intelligently is to be had only by observation, for everything depends on conditions which one must learn to recognize.

This article has been prepared with the desire of directing the attention of the farmer to those things which it is necessary for him to consider in deciding on a treatment, and to furnish the necessary information as to the means of such treatment.

Mistakes Made.—The chief mistakes made in applying remedies for insects are the following:

First—Applications are often made when there is absolutely no need for treatment—when there is nothing to destroy or to prevent.

The majority of people have now given up the practice of taking medicines unless they are sick; but many of our most progressive orchardists consider it a mark of advanced farming to treat their trees with religious regularity, whether they show distress or not. There may be localities where the presence of a certain insect makes such regular treatments useful, and we have nothing to say against such preventive treatments when there is something to prevent, but are only condemning a very common practice in cases where the treatment is absolutely useless.

Second—Applications are often wrongly timed; either applied before there is any chance to produce good results, or after the injury has been done.

Our attention has been called to not a few cases of a winter wash having been applied to apple trees as a remedy for codling-moth. The time might as well have been spent in whitewashing the fence, so far as any effect upon the insect is concerned; indeed, it now appears that, at least in many parts of the State, the first treatment in the spring might as well be omitted. It is commonly true that a plant affected in any way will look its worst at about the time that the injury ceases, and at this time it is no uncommon thing for an unobservant man to apply a remedy; and no matter what is applied if he remains equally unobservant he will think he has found a cure. This explains many of the recommendations honestly made by honest men of remedies entirely useless.

Third—Often the wrong kind of an application is chosen for the particular trouble, so that no results can follow.

The use of paris green for sucking insects is one of the commonest mistakes. The number of kinds of treatments which are now recommended by the best authorities is not large, and the purposes for which they may be used are very distinct and easily understood, and it does not seem that there is any excuse for making this mistake.

Fourth—Applications are often made for troubles that are incurable by any known method.

It too often occurs that a person will go on year after year making a treatment and not give one moment's attention to the results. No treatment should ever be made without careful observation to determine the results. Without this, one will often go through the motions without accomplishing anything.

Fifth—Expensive methods are employed when cheaper ones will accomplish the results as well, both as regards the material used and the labor employed.

Under this head there will be condemned, practically, all of the proprietary mixtures on the market. There is nothing sold that is more efficacious than the remedies recommended in this article; and to pay more for a secret remedy just because it is well advertised, is simply paying for that advertisement. Many of the secret remedies are good and effectual, but cheapness is a matter that should not be overlooked.

In the matter of labor there is at present a great amount of waste, and this is especially true with summer washes. No more time should be spent on a tree in applying summer sprays than is necessary to thoroughly wet it, and if it is allowed to drip, too much has been put on. The amount of time necessary to cover a certain area can be readily determined by spraying against the side of a shed where the wetness will show; and one that has not tried it will be surprised how rapidly it may be done. For any but winter washes the truck or wagon need not stop at all while the spraying is being done, and those manipulating the nozzle should ride. The labor in spraying should be the least item, while now it is generally the largest.

Sixth—The ingredients of remedies as purchased are frequently of poor quality.

This may occur as the result of the dishonesty of the dealer, but more often, perhaps, because of the desire of the purchaser to obtain a cheap article regardless of quality. It is essential that the purchaser insist on receiving good chemicals, or his money and labor will be in vain.

There is no reason why these mistakes might not to a greater degree be avoided. Mistakes of judgment will also cause loss in this as in any other operation, but there is no reason why those due to ignorance should be allowed to amount to half the cost of such applications.

In the following pages we will attempt to present, in a brief compass, the more important points to be considered in the treatment of insects. But it should be distinctly recognized that local experience and experiment are the only real guides for successful practice. Especially in this State, where our conditions are so wonderfully diversified, it is impossible to formulate detailed programs or calendars of operations which will be of general value.

Any one with ordinary intelligence, however, who is willing to observe and think, has no excuse for falling into the mistakes indicated above.

CLASSES OF PESTS.

The serious insect pests that attack plants we may classify according to their way of attacking the plant, into a number of groups, as follows:

1. *Root-feeding insects*, which attack the roots of plants; they may devour the roots, suck the sap, or cause swellings to form; and the same insect may even attack the plant above ground as well as on the roots.

2. *Boring insects*, which live within the plant and mostly attack the stem or trunk, but may also bore into the larger roots on the one hand, and into the interior of leaves and fruit on the other.

3. *Sap-sucking insects*, which attack the upper parts of the plant, puncturing the leaves and stems to obtain their food. These resemble the forms that suck the sap from the roots, but the latter are a different and much more difficult economic problem.

4. *Defoliating insects*, which eat the leaves and other green parts of plants.

ROOT-FEEDING INSECTS.

Fortunately the number of root-feeding insects is not large, for there is no application known, that is practical for general use, by which they can be treated. It is not that the insects are hard to kill, but that the nature of the soil is such that it is very difficult to reach them.

A large number of remedies have been proposed and tried. A majority of them consist in dissolving in the water of the soil some substance fatal to insect life. The substance is sometimes applied dry, like a fertilizer, and subsequently dissolved by the rains or by water applied to the ground; or sometimes a solution of the substance is poured over the ground. Another class of remedies contemplates filling the air spaces in the soil with a poisonous vapor. A third class of remedies are those intended to suffocate the insects by removing the air from the soil; this is generally accomplished by filling the soil with water. Finally, the plan has often been tried of penetrating the soil with something distasteful to the insects in order to drive them away.

The last class of remedies has been very attractive to many people, but no one has yet found any substance that is so distasteful to any

insect as to produce practical results. The other three classes are more or less effectual, and especially the use of water. The great amount of water necessary, however, makes it impracticable except under very favorable circumstances. Of the others the best known process—the use of carbon bisulfid—is not certainly effectual, unless used in such quantity as to destroy at the same time the roots of the plants; and thus is practically useless, except for disinfecting soils. The very exhaustive and unsuccessful experiments made with the phylloxera, especially in France, make it appear doubtful if anything completely effective will ever be found in the way of treatment for root insects.

The solution of the problem for trees and vines seems to be along the line of the use of resistant roots. Very satisfactory resistants for the phylloxera of the grapevine* and for the woolly aphis of the apple are now on the market. In regions where these insects are troublesome, new plantations should not be made except upon these roots.

For annual crops, the most promising methods at present known are crop rotation, starvation, and trapping.

The *crop rotation* method depends for its success upon the fact that most of the injurious root-feeding insects or worms are decidedly more numerous in a certain field in certain years, and especially after certain crops. By planting only those crops that are the least injured by the attacks, in the years following these crops, the injury can, to some degree, be avoided. Local experience will show the particular system of rotation which will give the best results with the insects that are most abundant in that particular region.

The *starvation* method is by clean fallowing the land, and is not particularly useful after a crop like potatoes, where considerable living vegetable matter is left in the soil. It is the most thorough method if everything is kept off the ground, and can be used to advantage in connection with trapping.

The *trapping* method consists of providing food for the insects which has first been treated with a strong dose of poison. It is especially useful in gardens where root-feeding insects are often a very serious pest. Any green food will do for traps. Alfalfa is commonly used. It is scattered around in small piles and may be partly covered with soil to prevent it from drying out too fast.

There are a few exceptional cases where a treatment can be made which will do some good. The woolly aphis of the apple tree, for instance, produces great excrescences on the trunk just below the surface of the ground; resulting from the attempts of the tree to sucker and the production of swellings on these insipient suckers. These irregular swellings very easily become infested by toadstool fungi and

* Bulletin No. 148, Calif. Agr. Exp. Station.

then the fate of the tree is sealed. The use of wood ashes about the crown, while it may kill any small rootlets at this point, will not injure the tree as a whole, and will prevent the insects from living at this part of the tree.

When the attack of root-feeding insects is not too severe the plant may not suffer very much, especially if it is otherwise in the best of condition and has plenty of water. The plant would in such case simply replace the destroyed members and there may be scarcely an appreciable decrease in crop.

Some of the root-feeding insects, especially the plant-lice, which produce swellings in the roots, are followed by another complication. These swellings are liable to become affected with rot organisms. Certain varieties of plants are more subject to this trouble than others, and some regions also appear more subject to it, probably on account of climatic conditions. This is undoubtedly the principal reason why the woolly aphis is so fatal in Australia, and why it is here often so fatal to the pear.

A sucking insect can do scarcely any injury to a healthy plant when attacking the roots, unless some complications like the above arise, or unless the plant is allowed to suffer from want of cultivation or other such causes. With no other class of insects is good care more essential as a means of preventing injury.

BORING INSECTS.

About the only thing that can be done for boring insects is to prevent, by some means, their entrance into the plant. This may be done by mechanical means, by covering the threatened parts with something which will either prevent the egg-laying, or which will form a barrier to the ingress of the young insect. In many cases schemes of this nature that have seemed to promise well have not proven effectual in actual practice. Thus, cylinders of wire mosquito net, an inch or two larger than the trunks of the trees, have been recommended as an effectual bar against the borer that attacks the butts of peach trees. In reality this insect will lay its eggs above the trap, and the mesh of the net is far too coarse to exclude the young worms. Again, the coating of the plant with a poisonous substance often fails, because of the entrance of the insect into cracks caused by the expanding bark. It would not do to encase the tree in a coating that would prevent this expansion. It would also be fatal to so coat any green part as to prevent the normal transpiration of the plant. Nothing likewise could be used on any part of the plant that would penetrate into the living cells. The mechanical, or barrier methods, therefore, should be carefully tested before being used extensively.

Insects like the codling-moth which bore into the fruit, can be very successfully treated, because of their habit of feeding for some time on

the surface of the fruit before entering; and the peach moth spends a considerable part of its life making a series of small burrows in the bark of the twigs and branches, thus offering a number of opportunities to kill it. Likewise the plum curculio of the Eastern States feeds for some time upon the plant before laying its eggs, and so may be killed and the egg-laying prevented.

After the insects have entered the plant, about the only thing remaining to be done is to dig them out one by one; though for some living very near the surface it is said that scalding hot water, applied freely to the trunk, will destroy the insect without injury to the tree.

It is doubtful, however, if by either of these means enough injury is not directly or indirectly done to the plant to more than equal the good attained.

Recently carbon bisulfid and hydrocyanic acid gas have been used with remarkably good results. The use of these substances is as yet limited to a few cases, such as trees valuable enough to permit of rather expensive work, or where the injury is limited to a small area, as in the peach-tree borer.*

The amount of injury resulting from the attacks of borers is most variable, and has no relation, in most cases, to the amount of substance devoured by the insect. In no case is the injury due to the quantity of substance eaten, but usually results from a disturbance of the connection between the top and the roots. In the case of annual plants the amount of tissue eaten at one point is so large that there is not enough left to carry an adequate supply of sap to the top; therefore it withers and dies. If the same amount of tissue had been removed, but extended over twice the distance on the stem, no injury might have resulted. The plant is always provided with more of every tissue than is really needed by it, as a provision against emergencies. A plant therefore that is injured by a borer, if the injury is not too severe, may, if the other conditions are favorable, produce just as good a crop, but it is less able to pass through trying experiences; and the same may be said of almost all kinds of plant diseases. The constitution has simply been undermined.

Borers attacking small twigs sometimes eat out so much that the twig is no longer strong enough to resist the beating of the wind, and is broken off in the gale. It is generally better, in such cases, that the twig be so broken off that the plant may immediately replace it, because it will take the twig a long time to heal up and make good such an injury. The injury to the plant in this case consists not so much in the loss of the twig as in the time at which the twig is removed; which is often such as to disarrange the plans or rather the conditions of the plant in regard to pruning, in such a way that it is not possible to

* Bulletin No. 143, Calif. Agr. Exp. Station.

secure the condition most favorable to the setting and maturing of the crop. The loss of a few twigs, of course, amounts to nothing, but if many twigs in a tree are affected, a serious disarrangement in the condition of the tree may result.

Borers in the trunk of the tree menace its health in another way. Here, whatever injury is done results almost wholly from the destruction of the growing layer of tissue just beneath the bark. The holes made in the heart-wood produce no injury, except to its value as timber; but the destruction of the growing tissue beneath the bark is dangerous in that, if the dead spot is of large enough extent, the wood immediately beneath it may dry out and reduce, by just that much, the water-carrying power of the trunk. The tree thus becomes less able to withstand drought. If the dead tissue is extensive enough, the trunk may so dry out that the top will die for want of water, even though there is plenty in the soil. If the tree is protected with grafting wax until the wounds made by borers have time to heal over, no bad results will usually follow.

SAP-SUCKING INSECTS.

In this category are included some of the easiest as well as some of the most difficult insects to destroy, but they are all capable of successful treatment, so far as we know. It may often be, however, that the cost of a treatment which is effective will be so great as to be prohibitive. This is true generally of field crops, where the cost per acre for treatment may often be more than the saving that can ensue from the application. The insects of this class are not affected by poisons like paris green, because *they get their food by inserting their beak into the plant;* nothing, therefore, on the surface of the leaves will have any preventive effect.

There have been many attempts to inject some substance into the plant which will poison the sap; but the cells of the plant are, if anything, more delicate than the insect, so that the plant is always killed first.

The only feasible plan, therefore, is to spray on the plants some caustic or oily substance, or to envelop them with some poisonous gas.

Plant-lice are ordinarily very easy to kill, but protected insects like the scales, or very active ones like the so-called grape thrips, are much more difficult to deal with. The latter are probably best treated by causing them to leap or fly against a "hopper-dozer" of some form, catching them as they drop to the ground in the evening, or early in the morning; or in nets.* The "hopper-dozer" is the name applied to any surface coated with any substance fatal to the insect, and against which the insect is made to jump or fall. For such an insect as the vine hopper a palm leaf fan makes a very convenient form of dozer.

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* Bulletin No. 116, Calif. Agr. Exp. Station.

There is the greatest amount of misconception as to the nature of the injury produced by sap-sucking insects. Except during dry spells, or when the numbers are excessive, or when they attack particular parts of the plant, the injury they do is scarcely worth considering. Under these adverse conditions, however, they are often fatal to the plant. No other class of injury renders a plant less able to successfully pass through a drought than does that caused by sucking insects; in an arid climate like that of California the summer is all droughty, and that is one reason why they are so injurious with us. A plant has the means of lessening the rate of evaporation during the dry part of the day, and can thus thrive in comparatively dry conditions; but if infested by sucking insects it loses water at a rapid rate to supply the necessities of the insects preying upon it. The result is the same as though the drought was much more severe; the leaves ripen and drop prematurely, and the young growth becomes sunburned and dries up, and the whole plant may die. The insects of this class often reproduce very rapidly, and so become very numerous; no plant can withstand an overwhelming attack.

The injury to certain parts of the plant is often quite serious. Thus, very commonly, the attack will be concentrated upon the growing tip of the twig and prevent its healthy and normal growth. In this way the plant may be prevented from making the necessary amount of foliage during the time when the conditions are favorable to its production, and the injury will be greater than is apparent. Some insects at times confine their attack to the bud, or young fruit or seed, and cause its dropping or imperfect development. This injury may not seriously damage the plant as a plant, and yet may destroy its profitableness as a crop producer.

In certain species the control is made more difficult by the distortion of the undeveloped leaves where attacked by the lice. The curled leaves which result, form a perfect protection for the insects against any spray that might be used. In these cases the application must be made before any of the leaves have become curled.

A secondary injury is sometimes produced by the growth of a fungus on the excretion of these insects, as in the case of the smut fungus on citrus fruits, which may so disfigure the fruit as to cause very serious loss.

DEFOLIATING INSECTS.

The insects eating the leaves of plants are, as a rule, the easiest to destroy, and at the least expense, because the leaves may be covered with relatively cheap poisonous substances; and as the insects eat the leaf, they will also consume the poison and be killed. Only the more valuable field crops can be thus treated economically, however, for even as cheap a process as this is too expensive for most of the staple crops.

When insects are excessively abundant, as in the case of attacks of swarms of locusts and invasions of army worms, all known applications become useless, because with their great numbers everything green is devoured before any one insect can have taken enough poison to kill it.

The use of a mixture of bran, molasses, and arsenic, or horse manure and arsenic, both of which seem to be preferred even to foliage by the insects, sometimes does good service if the number of the insects is not too great, and the poison is placed on their way to the unattacked territory.*

Insects of the defoliating class can also be killed by the same remedies that are used for sap-sucking forms; but, as in the case of the latter class, the insect must actually be touched by the remedy to be affected by it.

Often it will be found that the use of other measures is more profitable than spraying. The use of barriers is the most effectual against certain insects of this class. Climbing cut-worms can be prevented from ascending trees, by taking a piece of cotton-batting about ten inches wide and long enough to lap about two inches, wrapping it around the trunk of the tree, tying it fast by means of a string near the lower edge and then pulling the upper edge down over it like an inverted funnel. The use of a sticky substance painted on a strip of paper around the tree also prevents the passing of any insect that gets on the tree by crawling up the trunk. The use of the paper is to prevent injury to the bark that may be caused by the penetration of the substance used as a barrier.

The jarring of insects onto hopper-dozers, or on sheets from which they may be gathered and destroyed, is effectual against some insects. The ordinary insect net is the best thing that can be used for some, and especially for the active flying species. Hand-picking is by no means to be despised, and in many cases (but generally on a small scale) is the most economical proceeding. This is especially true for large insects and for those that are gregarious; they may often be conveniently shaken down into a vessel containing a little coal oil.

The injury done by defoliating insects depends almost wholly on the time of their attack. If done late in the year it may not be at all serious. The greatest injury is generally done if the leaves are taken off while the crop is being produced. If late in the spring both the crop and the plant are in danger; and chiefly the crop if earlier. This kind of injury is so evident that one is not likely to make a wrong estimate of its amount.

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* Bulletin No. 142, Calif. Agr. Exp. Station.

REMEDIES AGAINST INSECTS.

There are a great many substances that may be used successfully against insects; but we recommend only a small list, selected because of their effectiveness and cheapness. Remedies are applied as a dry *powder*, as a *gas*, or as a fluid *spray or wash;* the great majority being in the latter form.

POWDERS.

The most common way of applying powders is the "pepper-box" method, in which the material is carried in a vessel provided with perforations, through which it sifts as the vessel is shaken over the plant. A modification of this, much used in the cotton fields of the Southern States, consists of bags of the material suspended from the ends of a pole long enough to reach from one row of cotton to the next. This is carried by a man riding on a mule, and the jar causes the powder to sift through. Cloth is chosen for this purpose, which is fine enough to allow only the right quantity to be distributed. A third method, much used in this country, is a blowing device, which is very satisfactory for field use, and does very rapid work. Only three remedies are recommended to be used in the dry form, and these have a rather limited use.

Air-Slaked Lime.—This is the powder resulting from the exposure of ordinary lime to the action of the air for some time. It is only recommended as a remedy against insects which have a slimy coating over the body. For these it is cheap and effectual. It is not as cheap, however, as paris green, and is particularly recommended where the latter is objectionable because of its poisonous nature. The cherry slug, for instance, often attacks the plant even as late as picking time, and paris green should not be applied later than two weeks before picking. The action of the lime is on the glands of the skin that secrete the slime, and so is only fatal to slimy creatures. For true slugs, which are not insects, but have a similar slimy coat, it is the best remedy we know of; but it must be applied in the evening or early morning, while the animals are on the plants; and may have to be repeated two or three nights in succession to kill all. Except in gardens, it may not pay to make more than the one application, which will, if rightly timed, destroy most of the slugs.

Sulfur.—This is a widely used remedy for certain fungous diseases, and it has likewise been found to be a successful remedy for the so-called *red spider*, also called yellow mite—animals somewhat related to the true insects; fairly good results are also reported in its use against the *thrips*. For these purposes the sulfur is used in the same way as for the mildew.

The powder is usually applied by the pepper-box method. It only becomes effectual as the heat of the sun vaporizes it; the field thus

treated smells strongly of the sulfur during the warmer part of the day, when the vapor is being produced. On wet, cloudy days the sulfur is inert, but the first bright day makes it effective. It may be possible to artificially vaporize the sulfur on a large scale for use in such weather; but no attempt has yet been carefully made, except in greenhouses, and then with the best of results. The vapor of sulfur must be used, and not the gas produced by burning, which is very injurious to foliage.

There are two forms of sulfur used for these purposes, the ground and the sublimed or flowers of sulfur, and are about equally pure, but the nodular projections of the latter, allowing it to catch on the rough places on the leaf, make it possible to produce the effect desired with a considerably weaker application. The saving here is about enough to compensate for the difference in price. At the same time, the sublimed sulfur is more apt to contain some sulfuric acid, and when it does, it may injure the foliage if not applied evenly or if applied too thickly. One can recognize the presence of the acid by the sour taste, and sulfur that is sour should be avoided. When *sulfur is burned, the fumes are very injurious to plant life*, because they become sulfuric acid on combining with the water and oxygen of the air or plant.

Paris Green or Other Arsenicals.—The arsenical poisons while occasionally used in a dry form, are more commonly suspended in water to be used as a spray. They are used for the same purposes in either form. A common practice is to dilute the poison with flour, dust, or other powder, so that it can be more easily and evenly distributed. If not so diluted, care must be taken not to apply it so thickly in places as to endanger the foliage.

GAS TREATMENTS.

Gases have the property of diffusing themselves with great rapidity, so that when applied in a closed space, every part of that space will in a short time contain some of the gas. Thus, no other method of killing insects is calculated to be as thorough in its work. In an open space this property of diffusing destroys, to a great extent, its utility. Sulfur applied as a powder, as has already been stated, is not effective until it becomes a vapor; and then the dissipation is not as much as with most gases, because of the weight of sulfur vapor and the fact that it is applied over whole fields at once.

The impracticability of inclosing most cultivated plants, and the cost of the treatment, both in time and chemicals, make the method useful to only a very limited extent. We recommend but two gases.

Carbon Bisulfid.—This substance is not available for plants, or rather the parts of plants in active growth, and is chiefly used for stored products, such as seeds and grains. It can be used for disinfecting soils and ridding other articles of insects.

In disinfecting soils an injector is used. A number of forms of the latter are on the market in Europe, where phylloxera eradication has required them. It is doubtful if this method of soil disinfection would be profitable in this country for the destruction of any insect.

For destroying insects in seeds or grain, carbon bisulfid is a very cheap and satisfactory means. The bin or box containing the seeds to be disinfected should be tight, at least at the sides and below.

A dish is placed on top of the material to be treated, and a quantity of the carbon bisulfid poured in. This evaporates rapidly, and the vapor being heavier than the air, sinks down into the lower part of the bin. The top should be covered also, in order that the vapor may remain a long time in the grain.

Very rarely will bins be perfectly tight, so that the exact amount necessary can not be stated. Usually the estimate is made at one pound to the ton of grain, which is sufficient for a fairly tight bin.

Grapevine cuttings are most successfully disinfected in a similar way, by placing a saucerful of the bisulfid on the cuttings in a tight box, and leaving for forty minutes.

The yellow-jacket, our common wasp, which is so injurious to fruit, and which makes its nest in the ground, is easily killed by this substance. The nest is located, and about dark, when the wasps are all in, about an ounce of carbon bisulfid is poured down the hole and a handful of earth thrown over it to keep the vapor in. By morning all will be found to be dead. Ants' nests can be destroyed in the same way.

Carbon bisulfid is also one of the best remedies for gophers and ground squirrels. If used in the fall, after the rains have begun (so that the ground is not too porous), an ounce poured over a rag and stuffed into a hole and covered with earth will destroy the inmates.

Recently carbon bisulfid has been successfully used for destroying the root-crown borer of the peach in Santa Clara County. Except where the soil is very permeable a trench should be dug around the trunk and the surface soil scraped in until it is level, and then about an ounce of the bisulfid poured around and the earth mounded slightly to retain the fumes. If the soil is very dry much greater quantities would have to be used, and if wet there is danger to the tree if the chemical is allowed to remain too long. It is good policy to remove the earth if an appreciable quantity of gas remains after two days. When the soil is moist care must be had, when digging the trench, not to glaze over any of the soil next to the tree, or the gas will be effectually kept out of the burrows and the insects will not be killed. The soil condition is the most important consideration in this treatment.*

Hydrocyanic Acid Gas.—This is practically the only gas which is strong enough to kill the insects on a tree with safety to the leaves, and

* Bulletin No. 143, Calif. Agr. Exp. Station.

within a time short enough to make its use practical on a large scale. Its work is very effectual and satisfactory, but is very expensive, and, therefore, is only available for the more profitable trees, such as the citrus varieties. It may also be used for disinfecting. The gas is extremely poisonous, and, sometimes, for reasons not entirely understood, is very injurious to the foliage; but the injury is almost all prevented by its use at night.

The process is to cover the tree with a tent of sail-cloth, often oiled to make it tight, and in a vessel beneath the tent the chemicals which make the gas are placed. About fifty minutes is considered necessary for effective work. The original recommendation was an ounce of potassium cyanide for 150 cubic feet.

The common practice in this State is to use it decidedly stronger for small trees and weaker for the largest trees. In the smaller trees it is safe to use it stronger, as the small amount of gas used is very quickly diffused. When it is produced in large quantity, as is necessary for a large tree, some of the gas, scarcely at all mixed with air, may come in contact with the leaves and injure them. The leakage of gas in the tents commonly used is so great that the dose should be proportioned to some extent upon the area of the tent surface. The whole matter is so complicated that we can not attempt to discuss it here, but will refer to a recent bulletin on the subject.*

For disinfecting nursery stock, seeds, or anything not growing, it is possible to increase both the dose and the time of treatment. The formula is one part by weight of potassium cyanide to a mixture of one part of sulfuric acid and two parts of water, both by volume. Upon adding the cyanide to this diluted acid there is an immediate evolution of gas. The greatest caution should be exercised in handling these chemicals and particularly should one be careful not to breathe the gas as it is being generated.

SPRAYS OR WASHES.

The most important remedies for plant pests are applied as sprays or washes. By the word washes one would naturally understand a more copious application than a spray, but in ordinary usage the terms are identical.

For very low plants an outfit working on the principle of a sprinkling-can will do; but for better and more economical work, and work on taller plants, some form of force-pump or spray-nozzle is necessary.

There are many forms of pumps on the market that are good for the purpose. A good spray pump should maintain a fairly constant and sufficient pressure, and its valves and general construction should be simple, and its parts easily replaceable.

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* Bulletin No. 152, Calif. Agr. Exp. Station.

The nozzle should, for most spraying work, be such as to break up the stream into a fine mist; but for scale insects one giving a stream of considerable force is desirable. The shape of the spray is usually either conical or fan-shaped, and each has its particular advantages for its own class of work.

The construction of the nozzle should be such as to permit of easy, quick, and thorough cleaning. A few forms designed to clean themselves automatically, work well.

In most spraying, the object is to get the largest possible proportion of the spray to remain on the leaf or stem, and to have it well distributed. This is best accomplished by covering the leaf with minute globules like dew. As soon as they run together and drip from the leaf the distribution is not perfect, and there is actually less left on the leaves.

When the nozzle is held as far from the plant as the stream will carry, the full effect of the nozzle is obtained in the breaking-up of the stream into mist, and so can produce most perfectly this dew-like condition.

For scale insects the object is somewhat different. The plan for these is to thoroughly wet the surface of the bark and the edges of the scale, to insure the penetration of the wash beneath the scale, and thus to kill the old scale, or the eggs and young hidden beneath. This thorough wetting is secured by holding the nozzle close to the plant and applying a great deal of wash with a high pressure. Washes are sometimes applied hot, and when the nozzle is held close to the plant the spray will penetrate better, and for this reason will do better work.

Lime, Salt, and Sulfur Mixture.—This mixture is of California origin and is considered the best remedy for the San José scale and for peach worm, as well as for certain fungi, particularly the curl leaf of the peach.* It is also very efficient in softening and smoothing up old rough bark. The formula most extensively used is 40 pounds of lime, 20 pounds of sulfur, and 15 pounds of salt, with enough water to make 60 gallons.

The sulfur, about a third of the water, and a quarter of the lime are boiled together for an hour and a half or two hours. The salt and the remainder of the lime, after slaking, are mixed separately and finally added to the lime-sulfur mixture and the whole boiled another half hour. The mixture requires careful straining to prevent clogging in the nozzle. It should be applied hot and in good quantity.

Sulfid of Potash Wash.—This mixture was found very effective against red spider.† The formula is 32 pounds of potash, 37 pounds of sulfur,

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* Bulletin No. 144, Calif. Agr. Exp. Station.

† Bulletin No. 145, Calif. Agr. Exp. Station.

and 5 pounds of salt, and water to make about 500 gallons of wash. The ingredients are placed together with a very small amount of water, when a violent chemical reaction at once sets in. After this has subsided the mixture is diluted to the desired extent.

Resin Soap.—The cheapest insecticide which kills by contact is resin soap. It is for scale insects, and has good penetrating power. Like all insecticides which kill by contact, the effect of the spray is soon gone, and it only kills the insects which are wet with its spray. It is generally applied warm.

In making the soap, the ingredients are placed in a closed kettle with enough water to cover, and are boiled for two hours, when all will be united into a soap. In diluting, only a little water should be added at a time, and stirred in; or, better, hot water should be used, because of the danger of chilling the soap and causing it to harden, when it is almost impossible to dissolve it again.

The proportions are 8 pounds of resin, 2 pounds of standard caustic soda, and 1 pint of fish oil, for 40 gallons, for use on trees in foliage; and the same for 25 to 30 gallons for winter use.

Distillates.—Distillates of petroleum have of late years become very prominent as insecticides. The safest of the distillates to use on green parts of plants is ordinary kerosene. The best manner of applying these substances is by means of a mechanical mixing device, of which there are many forms on the market. A very satisfactory home-made mixer for a barrel is a vertical shaft with paddles, which may be rotated by hand with a crank or gearing at the top. The amount of oil used varies from 1 to 10 per cent for plants in foliage, only kerosene for the latter, and from 5 to 25 per cent for dormant trees. Different plants will stand different amounts of oil. The personal equation of the sprayer is an important item, since the oil accumulates if one continues to spray; and thus it happens that with the same nozzle and outfit one person may put as much oil on a tree at 3 per cent that another would apply at 6 per cent. One should use a nozzle capable of producing a very fine mist, and the operation should be stopped before the drops run together and drip from the leaves.*

Kerosene Emulsion.—While not as cheap as the materials described above, still because of its safety to the plant when properly made, it is valuable when a relatively small quantity of spray is desired.

The ordinary form of the emulsion is something of an art to properly manufacture. The ingredients are 2 parts of kerosene to 1 of sour milk, or of strong soap solution. The latter must be made boiling hot and added to the kerosene, and the whole pumped through a spray nozzle for fifteen minutes. After pumping a few minutes the whole mass will

* Bulletin No. 153, Calif. Agr. Exp. Station.

become beautifully creamy and apparently perfectly emulsified; but if a little is placed in water it will be seen that some of the kerosene separates out and rises to the surface. The pumping must therefore be continued to about the time indicated. When the emulsion is perfect there will be no separation when diluted. If the soap is of poor quality or the water is hard, more soap must be used; and, on the other hand, if both are good, not as much is needed as recommended below, which is intended to suit the average conditions.

The proportions are 3 ounces of soap in 3 pints of water (or 3 pints of sour milk) and 3 quarts of kerosene for 10 gallons of emulsion for scale insects, or for 15 gallons of emulsion for plant-lice.

Another formula, which is easier made but more expensive, and so only recommended for use on a small scale, consists in using eight times as much soap. When so made, the creamy mixture described above, obtained within five minutes, is a permanent emulsion.

The Arsenicals.—These poisons are by far the cheapest insecticides known. They are only efficient against insects that *eat the leaves*, and are useless for sucking insects or scales. They are also useless against overwhelming numbers of insects, such as swarms of grasshoppers, which are able to eat up the plant before getting enough poison to kill them.

Arsenic is the active principle in all these poisons and usually constitutes about one half the substance of the poison. Paris green, which is an aceto-copper arsenite, is the most widely used of all the arsenicals,* though several others seem about equally satisfactory. All forms of arsenicals should be insoluble in water, and it is well to use enough lime or other ingredient which may mechanically protect the plant, since there may be otherwise considerable danger of burning the foliage.

Most arsenicals require constant stirring, or the material will settle to the bottom, and so not be uniformly distributed. For the best results, the poison should not be allowed to drip from the tree, and the finer the spray the better.

These poisons do not, as a rule, remain any great length of time on the plant, but must be renewed every two or three weeks, or while the danger of insect attack exists. In mixing the poison, it is well to first make a paste with a little water and then dilute, as otherwise it is difficult to wet the leaves with it. The amount used is about 1 pound to 200 gallons of water.

When it is desirable to use paris green and Bordeaux mixture at the same time, as for codling-moth and scab, the green may be stirred into the Bordeaux mixture at the usual proportions, *i. e.*, 1 pound to 200 gallons.

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* Bulletins Nos. 126 and 151, Calif. Agr. Exp. Station.

TABLE OF FORMULÆ FOR WASHES AND SPRAYS.

Name.	Strength Desired.	Ingredients.*	Per Cent.	For 5 Gallons (Oil-Can).	For 40 Gallons (Barrel).	Directions for Mixing.
Lime, Salt, and Sulfur. For peach worm, San José scale, etc.	For winter use only	Lime	9.00	3 lbs.	24 lbs.	Boil sulfur and one half the lime 1½ hours; mix and add other ingredients and boil ½ hour longer.
		Salt	3.00	1 lb.	8 lbs.	
		Sulfur	4.50	1½ lbs.	12 lbs.	
Sulfid of Potash. For red spider.	For summer use	Potash	.80	4⅓ ozs.	2 lbs.	Mix these with a very little salt and water and dilute after reaction is complete.
		Sulfur	.92	5 ozs.	2½ lbs.	
Resin Soap. For scale and other insects.	Usual strength	Resin	2.40	1 lb.	8 lbs.	Boil two hours; dilute with warm water.
		Caustic soda	.60	¼ lb.	2 lbs.	
		Fish oil	30	2 ozs.	1 pt.	
	Extra strong for winter use	Resin	4.00	1½ lbs.	12 lbs.	
		Caustic soda	1.00	6 ozs.	3 lbs.	
		Fish oil	.50	3 ozs.	1½ lbs.	
Kerosene Emulsion. For scale and other insects.	Weak, for plant-lice	Soap *or*	.15	1 oz.	½ lb.	Mix hot, with spray pump, fifteen minutes: use either sour milk or a soap solution.
		Sour milk	2.50	1 pt.	1 gal.	
		Kerosene	5.00	2 pts.	2 gals.	
	Usual strength	Soap *or*	.25	1½ ozs.	¾ lb.	
		Sour milk	4.00	1½ pts.	1½ gals.	
		Kerosene	8.00	3 pts.	3 gals.	
	Usual strength	Soap	2.00	¾ lb.	6 lbs.	Mix five minutes.
		Kerosene	8.00	3 pts.	3 gals.	
Poison. For leaf- and fruit-eating insects.	Usual strength	Paris green *or* other arsenical	.12	¾ oz.	6 ozs.	

* Sufficient water is to be used in each case to make up the amount indicated in the next columns.

DIRECTIONS FOR SENDING SPECIMENS.

The Experiment Station will give special directions for specific insect troubles. Persons writing to the Station for this purpose should always forward at the same time specimens of the insect about which information is desired. These should *never* be simply inclosed in the envelope with the letter, as they will almost invariably be crushed, and will often be unrecognizable. The best package in most cases is a light wooden box. Tin boxes are good, if paper is placed within to take up any moisture that may arise. No provision need be made for ventilation.

SACRAMENTO
W. W. SHANNON, - - SUPT. STATE PRINTING.
1903.