U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 7.

SPRAYING FRUITS

FOR

INSECT PESTS AND FUNGOUS DISEASES,

WITH

A SPECIAL CONSIDERATION OF THE SUBJECT IN ITS RELATION TO THE PUBLIC HEALTH.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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FARMERS' BULLETINS.

The bulletins of this series may be obtained by applying to the Secretary of Agriculture, Washington, D. C. The following have been previously issued:

Farmers' Bulletin No. 1. The What and Why of Agricultural Experiment Stations. (A brief explanation of the object, origin, and development of the stations, their work in Europe and in the United States, and the operations of the Office of Experiment Stations of the Department of Agriculture.) Prepared by the Office of Experiment Stations; pp. 16. Issued June, 1889.

Farmers' Bulletin No. 2. The work of the Agricultural Experiment Stations; (Illustrations of Station Work in the following lines: better cows for the dairy; fibrin in milk; bacteria in milk, cream, and butter; silos and silage; alfalfa; and field experiments with fertilizers.) Prepared by the Office of Experiment Stations; pp. 16. Issued June, 1889.

Farmers' Bulletin No. 3. The Culture of the Sugar Beet. (Treats of the climatic conditions, soil, fertilizers, and cultivation required by the sugar beet, cost of growing, time to harvest, and method of soiling; describes briefly the process of beet-sugar manufacture, and gives statistics of sugar production and consumption.) By H. W. Wiley, chemist of the Department of Agriculture; pp. 24. Issued March, 1891.

Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. (Describes downy mildew, powdery mildew, black rot, and anthracnose of grapes, and gives instructions for their treatment and estimated cost of remedies.) By B. T. Galloway, Chief of the Division of Vegetable Pathology; pp. 12. Issued March, 1891.

Farmers' Bulletin No. 5. Treatment of Smuts of Oats and Wheat. (Describes the smuts of wheat, oats, and barley, the damage they cause, and the various methods of treatment which have been found useful for their prevention.) Prepared by the Division of Vegetable Pathology; pp. 8. Issued February, 1892.

Farmers' Bulletin No. 6. Tobacco: Instructions for its cultivation and curing. Prepared by John M. Estes, special agent; pp. 8. Issued February, 1892.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE ASSISTANT SECRETARY,
Washington, D. C., March 10, 1892.

SIR: I have the honor to transmit herewith for publication a bulletin prepared in accordance with my direction by the Divisions of Entomology and Vegetable Pathology, to be included in the series of farmers' bulletins of this Department, treating of the practice, methods, and effects of spraying fruit trees for insect pests and fungous diseases. This practice has been widely extended during the past few years, largely upon the lines laid down by this Department as the result of careful and extended experiments. The fact that the compounds as generally used are slightly poisonous in their character has led some persons to express apprehension lest their application should injure the fruit for consumption. This apprehension has been shown over and over again to be ill founded, frequent experiments under all possible conditions having shown that no spraying as prescribed by the Department experts has ever resulted in the slightest deleterious effects upon the fruit subjected to it. While this bulletin presents the subject of spraying in the most practical manner for the information of the orchardist and fruit-grower, it is mainly intended for the information and satisfaction of the consumer, by showing him exactly the character of the spraying recommended, and the utter impossibility of evil consequences to him.

The publication of this bulletin in this brief and practical form is rendered especially necessary and timely by the fact that persons antagonizing, from interested motives, the importation of American fruit into Great Britain have indulged in the frequent assertion that spraying as practiced in this country must necessarily have deleterious effects upon the fruit and injure it for consumption. It is believed that the present bulletin, and the simple facts therein arrayed, will serve a useful purpose in thoroughly exploding the baseless charges which have been leveled on this score against American fruits in Great Britain and other countries.

Respectfully,

EDWIN WILLITS,
Assistant Secretary.

Hon. J. M. RUSK,
Secretary.

SPRAYING FOR INSECT PESTS AND FUNGOUS DISEASES.

SPRAYING FOR INSECT PESTS.

The distribution of insecticide mixtures in the form of spray was first begun in this country on a large scale during the early spread of the Colorado potato-beetle in the Western States. Paris green was first used in 1869 both as a dry mixture diluted with flour, ashes, plaster, or slacked lime, and in liquid suspension in water. Spray machines soon came into use, and this method of application of insect-destroying mixtures was speedily extended to other insect pests. In 1878 poisoned spray was first used against the codling-moth, and the Entomologist of the Department had previously recommended this remedy for the cotton-worm and several other leaf-eating insects. During the progress of the investigation of the cotton-worm many spraying machines were developed, and from that time to the present the development of methods and machinery has been rapid, until at the present time the best remedies against perhaps the majority of our principal insect pests comprehend the application of an insecticide spray at one time or another.

INSECTICIDES USED IN THE FORM OF A SPRAY.

Kerosene emulsion.—This insecticide acts by contact and is applicable to all nonmasticating insects (sucking insects, such as the true bugs and especially plant-lice and scale-insects) and also to many of the mandibulate or masticating insects, such as the apple worm or plum curculio, when the use of arsenites is not advisable. Kerosene emulsion may be made by means of various emulsifying agents, but the most satisfactory substances—and those most available to the average farmer and fruit-grower—are milk and soapsuds. In each of these cases the amount of emulsifying agent should be one-half the quantity of kerosene.

One of the most satisfactory formulas is as follows:

		Per cent.
Kerosene	gallons.. 2	67
Common soap or whale-oil soap	pounds.. ½	33
Water	gallons.. 1	

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens upon cooling and should adhere without oiliness to the surface of glass. If the water from the soil is hard or has a large percentage of lime, add a little lye or bicarbonate of soda, or else use rain-water. For use against scale-insects, dilute one part of the emulsion with nine parts of cold water. For most other insects, dilute one part of the emulsion with fifteen parts of water. For soft insects, like plant-lice, the dilution may be carried to from 20 to 25 parts of water.

The milk emulsion is produced by the same methods as the above.

The resin washes.—These insecticides act by contact, and also, in the case of scale-insects, by forming an impervious coating which effectually smothers the insects treated. These resin washes vary in efficacy according to the insect treated. Experience has shown that the best formula for the red scale (*Aspidiotus aurantii* Maskell) and its yellow variety (*A. citrinus* Coquillett) is as follows:

Resin	pounds..	18
Caustic soda (70 per cent strength)	do....	5
Fish oil	pints..	2½
Water to make	gallons..	100

The necessary ingredients are placed in a kettle and a sufficient quantity of cold water added to cover them. They are then boiled until dissolved, being occasionally stirred in the meantime, and after the materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over. Too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water, and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve, or through a piece of Swiss muslin, and this is usually accomplished, when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound will be greatly accelerated if the resin and caustic soda are first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake, weighing

about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required. This insecticide may be applied at any time during the growing season.

A stronger wash is required for the San José scale (*Aspidiotus perniciosus* Comstock), and the following formula gives the best results:

Resin	pounds..	30
Caustic soda (70 per cent)	do....	9
Fish oil	pints..	4½
Water enough to make	gallons..	100

Place all the ingredients in a kettle and cover with water to a depth of 4 or 5 inches; boil briskly for about two hours, or until the compound can be perfectly dissolved with water. When this stage is reached the kettle should be filled up with water, care being taken not to chill the wash by adding large quantities of cold water at once. It may be thus diluted to about 40 gallons, the additional water being added from time to time as it is used.

This preparation should only be applied during winter or during the dormant period; applied in the growing season it will cause the loss of foliage and fruit.

In the application of both these washes a very fine spray is not essential, as the object is not simply to wet the tree, but to thoroughly coat it over with the compound, and this can be best accomplished by the use of a rather coarse spray, which can be thrown upon the tree with considerable force.

THE ARSENITES: LONDON PURPLE, PARIS GREEN, AND WHITE ARSENIC.

These poisons are of the greatest service against all masticating insects, as larvæ and beetles, and they furnish the most satisfactory means of controlling most leaf-feeders, and the best wholesale remedy against the codling-moth. Caution must be used in applying them, on account of the liability of burning or scalding the foliage.

The poisons should be thoroughly mixed with water at the rate of from 1 pound to 100 to 250 gallons of water, and applied with a force pump and spray nozzle. In preparing the wash, it will be best to first mix the poison with a small quantity of water, making a thick batter, and then dilute the latter and add to the reservoir or spray tank, mixing the whole thoroughly. When freshly mixed, either London purple or Paris green may be applied to apple, plum, and other fruit trees, except the peach, at the rate of 1 pound to 150 to 200 gallons, the latter amount being recommended for the plum, which is somewhat more susceptible to scalding than the apple. White arsenic does little, if any, injury at the rate of 1 pound to 50 gallons of water when freshly mixed. As shown by Mr. Gillette, however, when allowed

to remain for some time (two weeks or more) in water, the white arsenic acts with wonderful energy, scalding when used at the rate of 1 pound to 100 gallons from 10 to 90 per cent of the foliage; the action of the other arsenites remains practically the same, with perhaps a slight increase in the case of London purple.

With the peach these poisons, when applied alone, even at the rate of 1 pound to 300 or more gallons of water, are injurious in their action, causing the loss of much of the foliage.

By the addition of a little lime to the mixture, London purple and Paris green may be safely applied, at the rate of 1 pound to 125 to 150 gallons of water, to the peach or the tenderest foliage, or in much greater strength to strong foliage, such as that of the apple or most shade trees.

Whenever, therefore, the application is made to tender foliage or when the treating with a strong mixture is desirable, limewater, milky, but not heavy enough to close the nozzle, should be added at the rate of about 2 gallons to 100 gallons of the poison.

With the apple, in spraying for the codling-moth, at least two applications should be made, the first after the falling of the blossoms or when the apples are about the size of peas, and the second a week or ten days later. The first brood of the codling-moth lays its eggs in the flower end of the young apple, and the worms upon hatching gnaw their way into the interior of the apple, and on sprayed trees get poisoned in so doing, an infinitesimal amount being sufficient to destroy so minute a worm. The second spraying is for the purpose of destroying larvæ hatching from eggs which may be laid after the first spraying, as the arsenic is gradually washed off by rains.

For the plum curculio on the plum, cherry, peach, etc., two or three applications should be made during the latter part of May and the first half of June. The poison in this case is applied for the purpose of destroying the adult curculios which hibernate and gnaw into the young growth of the trees and even into the hard young fruit before laying their eggs. The eggs are pushed under the skin so that the larvæ are not ordinarily affected by the poisoning.

In the case of most leaf-feeding insects one should spray on the first indication of their presence.

Caution necessary in the use of these insecticides.—The relative susceptibility of apple, plum, and peach has just been indicated under the head of arsenical poisons, and these remarks apply equally well to the use of the kerosene emulsions. In the case of other plants thorough experiments are still necessary, and all insecticides should be used in comparatively high dilution. Tender-leaved plants, such as melons and cucumbers, are more readily injured; while plants with firmer and smooth leaves, like the orange, are least affected. Annual plants, such as cabbages and other garden vegetables, are more susceptible than perennials; but in the case of root crops, such as beets, turnips, radishes, and potatoes, there is not the same need of caution as to damage to foliage. Damage

to foliage is not shown at once, and in case of rain following an application another application should not be made for several days. Fruit trees should not be sprayed with arsenical poisons while in blossom, as there is no advantage in doing so, and honeybees are reported to be at times killed by working in the sprayed blossoms.

SPRAYING FROM THE HYGIENIC STANDPOINT.

The only insecticide sprays which are at all dangerous to use are the arsenic compounds, and even here the danger is greatly exaggerated by those not conversant with the facts. Paris green and London purple have for many years been extensively used in this country as insecticides and a case of fatal poisoning from their use as such has never been substantiated. The only danger lies in having the poison about a farm or plantation in bulk. In the early days of the use of Paris green against the Colorado potato-beetle a great deal of opposition was developed on account of the supposed danger, and only recently the sale of American apples in England has received a set-back owing to the supposed danger of arsenic poisoning from their consumption. The question as to whether arsenic may be absorbed by the growing plant in any degree was long ago settled in the negative by the best chemists in the country. Dr. William McMurtrie, formerly chemist of this Department, in 1878 showed that even where Paris green was applied to the soil in such quantities as to cause the wilting or death of the plants, the most rigorous chemical analysis could detect no arsenic in the composition of the plants themselves. Other experiments in a similar direction by Prof. R. C. Kedzie, of the Michigan Agricultural College, confirmed these conclusions. It is safe, then, to assume that the only way in which fruit or vegetables can convey the poison to the consumer will be through the very minute quantity of arsenic left upon the edible part of the plant. Against the possibility of such an effect the following facts may be urged:

(1) It would seem at first glance that the use of an arsenical poison upon a plant like the cabbage would be very unsafe to recommend, yet Paris green and London purple are used upon this crop to kill the several species of leaf-eating worms which are so destructive to it, and an absolute absence of all danger where the application has been properly made has been recently shown by Prof. Gillette, of the Agricultural Experiment Station of Colorado, by the following *reductio ad absurdum:*

* * * Where the green is dusted from a bag in the proportion of 1 ounce of the poison to 100 ounces of flour and just enough applied to each head to make a slight show of dust on the leaves, say, for twenty-eight heads of cabbage, 1 ounce of mixture, the worms will all be killed in the course of two or three days, while the average amount of poison on each head will be about one-seventh of a grain. Fully one-half of the powder will fall on the outside leaves and on the ground, and thus an individual will have to eat about twenty-eight heads of cabbage in order to consume a poisonous dose of arsenic, even if the balance of the poison remained after cooking.

(2) In case of spraying apple orchards for the codling-moth there is scarcely a possibility of injury to the consumer of the fruit. A mathematical computation will quickly show that where the poison is used in the proportion of 1 pound to 200 gallons of water (the customary proportion) the arsenic will be so distributed through the water that it will be impossible for a sufficient quantity to collect upon any given apple to have the slightest injurious effect upon the consumer. In fact, such a computation will indicate beyond all peradventure that it will be necessary for an individual to consume several barrels of apples at a single meal in order to absorb a fatal dose even should this enormous meal be eaten soon after the spraying and should the consumer eat the entire fruit.

(3) As a matter of fact careful microscopic examinations have been made of the fruit and foliage of sprayed trees at various intervals after spraying which indicate that after the water has evaporated the poison soon entirely disappears either through being blown off by the wind or washed off by rains, so that after fifteen days hardly the minutest trace can be discovered.

(4) In the line of actual experiment as indicating the very finely divided state of the poison and the extremely small quantity which is used to each tree Prof. A. J. Cook, of the Michigan Agricultural College, has conducted some striking experiments. A thick paper was placed under an apple tree which was thoroughly sprayed on a windy day so that the dripping was rather excessive. After the dripping had ceased, the paper (covering a space of 72 square feet) was analyzed and four-tenths of a grain of arsenic was found. Another tree was thoroughly sprayed and subsequently the grass and clover beneath it was carefully cut and fed to a horse without the slightest sign of injury.

The whole matter was well summed up by Professor Riley in a recent lecture before the Lowell Institute, in Boston, in the following words:

> The latest sensational report of this kind was the rumor, emanating from London, within the last week, that American apples were being rejected for fear that their use was unsafe. If we consider for a moment how minute is the quantity of arsenic that can, under the most favorable circumstances, remain in the calyx of an apple, we shall see at once how absurd this fear is; for, even if the poison that originally killed the worm remained intact, one would have to eat many barrels of apples at a meal to get a sufficient quantity to poison a human being. Moreover, much of the poison is washed off by rain, and some of it is thrown off by natural growth of the apple, so that there is, as a rule, nothing left of the poison in the garnered fruit. Add to this the further fact that few people eat apples raw without casting away the calyx and stem ends, the only parts where any poison could, under the most favorable circumstances, remain, and that these parts are always cut away in cooking, and we see how utterly groundless are any fears of injury and how useless any prohibitive measures against American apples on this score.

SPRAYING FOR FUNGOUS DISEASES OF THE APPLE, PEAR, AND OTHER FRUITS.

Probably in no other country of the world is spraying for fungous diseases of fruits practiced to the same extent as in the United States. Five years ago practically nothing was known of this subject; in fact, the number actively engaged in spraying their trees, vines, etc., for such diseases as apple scab, black-rot, downy mildew, and other diseases of the grape did not exceed half a hundred all told. Now, as a fair estimate, probably no less than 50,000 fruit-growers are engaged in this work. From the Atlantic to the Pacific and from the Great Lakes to the Gulf the methods recommended by the Department are practiced every year. Canada has also adopted many of the suggestions made by us, and even now Australia is actively engaged in experiments in the treatment of apple, pear, peach, and other diseases, in accordance with suggestions originating with this Department.

DOES IT PAY TO SPRAY?

This question is in large part answered by the facts already given. No work that did not carry merit with it could have had such a phenomenal growth. To give a more direct answer, however, it may be stated that last season two hundred and fifty grape-growers in different parts of the country made a series of observations with a view of obtaining some definite information as to the value in dollars and cents of the recommendations made by the Department in the treatment of grape diseases. The facts reported by these men show conclusively that the actual profit to them over all expenses resulting from the treatment of black-rot and downy mildew was in round numbers $37,000. Thirteen thousand dollars of this sum was reported from the State of New York alone.

Other examples equally as striking could be given, but this is sufficient for our purpose. Of course, every one is not successful, but where failure is reported it is usually easy to locate and remedy the trouble.

FUNGICIDES OR REMEDIES USED IN SPRAYING.

Numerous preparations have been recommended and used for this work. For all practical purposes, however, there are but four which properly may be called remedies. They are (1) Bordeaux mixture, (2) ammonaical solution of copper carbonate, (3) eau céleste, and (4) modi-

fied eau céleste. The latest experiments indicate that the best results will follow the use of these preparations when made as follows:

1.—BORDEAUX MIXTURE.

In a barrel that will hold 45 gallons dissolve 6 pounds of copper sulphate, using 8 or 10 gallons of water or as much as may be necessary for the purpose. In a tub or half barrel slake 4 pounds of *fresh* lime. When completely slaked add enough water to make a creamy whitewash. Pour this slowly into the barrel containing the copper-sulphate solution, using a coarse gunny sack stretched over the head of the barrel for a strainer. Finally fill the barrel with water, stir thoroughly, and the mixture is ready for use. Prepared in this way the cost of 1 gallon of the mixture will not exceed 1 cent, the price of copper sulphate being 7 cents per pound and lime 30 cents per bushel. In all cases it is desirable to use powdered copper sulphate, as it costs but little more and dissolves much more readily. It is highly important also that fresh lime be used.

It will be seen by those familiar with former suggestions made by the Department that the strength of this mixture has been diminished one-half. It was found as the result of experiments made in 1891 that a mixture of this strength, and even much weaker, gave practically as good results as the old formula, which required 6 pounds of copper sulphate and 4 pounds of lime to 22 gallons of water.

2.—AMMONIACAL SOLUTION OF COPPER CARBONATE.

In an ordinary water pail mix 5 ounces of copper carbonate with enough water to make a thick paste. Dissolve this paste in 3 pints of strong aqua ammonia; then dilute to 45 gallons. If three pints of ammonia are not sufficient to dissolve all the paste add enough to bring about this result. Copper carbonate occurs in the market in the form of a fine greenish powder. The retail price is usually 60 cents per pound. Aqua ammonia having a strength of 26° retails at 8 cents per pound. Upon this basis 1 gallon of the ammoniacal solution of copper carbonate will cost 1 cent.

In view of the fact that copper carbonate is sometimes difficult to obtain the following directions for manufacturing it are given:

In a half barrel, or some similar vessel, dissolve 3 pounds of copper sulphate in 2 gallons of hot water. In another vessel dissolve 3½ pounds of common washing soda or sal soda in 1 gallon of hot water. When cool pour the second solution slowly into the first; then as soon as all action has ceased add enough water to bring the whole up to 8 or 10 gallons and stir thoroughly. In twenty-four hours pour off the clear liquid, taking care not to disturb the sediment. Add fresh water and stir again. Again allow the solution to stand twenty-four hours, pour off the clear liquid as before; then remove the sediment, which is copper carbonate. Prepared in this way there is formed 1½ pounds of

copper carbonate at an expense for materials of approximately 18 cents per pound. The copper-carbonate paste may be immediately dissolved in aqua ammonia, using 2 gallons of the latter, or as much as may be necessary for the purpose. This concentrated fluid should be kept in well-corked jugs and when ready for use should be diluted at the rate of 1 pint to 12 gallons of water.

3.—EAU CÉLESTE.

Dissolve 2 pounds of copper sulphate in 8 gallons of water. When completely dissolved add 3 pints of strong ammonia and dilute to 45 gallons. Prepared in this way the solution will cost about two-thirds of a cent per gallon.

4.—MODIFIED EAU CÉLESTE.

Dissolve 4 pounds of copper sulphate in 10 or 12 gallons of water and stir in 5 pounds of washing or sal soda; then add 3 pints of strong aqua ammonia, dilute to 45 gallons. The cost will be 1½ cents per gallon.

HOW AND WHEN TO SPRAY.

It should always be borne in mind that no hard and fast rules can be laid down for work of this kind. Frequently the fruit-grower will have to use his own judgment, especially as regards the number of sprayings and the proper time to discontinue them. If this be not done serious results may follow. In the treatment of black-rot of the grape we have known vine-growers to continue the application of Bordeaux mixture through a protracted drought up to the time of ripening of the fruit. As a result, when the time arrived to send the grapes to market they were so badly spotted with the mixture that no one would buy them. Again we have found fruit-growers thoroughly imbued with the idea that the only proper way to spray was to rush through an orchard or vineyard with some new-fangled complicated machine, applying the solutions in daubs at one point and omitting whole trees or blocks of vines at another. Such work is to be regretted, as it may be the cause of much loss to those who have acted carefully and intelligently in the matter. For example, in the case of the grape scare in New York City the past summer grape-growers all over the country were made to suffer, partly through the folly of a few overzealous individuals who upon their own responsibility made more applications than were necessary and partly through the action of a somewhat hasty Board of Health.

Before taking up the subject of treatments proper it may be well to emphasize the importance and necessity of using the right kind of machinery. A sprayer to be effective requires first of all a good strong force pump. Next in importance is a nozzle that will throw a mist-like spray and will not clog when thick fluids are used. There are plenty of machines on the market filling all these requirements. For conven-

ience they may be divided into three classes: (1) horse-power automatic machines, (2) machines drawn by horse power, but operated by hand, and (3) hand machines. All belonging to the first group may be dismissed with the statement that they are unnecessarily expensive and complicated, and will not, even in the most careful hands, do the work as thoroughly and effectively as the machines belonging to the second and third groups. Of the second group, in which the cheapest, most practical, and efficient example is found in a strong, light, double acting, double-discharge force pump mounted on a barrel, it may be said that, while they can not do the work as rapidly as the machines of the first class they are more effective, much cheaper, and far less wasteful of the liquid used. To the third class belong the knapsack sprayers, which are the only ones necessary to notice in this connection. There is no question that for all moderately low-growing crops the knapsack sprayer fills every requirement. In no other machine is the work so absolutely at all times under control, it being possible to place nearly every drop of liquid exactly where it is wanted. Knapsack pumps are now used in many moderate sized vineyards; also in places where the horse-power apparatus, owing to the nature of the land or the manner of cultivation, can not be utilized.

Many firms throughout the country, as will be seen by reference to the columns of any good agricultural paper, are engaged in the manufacture and sale of the various machines mentioned.

Taking up the question of spraying more specifically we would call attention first to apple diseases and their treatment.

TREATMENT OF APPLE SCAB.

For this disease either modified eau céleste or ammoniacal solution of copper carbonate, preferably the former, may be used. At least four sprayings should be made, the first just as the flowers are opening, the second twelve or fourteen days later, and the third and fourth at similar intervals. In case the season is wet one or two additional treatments will undoubtedly pay. For trees 15 to 18 feet high the cost of four sprayings with either of the fungicides mentioned need not exceed 20 cents per tree. When the work is done on a large scale 16 to 18 cents per tree will cover the cost of four treatments. Two additional treatments will add to the cost from 6 to 8 cents per tree.

APPLE POWDERY MILDEW.

It is only in nurseries that this disease is destructive. Seedlings are especially subject to the mildew, the leaves being attacked as soon as they appear. As a result the trees make very little growth, are bark bound, and consequently unfit for budding. The ammoniacal solution has proved the cheapest and most effective remedy for this disease, and five sprayings seem to be required. The first application should

be made just as the leaves start in spring. At least three other sprayings should be made at equal intervals between the time of the first treatment and the time for budding. Ten or twelve days after budding the last spraying should be made, making five in all. For blocks of 50,000 to 100,000 seedlings the total cost of the treatment, as indicated, need not exceed 8 cents per thousand. In smaller blocks the average cost per thousand trees will be somewhat greater, as it requires practically as much time to prepare to spray 25,000 trees as it does 50,000. The knapsack pump is well adapted to this work and is extensively used by nurserymen. Larger machines, designed to be drawn by a horse, have been described by us in Circular No. 10 of the Division of Vegetable Pathology.

TREATMENT OF PEAR SCAB, CRACKING, AND LEAF-BLIGHT.

These diseases, caused by two different species of fungi, are now successfully combated by one line of treatment. In most sections all three diseases are found associated. Bordeaux mixture has given the best results in this work, although ammoniacal solution has proved almost as effective. The only objection to the latter is that it sometimes gives the fruit a rust appearance, which is not at all desirable. The first spraying for these diseases should be made when the trees are in flower. In ten or twelve days a second treatment should be made, followed by a third and fourth at the expiration of two and four weeks, respectively. In the nursery, pear leaf-blight is often exceedingly troublesome. It may be almost entirely prevented by spraying five or six times with the Bordeaux mixture, making the first application when the leaves are about one-third grown and the others at intervals of ten or twelve days throughout the season.

The cost of treating full-grown standard trees with the Bordeaux mixture as indicated will average from 12 to 14 cents per tree. For dwarf trees the cost will range from 8 to 12 cents each. The cost of treating with the ammoniacal solution will be considerably less, probably not exceeding 10 cents for standard and 8 cents for dwarf trees. In the nursery pear seedlings can be treated six times with the Bordeaux mixture for 50 cents per thousand.

TREATMENT OF LEAF-BLIGHT OF THE CHERRY, PLUM, AND QUINCE.

This disease, which seriously damages the trees both in the nursery and orchard, may be readily held in check by the proper use of either Bordeaux mixture or the ammoniacal solution. In the orchard and nursery the directions laid down for the treatment of pear scab, cracking, and leaf-blight are applicable here.

TREATMENT OF BLACK-ROT OF THE GRAPE.

Method A.—After pruning the vineyard and putting the ground in thorough order spray the vines first, as the buds begin to swell, with Bordeaux mixture. When the leaves are one-third grown make a sec-

ond application of the same fungicide, following with a third when the vines are in full bloom. After this, applications should be continued at intervals of ten or twelve days until the first signs of ripening are noticed. This will usually be three weeks or a month before the grapes are ready to pick. In no case should the treatments be continued up to the time of harvest, as this is entirely unnecessary; moreover, it is sure to render the fruit unsightly. It is important to bear in mind that in case of dry weather the sprayings should cease.

Method B.—Following the direction laid down under method *A*, with the exception that the ammoniacal solution be used instead of Bordeaux mixture.

Method C.—For the first three sprayings use the Bordeaux mixture, then substitute the ammoniacal solution for the rest of the season.

The cost of the treatment as laid down in method *A* need not exceed 2½ cents per vine. Method *B* will cost two cents and method *C* the same.

So far as efficacy is concerned there is little choice. All things considered, however, method *A* will doubtless prove the most satisfactory.

DOWNY MILDEW OF THE GRAPE.

When this disease occurs alone ammoniacal solution or modified eau céleste may be used. The first spraying should be made when the fruit is well formed, the others at intervals of ten or twelve days, as recommended for black-rot. What is known as brown-rot is caused by the fungus of downy mildew. It is seldom that brown-rot occurs in the berries without the leaves being also affected. In regions where this happens the treatment recommended for black-rot should be followed.

In some sections eau céleste has been more effective against these diseases than any of the other fungicides. This is notably the case in northern Ohio and western New York. Eau céleste, however, sometimes injures the foliage, and we do not advise its extended use.

ANTHRACNOSE OF THE GRAPE.

Use Bordeaux mixture the same as recommended for black-rot under method *A*.

USE OF COPPER COMPOUNDS FROM A HYGIENIC STANDPOINT.

Ever since the copper compounds came into general use as fungicides the question as to their effects, hygienically considered, has received more or less attention. With the exception of the New York City Board of Health no positive stand on this question has been taken so far as we are aware. Many vague and misleading statements, however, have from time to time appeared in the horticultural and agricultural papers. Every one familiar with the situation understands why these rumors, for such they can only be considered, are sent out. They are not aimed

particularly at the practice of spraying, but are simply efforts on the part of selfish competitors to cripple the legitimate trade of more energetic and wide-awake rivals.

We take the ground that fruit sprayed with the copper compounds in accordance with the directions of the Department is harmless. No better proof of this is to be found than that shown by the experience of this country. For five years the copper compounds have been used by hundreds and thousands of fruit-growers in every part of the United States, yet in all that time not a single authenticated case of poisoning, so far as we are aware, has been brought to light. It is true a few individuals have claimed that they were made sick by eating sprayed fruit, but in all such cases careful investigations have revealed that claims of this kind were absolutely without foundation. However, we do not consider these general statements sufficient to warrant us in taking the stand as regards the harmlessness of the copper compounds when properly used. More direct testimony is readily obtained and some of this we now propose to consider. The question may properly be discussed under two heads, namely:

(1) The present condition of our knowledge as regards the toxicology of copper; and

(2) Are the salts found in sufficient quantity upon the fruit at the time of harvest to prove injurious to health?

No doubt the majority of people, including physicians, would answer the first statement at once by saying that copper is a poison. When we come to look carefully into the matter, however, it is found that the very best authorities differ on the subject. For more than a hundred years the question as to the poisonous nature of copper has been discussed, and yet, after reading all the testimony, it is exceedingly difficult from the evidence adduced to form a definite opinion.

In 1885 the question was discussed before the Belgium Royal Academy of Medicine for seven months, the object being to obtain some authoritative data as to the effect of copper contained in French canned vegetables on the public health. While it was finally decided that the copper compounds in foods were harmful, no direct stand as to the poisonous nature of the substances was taken. Those who antagonized the view that copper was an actual poison cited many eminent authorities to bear out their assertions. In the whole discussion, however, it was remarkable that not a single case of injury to health resulting from the daily absorption of small quantities of copper was given. Many instances were cited, however, where foods containing copper in considerable amounts were daily consumed without any ill effects whatever. It is interesting to note in this connection that notwithstanding the discussion before the Belgium Academy the law of July, 1882, prohibiting the use of copper in the re-greening of fruits was repealed by the French authorities in the Department of the Seine. It appears, therefore, from all the evidence on the subject that the question under consideration is

not settled by any means. For this reason alleged cases of poisoning with copper should receive the most careful investigation.

We presume no one will deny that copper in large or even moderate doses is unwholesome. Looking at the question from this standpoint let us consider the second part of our subject, *i. e.*, Are the salts found in sufficient quantity in connection with properly sprayed fruit at the time of harvest to cause injury to health? At this point it may be well to add that all our remarks apply to the Bordeaux mixture, which contains about twenty times as much copper as the ammoniacal solution, the only additional fungicide worthy of consideration on account of its extended use.

According to Gauthier, professor of chemistry of the faculty of medicine, Paris, an adult can absorb daily for a period of several weeks without ill effects from 0.2 to 0.5 * gram of copper sulphate, or blue vitriol. Five-tenths of a gram is usually considered the maximum amount that may be absorbed for any length of time without injury to health, although cases are on record where as high as 2, 3, and even 4 grams have been absorbed for a number of days in succession without any ill effects whatever. Some recent French investigations have shown that a dog can absorb from 15 to 25 grams of copper sulphate without injury. Sheep have been fed 43 grams per day for several days in succession without any noticeable derangement of the system.

At this point we are confronted with a somewhat complex chemical question which makes it difficult to obtain results strictly comparable. The Bordeaux mixture, as elsewhere shown, is made by the addition of lime to a solution of copper sulphate. According to recent investigations, the reaction is an exceedingly complicated one, the details of which are unnecessary here. It has generally been accepted that the mixture as sprayed upon the vines consists for the most part of copper hydrate, which upon drying becomes an insoluble compound. We have, therefore, first of all the question to consider whether the hydrate is as likely to prove injurious to health as the sulphate in solution. No direct investigations upon this point have, so far as we know, been made. It has been shown, however, that doses of copper four to five times greater can be administered in an insoluble than in a soluble state. The question now briefly stated resolves itself into this: May we, without assuming too much, use the facts bearing on the harmfulness or harmlessness of copper sulphate when considering copper hydrate and copper oxide? We believe that this assumption is not only admissible but is erring upon the safe side; in other words, that if an adult can safely absorb 0.5 gram of copper sulphate a day without injury, he may with much less fear of ill effects absorb the same quantity of copper hydrate and copper oxide. In fact, as regards the ill effects of the latter, hygienically considered, there is a great deal of evidence which will be considered later.

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* 1 gram equals 15.438 grains.

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 on sprayed grapes have been made in Germany, France, America, and other countries. The result of all these 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 1,000 pounds of fruit would contain 17.5 to 35.0 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.

Turning our attention to another phase of the subject, let us consider some other articles of food and drink in no way connected with spraying. In the first place, it has recently been shown that grapes which have never been treated with any fungicide may contain as much as 2 milligrams of copper per kilogram—two parts in a million, or practically the same as the average amount found in connection with sprayed fruit. Finding copper, therefore, in connection with fruit is no indication that such fruit has been sprayed with the copper compounds. Perhaps if this fact is remembered in the future it may prevent hasty conclusions and consequent annoyance.

According to numerous analyses wheat may contain from 4 to 10 milligrams of copper per kilogram, the average being 7.2 milligrams per kilogram. The United States exported to Europe and other foreign countries in 1890, 54,387,767 bushels of wheat, weighing approximately 3,263,266,020 pounds or 1,480,217,466 kilograms. If each kilogram of wheat contained 7.2 milligrams of copper, then there were 10,657 kilograms or 23,495 pounds of this metal sent out of the country in wheat alone. In the face of these figures we do not see how any foreign country can logically object to American fruits on the ground that they contain copper without also objecting to wheat.

Wheat, however, does not contain anything like as much copper as some other foods and drinks. Beef and sheep liver, according to reliable and repeated analyses, contain respectively from 56 to 58 and 35 to 41 milligrams of metallic copper per kilogram of fresh substance, while in chocolate the enormous amount of 125 milligrams to the kilogram has been found. In conclusion, it is only necessary to call attention to one other matter to show how unjust and discriminating it would be to condemn American fruits on the ground that they contain copper in unwholesome quantities. Brief reference has already been made to the re-greening of vegetables, as practiced by the French. Peas, beans,

cucumbers, and similar products are plunged for eight or ten minutes in a solution of copper sulphate in order to fix the natural green coloring matter. After removing the vegetables from the copper sulphate solution they are washed in pure water, placed in jars containing a solution of common salt, sealed and sterilized by heat.

The analyses of such vegetables show that they contain copper in considerable quantity, as will be seen by consulting the table below:

Table showing copper in 1 kilogram of re-greened canned vegetables.

Vegetables.	Authority.	Amount of copper.
		Milligrams.
Peas	Galippe	48 to 60
Do	Carles	70 to 210
Do	Gautier	11 to 125
Beans		49 to 99
Cucumbers	Magnier	2
Tomatoes	Sestini	50 to 354

It appears from the foregoing that vegetables re-greened by the copper process may contain from two to sixty times as much of the metal as sprayed grapes. In other words, if 1,000,000 pounds of sprayed grapes contain 5 pounds of copper, 1,000,000 pounds of re-greened vegetables would contain from 38 to 150 pounds of the metal. Great Britain imported over 14,000,000 pounds of canned vegetables from France in 1890, and it is safe to say that these vegetables contained more than twenty times as much copper as all the sprayed fruit in the United States combined.

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