Issued June 27, 1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge.
MAYAGUEZ, P. R.

Circular No. 17.

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BY

R. H. VAN ZWALUWENBURG,
Entomologist,
AND
H. E. THOMAS,
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UNDER THE SUPERVISION OF
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[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Agronomist in Charge.*
P. L. GILE, *Chemist.*
W. V. TOWER,[1] *Entomologist.*
H. E. THOMAS, *Plant Pathologist.*
H. C. HENRICKSEN, *Specialist in Farm Management.*
W. A. MACE, *Agricultural Technologist.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
W. P. SNYDER, *Assistant in Plant Breeding.*
C. ALEMAR, JR., *Clerk.*

[1] Appointed Mar. 1, 1918, to succeed R. H. Van Zwaluwenburg, transferred to United States Department of Agriculture, Bureau of Entomology.

CONTROLLING INSECTS, FUNGI, AND OTHER PESTS IN PORTO RICO.

CONTENTS.

The object of this circular is to present in a convenient form the formulas of the standard insecticides and fungicides that have been found most valuable in Porto Rico, together with a discussion of their application.

TYPES OF INSECTICIDES.

Materials used to kill insects are called insecticides and may be divided roughly into four classes.

(1) Poisons, which kill after being introduced into the system through the mouth.

(2) Contact insecticides, which kill only after coming into direct contact with the body. Their action, formerly supposed to be suffocating or corrosive, is really more complex; they enter the tissues and interfere with certain vital processes, such as the assimilation of oxygen by the cells.

(3) Repellents, which deter insects from attacking the plant or animal for which protection is desired.

(4) Gases, which kill by suffocation. Their value is limited to use in inclosed areas.

RELATION OF FEEDING HABITS TO CONTROL.

It is necessary to know the feeding habits of any injurious insect before applying either of the more common classes of insecticides. An insect which feeds by biting off leaf particles and plant tissues has biting mouth parts and should be combated with poisons such

as Paris green or arsenate of lead. Examples of insects which feed in this manner are beetles, changas, roaches, and practically all caterpillars. Insects that feed by sucking juices from the plant tissues through a beak obviously can not be reached by stomach poisons; they must be combated with contact insecticides which kill only after coming in direct contact with the insect's body. Common contact insecticides are kerosene emulsion, soap solution, and lime-sulphur. Aphids, scales, and the eggplant lace-wing are common examples of sucking insects.

Both classes of insects can be controlled under certain favorable conditions by suffocating them with poisonous gases. This method of control is restricted to use against insects in inclosed places, and is particularly adapted to the control of granary pests.

POISONS.

HOW TO USE POISONS.

Stomach poisons are usually mixed with water, which serves both to dilute the material and to spread it evenly. The burning of foliage which so often follows the use of arsenicals (especially Paris green) is due to the presence of arsenic in water-soluble form. The best arsenical poison for spraying purposes is usually one which has the most arsenic in forms not soluble in water and at the same time the least water-soluble arsenic compounds. Corrosive sublimate, not an arsenical but in part a stomach poison, is unsafe to use on foliage.

On most surfaces a water suspension of poison will spread satisfactorily, but in the case of glossy leaves, such as those of cabbage, it is necessary to add soap to the spray to make it spread evenly and adhere.

Dusting in general orchard work is still in the experimental stage. Recent work[1] shows that it is about as effective as spraying against certain insects and certain diseases under favorable conditions. The use of large power blowers is not common in Porto Rico, but many small hand blowers are operated. These blowers consist of a rotating fan for driving the powder from the reservoir through a tube which directs and controls the application. Such a machine is not essential, as satisfactory work may be done on a small scale by dusting from a can with holes punched in one end or from a cheesecloth bag.

Paris green used on foliage must be diluted with 3 to 20 parts by weight of flour, ground gypsum, leached wood ashes, or, preferably, air-slaked lime. The strength used depends upon the kind of insect and upon the sensitiveness of the foliage treated. Powdered lead arsenate can be used pure on practically all foliage, or it may be

[1] Stewart, V. B. New York Cornell Sta. Bull. 385 (1917).

diluted with 1 to 5 times its weight of diluent. When using powdered arsenicals great care must be taken not to breathe any of the dust, and gloves should be used to protect the hands, especially if the skin is at all cut or broken.

Many insects, as changas and cutworms, can be combated by the use of attractive mixtures. These baits are usually poisoned with some form of arsenic, a cheap water-soluble compound such as London purple being as good for this purpose as more expensive poisons.

It must be constantly borne in mind when dealing with poisons that insecticides also are with few exceptions poisonous to human beings. Poisons should always be locked up when not in use and should always be kept in well closed containers and warningly labeled.

PARIS GREEN.

Paris green is a green powder composed of aceto-arsenite of copper. The pure substance should contain about 58 per cent arsenious oxid. The poison should be used at the rate of 1 pound to 150 to 200 gallons of water and applied as soon after mixing as practicable, for it dissolves in water, and arsenicals in solution cause leaf burn. Lime should be added in order to combine with any free arsenic or with any that may be freed by decomposition. For each pound of Paris green 1 to 2 pounds of quicklime should be added. This should be slaked in a little water and allowed to cool. The poison mixed with a little water to form a paste is then mixed with the lime and added to the rest of the water required by the formula.

Besides its burning effect on foliage caused by its partial solubility, Paris green has another disadvantage in that it is not strongly adherent. If only for the latter reason, it is not to be recommended for spraying in Porto Rico, where heavy showers are common. It has largely been superseded as a spray material by arsenate of lead. The cost of these chemicals in Porto Rico is at present practically the same, about 35 cents a pound in large amounts and 40 cents retail.

The principal use for Paris green is in the preparation of poisoned baits against changas and cutworms and in poisoning comején (*Eutermes morio*) nests. Comején colonies can be completely destroyed by placing small quantities of Paris green (or in fact any powdered arsenical) in the nests or runways. The white ants readily devour their own dead and so the poison is quickly spread throughout the colony. Possibly the powder has also an irritating and fatal effect on those comejéns whose tender skin it touches.

LONDON PURPLE.

London purple, a waste product in the manufacture of anilin dyes, is composed of arsenic and lime compounds, containing on the average about 45 per cent of oxids of arsenic. Unfortunately it is not at

present for sale on the island, but a demand for it should cause its reappearance on the local market. It is a much swifter poison for comejéns than Paris green, due to the finer division of the particles. It is not recommended as a foliage spray, but can be used as such at the rate of 1 pound to 180 to 300 gallons of water, with 2 pounds of quicklime added as in the preparation of Paris green. The lime does not insure against injury to the foliage but lessens the chance. As an ingredient of poisoned baits London purple is about as effective as Paris green.

ARSENATE OF LEAD.

By far the best poison for spraying purposes is arsenate of lead in both paste and powder form. It adheres to the leaves for a very long time, often almost three times as long as Paris green. It rarely burns foliage of most plants at reasonable strengths, and, due to its light weight, it remains in suspension much longer than any of the other arsenicals discussed. As precaution against injury to exceptionally tender foliage, 1 or 2 pounds of quicklime should be added to each pound of lead arsenate. Its comparatively low percentage of arsenic makes it a slow poison, and for this reason it is not desirable for making poison baits.

A very satisfactory lead arsenate can be made at home from arsenate of soda and acetate or nitrate of lead, but with the varying composition of these chemicals as found on the market and with such excellent commercial lead arsenates available, its manufacture at home is not to be recommended.

The powder rather than the paste is to be recommended. The powder known as "neutral" lead arsenate contains about 25 per cent arsenic oxid, while the "acid" form contains about 33 per cent. The neutral form is claimed to be more stable and it is also claimed that under peculiar atmospheric conditions, particularly in the presence of ammonia, the acid lead arsenate may cause burning of the leaves. No such case has been observed in Porto Rico, but it is perhaps well to know the differences in the two forms. The acid lead arsenate is the one generally found on the market in paste form. The paste is about 50 per cent water, hence the strength of lead arsenate here recommended must be doubled if the paste form is used.

For general spraying 3 pounds of the powder should be used to each 50 gallons of water. Many leaf-feeding beetles are so resistant to poisons that in spraying for them the dosage must be raised to 4 pounds. The poisoning of May beetles (caculos) with arsenical sprays is not practicable.

HELLEBORE.

Hellebore, a fine white powder consisting of the ground roots of the white hellebore plant (*Veratrum album*), is extensively used in temperate regions for treating fruits which are almost ready to eat,

though it will probably not be widely employed in Porto Rico. The material now on the market in the United States is prepared from the roots of green hellebore, *Veratrum viride*. As the substance gradually loses its poisonous properties upon exposure to the air, it is advisable to use only fresh material kept in a tightly closed container. It may be used dry mixed with 5 to 10 parts of flour, or as a spray (1 ounce in 1 gallon of water).

SODIUM FLUORID.

Sodium fluorid in its commercial form is a fine white powder costing from 30 to 60 cents a pound and containing 90 to 98 per cent of the salt. It is a stomach poison principally, although it has been shown to be a contact insecticide as well. It should keep indefinitely in tightly stoppered bottles. The chemical is easily procurable through wholesale houses, and a local demand for it can be quickly supplied. In asking for the chemical care should be taken to specify sodium fluorid, as the similarity of the name to sodium chlorid, common table salt, often results in mistakes. It is very satisfactory as a cockroach poison.[1] It should be dusted thinly but widely where the roaches are most numerous, for they will not eat it voluntarily but will clean it off their bodies.

Sodium fluorid is also very effective against lice on poultry and can be applied dry or as a dip. To prepare the dip tepid water should be measured into a tub and ¾ to 1 ounce of commercial or ⅔ ounce of chemically pure sodium fluorid added for each gallon of water. The application of the dry powder is made as follows:[2]

> The material is placed on a table in an open vessel, and the fowl is held by the legs or wings with one hand, while with the other hand a small pinch of the chemical is placed among the feathers next the skin about as follows: One pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one on the tail, one on either thigh, and one scattered on the underside of each wing when spread. Each pinch can be distributed somewhat by pushing the thumb and fingers among the feathers as the material is released.

ANT POISONS.

Some ants (notably house ants) can be controlled by the use of poisoned sirups. In California orange groves the Argentine ant is also dealt with by this means, and it is entirely possible that the common orchard ant in Porto Rico, the "brava," may be controlled in the same way.

The best formula is as follows:[3]

Granulated sugar	pounds	15
Water	pints	7
Tartaric acid (crystallized)	ounce	¼

Boil for 30 minutes and allow to cool.

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[1] Gates, M. F. U. S. Naval Med. Bul. 6 (1912), No. 2, p. 212.
[2] Bishopp, F. C., and Wood, H. P. U. S. Dept. Agr., Farmers' Bul. 801 (1917).
[3] Barber, E. R. U. S. Dept. Agr. Bul. 377 (1916), p. 18.

Dissolve chemically pure sodium arsenite	ounce	¾
In hot water	pint	1
Cool. Add poison solution to sirup and stir well, adding afterwards—		
Honey	pounds	1½

Mix thoroughly.

The advantages of this sirup over all others are that it will not spoil, is stable at high temperatures, does not crystallize, and retains its attractiveness for the ants.

A simpler formula which is much used is the following:

Dissolve 5 pounds of sugar in 1½ pints of water by heating gently in a double boiler. Then dissolve ¼ ounce of sodium arsenite in a little hot water and add to the sirup solution.

Do not increase the poison in either of these formulas. Their success depends upon the fact that they are slow poisons. A swifter poison by its effects would warn the ants not to take the sirup to their nests. The effectiveness of the sirups is due to the fact that the poison is imbibed by practically the entire colony, including the queens which are continually repopulating the nest, before the insects are aware of its nature.

For combating ants indoors, pour a little of the sirup over a sponge placed inside a can or jar having a perforated tin lid. If the ants avoid the jar after a time, move it a few inches and they will again revisit it. Continue until the ants have disappeared.

Outdoor applications of poison are made in California citrus groves by means of paraffined bags. The following directions are given by Barber[1] for the preparation of the bags:

Small 1-pound bags used in grocery stores are obtained, and two or three holes about one-fourth inch in diameter are cut through each folded bag with a leather punch or similar instrument. This provides each bag with two holes on each side for the entrance of the ants. Being opened, the bags are dipped in a pan of molten paraffin and set aside to dry. The paraffin, forming a waterproof surface, materially lengthens the life of the bag, which is protected from the entrance of water through the holes by part of another (2-pound) paraffined bag which covers the first one like a canopy. In use, each bag is provided with a small quantity of poisoned sirup and a piece of sponge, the protecting outer bag is drawn up over it, and the ends of both are folded over at the top and tacked to a tree.

Bags baited with sirup as described above lasted two to three months in good condition on trees at Mayaguez. Work done by the Insular Experiment Station[2] shows that this durability is not sufficient to effect complete eradication of the "brava" ant in citrus groves. A friction-top can may be used as container after indentation of its rim has been made; such a container is durable and can be recharged.

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[1] Loc. cit., p. 20. [2] Cotton, R. T. Correspondence, Oct. 15, 1917.

BAITS.

For cutworms.—Mix ½ pound of Paris green or London purple, or 1 pound of white arsenic, with 25 pounds of meal, middlings, or, preferably, bran. Stir a quart or two of cheap molasses into a gallon of water and moisten the bran, stirring thoroughly, until it makes a stiff mash. Do not make the mixtures too thin. Apply a day or two before setting out the plants, laying small heaps every 2 or 3 feet in the row; if the plants are already out, place a small heap near each. Apply as near nightfall as possible. Keep poultry and hogs out of treated fields.

For changas.—Mix thoroughly 2½ to 3 pounds of Paris green or London purple with 100 pounds of low-grade flour.[1] This is of special value in tobacco plantings and in gardens.

To protect valuable plants such as tobacco and tomato the mixture should be placed in a shallow trench, made with the finger, around and not less than 3 inches from the plant.

To exterminate the mole cricket from a given area apply the mixture broadcast. Keep the land to be treated free of all vegetation for at least a week before applying the poison. At dusk scatter the mixture in small piles at the rate of 250 to 300 pounds to the acre. After four or five days the changas will have eaten the poison, and planting can be done.

CONTACT INSECTICIDES.

GENERAL DISCUSSION.

The value of a contact insecticide depends largely upon the thoroughness with which it is applied. The insects to be killed must be actually touched by the spray.

Contact sprays, at strengths safe for plants in foliage, as plants always are in a tropical country, can not be depended upon to be entirely effective when applied for scale insects, as the eggs at least will survive. For this reason it is necessary when spraying for scales to repeat the application once or twice at intervals of about a month, depending upon the thoroughness of the treatment and the hardiness of the scale. The second spray will kill practically all the scales which have hatched since the first application and which will be but poorly protected as compared with older scales. Careless spraying, or a very heavy infestation of scale, will often make a third treatment necessary.

In using oil sprays in any form, the application should be just sufficient to wet the plant without allowing the liquid to run down the trunk and collect about the crown. Young trees in particular

[1] Crossman, S. S., and Wolcott, G. N. Porto Rico Insular Sta. Circ. 6 (1915).

are liable to serious injury from the accumulation of oil about their roots. The crown can be protected by mounding up loose earth and firming it about the trunk before the spraying is done; afterwards the heaped-up earth should be removed.

When refilling a spray tank, be sure that no free oil accumulates in the residue left from the previous tank loads of emulsion.

KEROSENE EMULSION.

Kerosene emulsion is the standard remedy against such soft insects as aphids and mealy bugs. It offers simply a means of diluting kerosene to strengths that will not injure plants. The materials for making it are usually at hand, and its preparation is not difficult.

Common soap	pounds	½
Water	gallon	1
Kerosene	gallons	2

Dissolve the soap in the water over a fire. Remove from the flame and add the kerosene slowly, stirring vigorously. This is best done by pumping the mixture back into itself with a bucket pump for about 10 minutes. The result desired is a creamy white emulsion containing no free oil. This is the stock emulsion and contains 66 per cent kerosene; properly made and protected from exposure to air it should keep a month at least.

Dilute as follows:

For aphids, 1 part to 11 or 12 of water.

For mealy bugs and crawling scale, 1 part to 8 or 10 of water.

Against mealy bugs it should be applied with sufficient force to penetrate the insect's protecting powdery coat. Successful use of kerosene emulsion is restricted to soft-bodied insects; paraffin-oil emulsion and lime sulphur are preferable for general spraying. The addition of 1 pint of carbolic acid to the formula, emulsifying it before the kerosene is added, makes the spray more effective, but for scale it is better to use one of the other sprays named.

Insects working in posts can be killed by the following modification of kerosene emulsion: The emulsion should be made with a gallon of 5 to 10 per cent sodium arsenite or corrosive sublimate solution in place of water. This preparation is not safe to apply to living trees.

CARBOLIC ACID EMULSION FOR ANTS.

Water	gallon	1
Soap	pound	1
Crude carbolic acid, 100 per cent (dark)	pint	1

Dissolve the soap in the water and add the carbolic acid, churning as for kerosene emulsion. This is the stock and does not thicken as kerosene emulsion does. It must be diluted 1 to 48 (1 pint to 6 gallons of water) and at this strength can safely be used on foliage.

Whenever the nests of ants can be located, this is a most effective remedy against them. Insert the end of the pump tube with the nozzle removed in the nest and flood it with the emulsion. Puddle the nest with the foot. After three or four days any surviving ants will have shown evidence of their work and the process should be repeated. More than two treatments are seldom necessary. The procedure as outlined has been successful whenever carried out.

OIL EMULSIONS.

Various oils can be substituted for kerosene in making emulsions. Heavy oils do not evaporate so readily as lighter ones and their effectiveness is thereby prolonged.

A good crude-oil emulsion is made as follows:[1]

Crude petroleum	gallon	1
Water	do	1
Soap	pound	½
Sal soda	ounces	6½

Dissolve the soap and sal soda in boiling water. Mix by pumping this solution into the oil for 15 to 20 minutes. Dilute 1 part of the stock solution with 15 parts of water.

PARAFFIN-OIL EMULSION.

This spray was originally developed for controlling the white fly in Florida, but has proved so successful against scales as well that in Porto Rico it is extensively used for general citrus spraying. The formula is as follows:

Whale-oil soap	8 pounds, or 1 gallon
Paraffin oil (24° to 28° Baumé)	2 gallons
Water	1 gallon

There are two brands of paraffin oil for sale on the island, both of which are very satisfactory. Corvus oil is sold by the Texas Co. and Red Junior oil by the West India Oil Co. Either brand can be had at the warehouses in San Juan, Mayaguez, and Ponce at 36 cents a gallon in case lots and 18 cents a gallon by the barrel.

The preparation of the emulsion is as follows:[2]

In preparing the stock mixture the soap should be put into a receptacle of about 5 gallons' capacity and the oil should then be added very slowly while the mixture is being vigorously stirred. It is important that the oil be added in small quantities at first and also that the stirring be sufficient to keep the oil and soap in the form of an emulsion after each addition of oil. Thus at first

[1] Tower, W. V. Porto Rico Sta. Bul. 10 (1911), p. 29.
[2] Yothers, W. W. U. S. Dept. Agr., Bur. Ent. Circ. 168 (1913), p. 5.

about a pint of oil should be added to the soap and the mixture stirred until no free oil appears. As the amount of oil is increased it should always be stirred or mixed thoroughly before the next addition is made. After the required amount of oil has been added and after free oil has ceased to appear on top of the soap, the water is slowly poured in, about a quart at a time. To determine whether the mixture will form a perfect emulsion add a little of it to soft water, and if no oil floats the mixture is perfect and may be used for spraying. The presence of floating oil indicates an imperfect mixture and results from adding the oil too suddenly or from insufficient stirring. This condition may be remedied by the addition of more soap, which is preferable to throwing away the entire mixture.

For spraying orange trees use 1 gallon of the stock mixture prepared as just described to 50 gallons of water, or use the entire amount to make 200 gallons of spray material. This dilution contains approximately 1 per cent of oil, which is the maximum strength required for white flies and the purple scale. * * *

Many alterations may be made in the foregoing formula. The quantity of soap will depend largely upon the time consumed in adding the oil and the amount of stirring accompanying this process. The amount of soap is lessened if the stirring is uniform and if ample time is taken in the preparation. Petroleum fuel oil, or "crude oil," and distillate, or gas oil, may be used instead of the paraffin oil, but in these cases a mixture of about twice the strength will be needed to kill the insects. The amount of water is unimportant, since the emulsion should be perfect if either 1 or 4 quarts be added. The only thing to be remembered is that the diluted spray should contain the required percentage of oil.

If whale-oil soap in hard form is used, it should be reduced to a fluid state by boiling with water or by allowing it to stand a few days in water. The emulsion can be made with common laundry soap, but such stock does not keep well and should be used within a day or two. The whale-oil soap is preferable.

MISCIBLE OILS.

The miscible ("mix-able") or so-called "soluble" oils vary in composition, but are all petroleums to which have been added vegetable oils cut or saponified with alkali. They are, therefore, liquid petroleum soaps.

There are several very good brands of commercial miscible oils, and it is doubtful if it pays any longer to make the mixtures at home. These commercial oils should be diluted 1 to 25 or 30, according to the manufacturers' direction and at such strengths are satisfactory for foliage spraying. A commercial preparation can be purchased on the island at 60 or 65 cents a gallon in 30 or 50 gallon lots.

A very good homemade miscible oil can be made according to the following directions, taken from Bulletin 10 of this station:

Directions for making miscible oils.—There are three steps to be taken in making miscible oil emulsions before the emulsion for spraying is obtained. First, the cooking of the soap and the adding of the kerosene and water.

Second, making the stock emulsion out of the soap solution and various oils. Third, diluting the stock emulsion for spraying.

The soap solution should be made in the open air or under an open shed, as the mixture is inflammable when it reaches 300° F. It is also advisable to make the soap solution in a receptacle that is large enough to allow plenty of room for boiling. When the soap reaches 240° F. it begins to boil and continues to boil very violently until it reaches about 280° F. During this time the mixture foams and increases to at least double its volume. It is, therefore, very necessary that the receptacle be sufficiently large. When the soap reaches 300° F., it should be removed from the fire and the kerosene and water added. First, pour the kerosene in slowly, thoroughly stirring the mixture; allow this to cool a little, then add the water. It is better to let it cool until the soap plus the kerosene is below 212° F. The following formula is used in making the soap solution:

Menhaden oil	gallons	10
Carbolic acid	do	8
Caustic potash	pounds	15
Heat to 300° F., and then add:		
Kerosene	gallons	14
Water	do	22

In making the soap it is well to have the kettle covered with boards with a hole in the center through which a thermometer can be placed to take the readings. It does no harm if the soap reaches 310 or 315° F., but it is not safe to continue the boiling after the soap has reached 300° F., as it is more liable to take fire. After the soap solution is completed the fire can be drawn and the mixture placed in a barrel, after which the kerosene and water are added. The soap should be slightly ropy, but should run readily and not separate upon standing. A half barrel of this soap has been left standing for six months without undergoing any change.

Stock emulsions are made by the following formula:

Soap solution	gallons	8
Crude oil	do	18
Rosin oil	do	4
Water	do	3

Or more if needed.

This formula does not state definitely the quantity of water necessary to obtain an emulsion free from oil, as the amount to be used often varies. After the stock emulsion has been thoroughly mixed, try a few drops in a glass of water, and if no oil appears the emulsion is ready to be diluted with the water for spraying. It is recommended to use 1 gallon of the stock emulsion to 25 gallons of water for trees without fruit.

SOAP SOLUTIONS.

One of the simplest and most satisfactory remedies for soft-bodied insects attacking house plants is soap solution. Dissolve 1 pound of laundry soap in 4 or 5 gallons of water, and apply either with a brush or syringe.

An even more effective soap solution, but limited to outdoor use because of its odor, is whale-oil or fish-oil soap. Used at the rate of 1 pound in 6 gallons of water, it makes an effective spray against

the common eggplant lacewing. Shave the soap into a small quantity of boiling water and put into solution; then add enough cold water to bring it up to the desired amount.

TOBACCO EXTRACTS.

Tobacco extracts can be made at home by heating or steeping 1 pound of tobacco stems or dust in 1 gallon of water. Do not allow the water to boil or some of the insecticidal properties will be lost. Dilute with one or two times its volume of water, according to the plants to be treated and the strength of the solution. Add a little soap as a spreader. The drawback to homemade tobacco extracts is their uncertain strength.

Several brands of highly concentrated tobacco extracts are on the market, all containing known and guaranteed amounts of nicotin. These are diluted according to their concentration and the insect to be sprayed. To each 50 gallons of spray add 1 pound of soap to make the material spread evenly and rapidly. Tobacco extracts, properly diluted, are the best sprays we have for the common red-banded thrips.

The combination of tobacco extracts with Bordeaux mixture or with Paris green is of doubtful safety.

LIME-SULPHUR SOLUTION.

Lime-sulphur solution has long been the standard winter spray for many scales in temperate climates. Its use at strengths not injurious to foliage has not been satisfactory for certain scales. This is especially true with regard to the purple scale so common on citrus in Porto Rico, the eggs of which are not killed by lime-sulphur. Paraffin-oil emulsion when properly made is much more effective against scales. The value of lime-sulphur lies in that it is a combination spray, being a fungicide as well as an insecticide.

Lime-sulphur can be made at home or can be purchased in concentrated liquid or powdered form. To-day the commercial product, which is as good as can be made on the plantation, is so much more convenient than the homemade mixture that the use of the homemade article has almost ceased.

Homemade concentrated lime-sulphur.—The best results have been had with the following formula:

Stone lime	pounds	50
(Or hydrated lime)	do	66
Sulphur	do	100
Water	gallons	50

Put about 10 gallons of water in the cooker, start the fire, and add the lime. As soon as slaking has well started, add slowly the sulphur previously made into a thin, lumpless paste by the addition of water. Mix thoroughly, adding enough water to keep the mixture fairly thin but not enough to "drown" the lime. After slaking is over, add the remainder of the water, using 5 to 10 gallons in excess of the amount called for if the cooking is done over a fire, and about 5 gallons less than the formula requires if cooking is done by live steam.

Stirring should continue throughout the process, being especially important during the early stages until the sulphury scum disappears. Especial care should be taken to break up all lumps. Boiling should continue vigorously for 50 minutes to 1 hour so as to completely dissolve all the sulphur grains. Ten minutes' boiling under or beyond these limits will not matter, provided the volume is kept up and the sulphur is dissolved. Too much or too little boiling increases the sediment.

The finished product should be carefully strained through a fine brass mesh. It should keep indefinitely if properly made and protected from air by storing either in filled barrels or with a layer of heavy oil over its surface. The sediment is of little or no fungicidal or insecticidal value, and should be eliminated as far as practicable.

Commercial lime-sulphur concentrate.—This is a clear, deep-red liquid of much higher concentration than is usually obtained with the homemade solutions. The brands vary from 32° to 35° Baumé, and should be diluted accordingly.

Recently a powdered form of lime-sulphur has appeared on the market, selling in Porto Rico at 13½ cents a pound. The manufacturers recommend that 2½ to 3 pounds be dissolved in 50 gallons of water, and state that 4 pounds to 50 gallons is safe on citrus foliage.

Dilutions of concentrates.—To dilute concentrates accurately requires the use of a hydrometer having a specific gravity scale. A good hydrometer can be had for about $1.25. Some hydrometers have only a Baumé scale, and for convenience the equivalent specific gravities and Baumé readings are given in the table below. Sprays of any desired density can be obtained from any concentrate by dividing the decimal of the specific gravity of the concentrate by the decimal of the specific gravity desired. The result is the total number of dilutions in the dilute spray; i. e., it includes the original measure of the concentrate besides the number of times it is to be diluted. Hydrometer readings should not be made while the concentrate is still hot.

Example: A commercial concentrate of 32° Baumé has a specific gravity of 1.2831 (see table); a dilute spray with a specific gravity of 1.009 is desired. Dividing 0.2831 by 0.009 gives 31.4; therefore, to 1 part of the 32° concentrate add 30.4 parts of water to obtain a specific gravity of 1.009.

Equivalent values of Baumé readings and specific gravity.

Degrees, Baumé.	Specific gravity.	Degrees, Baumé.	Specific gravity.	Degrees, Baumé.	Specific gravity.
15	1.1153	23	1.1885	31	1.2719
16	1.1240	24	1.1983	32	1.2831
17	1.1328	25	1.2083	33	1.2946
18	1.1417	26	1.2184	34	1.3063
19	1.1507	27	1.2288	35	1.3181
20	1.1600	28	1.2393	36	1.3299
21	1.1693	29	1.2500		
22	1.1788	30	1.2608		

For citrus, the dilution should have a specific gravity of 1.008, although sometimes the foliage can stand as high as 1.01 or more without injury. For rust mite a dilution of the 32° Baumé concentrate of 1 to 75 (giving a specific gravity of 1.003) is effective against adults and eggs. Ripe fruit should not be sprayed with higher concentrations than 1.007.

Tobacco sprays and neutral lead arsenate may be used in combination with lime-sulphur, but Paris green, oil emulsions, and soaps can not be. The combination of lime-sulphur and acid lead arsenate is a doubtful one as regards safety to foliage.

SULPHUR.

Powdered sulphur, called flowers of sulphur, is used dry as an insecticide, especially against red spider and other mites. Dust the foliage thoroughly while still wet with dew, and if possible, in the absence of a breeze. The warm sunshine acting on the sulphur liberates two gases which are the killing elements. Hydrated lime may be mixed with flowers of sulphur to make it more adhesive.

CEBADILLA.

This is a brown powder made of the dry seeds of certain Mexican plants, chief among which is *Asagræa officinalis*. Its poisonous action is due to the presence of certain alkaloids.

Put 1 pound of cebadilla in 5 gallons of water and let the materials stand for two days. The resulting brown liquor may be used without danger of injuring the skin and is effective for even such tough pests as cattle ticks.[1]

LARVICIDE FOR MOSQUITOES.

A mosquito larvicide developed by the department of sanitation of the Isthmian Canal Commission at Panama has been found very satisfactory. The high price of carbolic acid may restrict its use at present, but a return to normal prices should make the formula avail-

[1] Mayo, N. S. Estac. Cent. Agron. Cuba Bul. 6 (1907), p. 23.

able for use by local sanitation boards. It is made on a large scale as follows:

Heat 150 gallons of crude carbolic acid to 212° F., then add 150 pounds of finely broken resin. Keep the mixture at a temperature of 212° and add 30 pounds of caustic soda, keeping it at the same temperature until a perfectly dark emulsion without sediment is obtained. The mixture should be thoroughly stirred from the time the resin is added until it is done.

"The resultant emulsion makes a good disinfectant or larvicide. In fact, 1 part of it to 10,000 parts of water will kill Anopheles larvæ in less than half an hour * * *. This property of killing larvæ rapidly is of great importance in the Tropics, where continuous rainy periods make crude oil or kerosene much less valuable as a larvicide than in northern latitudes having less rainfall."[1] For streams with a fair velocity the use of crude oil is recommended.

PYRETHRUM.

This is a yellowish powder sold under the names of "buhach" and Persian insect powder. It is the ground flowers of the Pyrethrum plant. It is not poisonous to man or higher animals, and its chief value is against household pests such as roaches and bedbugs and in small gardens where the use of arsenical poisons would be inadvisable. Only fresh material should be used, as it deteriorates rapidly.

It may be dusted on plants or in rooms pure or mixed with half its bulk of flour. It may also be used as a spray at the rate of 1 ounce to 2 gallons of water. The mixture should stand 24 hours before applying. If it is desirable to use the mixture immediately, it should be boiled for 5 or 10 minutes. A little of the powder burned in a closed room will kill all mosquitoes confined there.

COAL-TAR PRODUCTS.

Creolin, creosote, and various other coal-tar preparations are valuable insecticides. To rid poultry houses of mites they should be used pure or as directed on the package, all cracks and crevices being thoroughly sprayed.

A 3 per cent mixture of creolin (about 4 tablespoonfuls to 1 gallon of water) makes a very good bath for ridding house pets of fleas.[2] A 5 per cent mixture is fairly effective as a spray against cattle ticks but injures the skin somewhat at that strength.

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[1] Howard, L. O., Dyar, H. G., and Knab, F. The Mosquitoes of North and Central America and the West Indies. Carnegie Inst. Washington, Pub. 159 (1912), vol. 1, p. 385.

[2] Bishopp, F. C. U. S. Dept. Agr. Bul. 248 (1915), p. 23.

Coal-tar creosote is an excellent preservative of woodwork against white ants, serving also as a preventive of fungus attacks. A superficial application with a brush will give temporary protection even to timber in direct contact with the ground, and impregnation under pressure results in much longer protection.[1]

REPELLENTS.

Any material applied to plants, animals, or objects in such a way as to prevent insect attack is known as a repellent.

ANT BANDS.

Corrosive sublimate.—Corrosive sublimate, besides being a stomach poison, is a powerful repellent. Cotton tape soaked in a strong water solution of corrosive sublimate and wrapped about furniture legs will prevent ants from ascending.

A less unsightly method of application is a solution made as follows:[2]

Corrosive sublimate	grams	20
Ethyl alcohol	cubic centimeters	60
Shellac	grams	31

Dissolve the corrosive sublimate in the alcohol and then add the shellac, shaking until all is in solution. This should be applied with a brush in a band 6 to 8 inches wide, thoroughly covering the surface. Methyl alcohol destroys in some way the repellent effect of the corrosive sublimate; it can not be substituted for ethyl alcohol. Properly used, shellac bands should remain effective for a year or more.

Do not use corrosive sublimate bands in contact with metal.

Bear in mind that corrosive sublimate is an extremely dangerous poison.

Tree sticky.—Commercial tanglefoot has long been known as a valuable tree-banding material. Its effectiveness can be greatly increased by the addition of sulphur.[3]

To 6 parts by weight of tree sticky (homemade or commercial) add 1 part of flowers of sulphur, mixing thoroughly. Apply in a band about 6 inches wide and one-fourth inch thick to a broader band of canvas soaked in paraffin. Applied directly to the trunk the mixture may cause injury. Bands so made and applied have remained effective on trees at Mayaguez for 6 months.

Homemade tree sticky.—A very good substitute for the commercial preparation can be made by boiling for half an hour 1 pint of linseed oil and 2 pounds of rosin.

LIME.

As protection against slugs ("lapas"), air-slaked lime should be thoroughly dusted or scattered on the soil for a distance of several inches around the plant, or in the case of garden beds the whole bed should be thoroughly dusted with lime.

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[1] Snyder, T. E. U. S. Dept. Agr. Bul. 333 (1916), p. 29.
[2] Horton, J. R. Mo. Bul. Com. Hort. Cal., 5 (1916), No. 11, pp. 419–421.
[3] Horton, J. R. Loc. cit., p. 426.

Air-slaked lime as seed preservative.—A simple and promising treatment to prevent weevil injury to peas, beans, and cowpeas has been recently discovered by Z. P. Metcalf, of the North Carolina Station.[1] The treatment has also given good results with corn in Porto Rico. Use 1 part by weight of air-slaked lime to 2 parts of the seeds. For small amounts of seeds (a half peck or less) 4 parts of lime to 1 of seeds are recommended; for amounts up to 3 bushels, equal amounts of lime and seed. This treatment does not injure the seeds either for eating or for planting.

FLY REPELLENTS.

The horn fly is a great pest in the drier parts of the island. The applications of repellents in the case of dairy cattle will in some cases prove practicable.

Fish oil is one of the best repellents, either alone or in combination with other substances.[2] Heavy applications of fish oil should be avoided, as they make the hair sticky and cause it to fall out. The use of oils on cattle is not wholly desirable in a hot climate, due to their heating action. Cattle treated with oils should at least not be driven hard and should be well watered. The best fly repellents are effective for only a few days.

Formulas for the preparation of fly repellents given by H. W. Graybill,[2] are presented below.

The following mixture (the Moore formula) is effective for about three days:

	Parts.
Fish oil	100
Oil of tar	50
Crude carbolic acid	1

Light applications should be made with a brush, as heavy applications with a spray pump may result in serious injury.

The following (Jensen) formula is said to be effective for a week:

Laundry soap	pound	1
Water	gallons	4
Crude petroleum	gallon	1
Powdered naphthalin	ounces	4

Dissolve the soap in the water over a fire; dissolve the naphthalin in the oil; mix the two solutions and churn vigorously for 15 minutes. Apply lightly with a brush.

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[1] Jour. Econ. Ent., 10 (1917), No. 1, pp. 74–78.
[2] U. S. Dept. Agr. Bul. 131 (1914).

A formula used to prevent the attraction of the screw-worm fly to wounds is the following by Jensen:

Coal tar	ounces	12
Carbon disulphid	do	4

Mix the materials thoroughly, keep in a well-stoppered bottle, and apply with a brush.

Another formula, much used for wounds in the Southern States, calls for—

Oil of turpentine	dram	1
Phenol	do	1
Cottonseed oil to make	ounces	4

Mix and apply freely to wounds.

NAPHTHALIN AND CAMPHOR.

Naphthalin is repellent to certain insects and will keep moths out of clothing. Camphor, cedar, and tarred paper are also useful against moths, but are much less powerful.

FUMIGANTS.

The principle of fumigation is of great value, for gas or vapor will penetrate where no spray can. Its effective use is confined to reasonably tight places.

CARBON DISULPHID.[1]

Carbon disulphid (carbon bisulphid and "high life" are other common names) is a colorless or yellowish liquid giving off a gas heavier than air. The pure liquid is completely volatile and does not stain or injure the finest fabrics or foodstuffs. "The ordinary commercial article, however, has a decidedly yellowish color, due to the excess of sulphur, and a decidedly unpleasant odor, due to the hydrogen sulphid contained in it. The commercial article, therefore, should not be poured directly upon goods that would show stains, or upon food materials, although the vapor from it will not do them harm." The germination of seed is not lowered by treatment with carbon disulphid if dry when treated and well aired afterwards.

The liquid itself is not explosive and can be safely handled if in tight containers. The vapor, however, is highly inflammable and explosive when mixed with air in certain proportions. "*There must therefore be no smoking or carrying around of lights where carbon*

[1] Hinds, W. E. U. S. Dept. Agr., Farmers' Bul. 799 (1917).

*disulphid vapor is strong, and it is hardly safe * * * to turn on or off an electric light or fan. * * ** Carbon disulphid should not be applied to corn in the bin or to other grain when the mass is known to be in process of heating spontaneously."

The amount of carbon disulphid necessary for fumigation varies with the tightness of the fumigating room or bin, ranging from 1 to 2 pounds per 100 cubic feet. The latter strength is required in rooms only ordinarily tight. Fumigate for 12 to 24 hours. The liquid should be poured into shallow jars set on top of the goods to be fumigated, as the gas diffuses downward. The most important use for carbon disulphid as an insecticide is in the fumigation of stored grains.

Leguminous seeds can be fumigated in an air-tight barrel, using about one-half cupful per barrel, covering the top tightly with a wet blanket or several thicknesses of wrapping paper. Fumigated grain should be well aired before storing.

Colonies of ants can be destroyed by sprinkling the nest with 1 to 3 ounces of carbon disulphid, setting an inverted tub over them, and continuing the fumigation for five or six hours.

A few ounces of carbon disulphid poured down a crab hole will kill the occupant. Close the mouth of the hole to serve as an indication if the crab survives and digs its way to the surface.

Clothes and household goods can be fumigated for clothes moths and other pests by placing in a barrel or box and applying one-half cupful of carbon disulphid. If the box or barrel is tight the goods can be safely left there in storage.

Carbon disulphid retails in Porto Rico at about 25 cents a pound.

CARBON TETRACHLORID.

Carbon tetrachlorid is an excellent substitute for carbon disulphid and has the advantage of being nonexplosive. It is not so active as carbon disulphid and twice the amount recommended for the disulphid must be used.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas, besides being perhaps the most active fumigant, is also one of the most dangerous and deadly poisons to man. Its application in houses should not be attempted unless the operator is thoroughly acquainted with every step in its use and awake to every precaution that should be observed. It should never be used for fumigating any part of an inhabited house, unless the entire building can be vacated for one or two days to insure thorough airing.

The gas is produced by combining potassium cyanid or sodium cyanid with sulphuric acid and water in earthern crocks of generous

size. Pour the necessary amount of water into the crock, then add the acid. Considerable heat will be evolved; therefore never pour the water into the acid, or painful acid burns may result from spattering of the materials. Place the proper amount of the cyanid in a loose paper, drop the package into the crock and at once leave the room, closing it up air-tight. *Never on any account tarry in a room after the cyanid has been dropped into the acid.* In fumigating large rooms the cyanid can be dropped into several jars simultaneously by means of a string operated through the keyhole. After fumigation is over, the windows should be opened from the outside and the rooms allowed to air thoroughly. For fumigating houses the usual dosage is 1 ounce of potassium cyanid for each 100 cubic feet of space. This amount should be doubled for poorly constructed houses. Fumigate for 12 hours, at least, and 24 if possible. All liquid or moist foods should be removed before fumigation.

Young plants can be fumigated by using 0.02 gram of potassium-cyanid per cubic foot, keeping the fumigating chamber closed for 40 minutes to 1 hour. To obtain the number of ounces required divide the number of grams required by 28.35.

If potassium cyanid is used it should be of 98 to 99 per cent purity and always in the proportion:

Potassium cyanid	ounce	1
Sulphuric acid	fluid ounce	1
Water	fluid ounces	3

Sodium cyanid produces about one-third more gas than potassium cyanid does, so that the amount of sodium salt required is only two-thirds of the amount of potassium cyanid called for. Always use the sodium salt in the proportion:[1]

Sodium cyanid	ounce	1
Sulphuric acid	fluid ounces	1½
Water	do	2

The sulphuric acid should test 66° Baumé, which is about 93 per cent pure.

The residue after fumigating with hydrocyanic acid should always be disposed of by burying deeply in the soil.

A solution of potassium cyanid is often effective against ants. Dissolve 1 ounce in 1 gallon of water and apply freely to each nest.

SULPHUR FUMES.

The fumes of burning sulphur (consisting mainly of sulphur dioxid) are a standard remedy for bedbugs in empty buildings and barracks. Burn sulphur in a fireproof vessel placed within a still

[1] Essig, E. O. Injurious and beneficial insects. Mo. Bul. Com. Hort. Cal., 4 (1915), No. 4, Sup. p. 491.

larger vessel, at the rate of 2 pounds to 1,000 cubic feet, and continue the fumigation for 24 hours. It should be borne in mind that the fumes injure vegetation, destroy the viability of seeds, bleach fabrics, and tarnish metal work.

HEAT AS A MEANS OF KILLING INSECTS.

Heating is a simple and practical way of killing insects infesting foodstuffs. Adults, larvæ, and eggs of grain-infesting insects are killed by exposure to a temperature of about 125° F. for any length of time.[1] Bulky packages should be exposed to the heat for an hour or two to insure perfect penetration. Flour heated in this way is in no way injured for use. Grain intended for planting should not be heated above 130° F. An oven and a thermometer will make this method of insect control a practical one in any home.

THE COMPATIBILITY OF INSECTICIDES AND FUNGICIDES.

The expense of applying sprays can often be reduced by combining two or more spray materials intended for different purposes and applying them together. The following table adapted from Gray[2] will show at a glance which of the standard insecticides and fungicides can be combined together without danger of injury to the plants, and which can not:

Compatibility table—insecticides and fungicides.

	Fungicides.			Contact insecticides.			Alkalis.	Acids.
	Bordeaux.	Lime-sulphur.	Iron sulphid	Tobacco.	Soaps.	Emulsions.		
Stomach poisons (arsenical):								
Paris green	A–1	D	A–1	?	D	D	D	D
Calciun arsenite	A	D	A	A	D	D	D	D
Lead arsenate (acid)	A–1	?	A–1	A	D	D	D	C
Lead arsenate (neutral)	A	B	A	A	A	A	A	D
Zinc arsenite	?	D	A–1	A	D	D	D	D
Contact insecticides:								
Lime-sulphur	?	.....	.....	A	C	D	C	C
Emulsions	?	D	C	A–1	A	.....	D	D
Soaps	A–1 or B	C	C	A	.....	A	A	C
Tobacco	C or D	A	A	.....	A	A–1	A or B	A
Acids	D	C	D	.....	.....	.....	C	.....
Alkalis	B	C	D	.....	.....	.....	.....	.....

KEY TO CLASSIFICATION.

A–1 = Better results by mixing } Compatible.
A = Properties not changed by mixing }
B = Efficient, noninjurious }
C = Inefficient, noninjurious } Incompatible, chemically.
D = Dangerous mixtures }

[1] Dean, G. A. Jour. Econ. Ent., 4 (1911), pp. 142–161; 6 (1913), pp. 40–55.
[2] Gray, G. P. Mo. Bul. Com. Hort. Cal., 3 (1914), No. 7, p. 266.

METHODS AND FORMULAS USED IN PLANT DISEASE CONTROL.[1]

GENERAL METHODS.

It will simplify the work in combating disease if the planter will bear in mind that the plant, like the animal organism, is usually less susceptible to disease when it is in vigorous growing condition. Notable exceptions or apparent exceptions to this are smut of corn and scab of citrus. The majority of the fungus pests are weaker parasites such as the withertip fungus (Colletotrichum) of citrus and the Cercospora leaf-spot fungus of coffee. Hence the methods of cultivation, drainage, fertilization, and general good farming practice will tend to decrease the amount of disease in the resulting crop.

Seed selection.—The value of the selection of healthy seed is widely recognized but unfortunately is frequently disregarded. The bean seed so much in demand at present is a carrier for two of the worst diseases affecting this crop, namely, anthracnose (Colletotrichum) and blight (Bacterium). The removal of all shrivelled and discolored seed would greatly reduce the damage caused by these and other diseases.

Many of the cane planters year after year plant seed taken in cartloads from the fields, little or no attention being given to the removal of diseased or poorly developed canes. This practice obviously multiplies the opportunities for the spread of disease. Similar conditions are equally apparent in the planting of other crops. The systematic selection of seed has long since become a part of the regular farm routine in other countries. As the agriculture of the island becomes more intensive this practice can not be neglected.

Removal of diseased material.—Disease is often carried over from some of the principal crops grown in Porto Rico, it should be practiced whenever possible not only to prevent the accumulation of disease, but to maintain the vigor of the plant and the fertility of the soil as well. The climate of the island, with its even temperature and abundant rains, is especially favorable to the rapid accumulation of fungi with a crop which is grown successively on the same land year after year.

Removal of diseased material.—Disease is often carried over from one planting season to another on the unused vines, leaves, and other plant parts. For this reason it often becomes necessary to collect and burn this refuse, which would otherwise add valuable humus to the soil.

In many crops a very marked difference is seen in the susceptibility of individual plants to disease. This condition is frequently found

[1] Much of the data in this paper comes directly or indirectly from the literature cited. Acknowledgment is made herewith of the material thus obtained which is not referred to directly.

in the case of the citrus scab. Highly susceptible plants become troublesome sources of infection for the surrounding plants. In a similar manner disease is often harbored by weeds or other plants which grow in such profusion along fences, windbreaks, and in like situations.

The cutting out of affected parts is of prime importance in combating those diseases which produce cankers of the branch and trunk. Each cankered branch may produce myriads of spores which, when borne by wind or water to other parts, are capable of setting up new infections. The larger wounds produced by pruning should be protected from wood-rotting fungi by some antiseptic covering such as white lead or tar. This subject is treated at length in a recent Circular of the Insular Experiment Station of Porto Rico.[1]

Resistant varieties.—Probably the most promising single measure for control of plant diseases is the breeding (which includes selection) of plants resistant to disease. While much of this work can more profitably be done by specialists, the planter can in most crops reduce or eliminate disease by continually selecting seed from the most desirable variety or individual within the variety.

Soil sterilization.—The complete sterilization of soil in a practical way is not possible with the present methods, except in small areas such as seed beds and greenhouse benches. Formalin is frequently used for this purpose. It is diluted about 1:150 in water and applied at the rate of ½ to 1 gallon of liquid to 1 square foot of surface, depending on the depth of soil. The soil should be covered with paper or other material for a day or two and then aired for several days before planting.

Small quantities of soil may be conveniently sterilized in pots or tins placed on a stove or in an oven. Excess of dry heat should be avoided since it changes the physical and chemical composition of the soil.

The most satisfactory method in use at present for soil sterilization is the application of steam under pressure. The necessary equipment consists of a small boiler and a shallow metal pan connected by hose to the boiler. The pan is inverted and driven into the loosened soil and the steam is forced into it until the pressure reaches 80 to 100 pounds. This pressure should be maintained for one hour. Instead of the pan a system of perforated pipes may be thrust into the soil or permanently buried in it if the bed is to be used year after year. Steaming kills fungi, weed seeds, and insects alike, and does the work more thoroughly than the usual chemical applications.

In treatments for the nematode, probably the most troublesome soil organism in Porto Rico, complete sterilization is extremely difficult. In addition to the above measures the application of potash

[1] Stevenson, J. A. Porto Rico Insular Sta. Circ. 10 (1917).

and nitrogenous fertilizers and the growth of immune crops, such as velvet beans, have some value.[1]

Quicklime is frequently applied to the soil as a means of partial sterilization. It has been used against the root disease of sugar cane with good results.[2] For this disease the lime should be applied during the rainy season at the rate of ½ to ¾ pound per stool, covering about 1 square foot around each stool. The value of this application depends for the most part on the caustic action of the unslaked lime; hence only quicklime should be used.

Thorough cultivation of the soil will not only reduce the fungi but will stimulate the plant to greater resistance to the fungi which remain. Wide planting and the reduction in number of shade trees, whenever possible, will retard the development of fungi both in the soil and on the plant above ground.

FUNGICIDES.

Corrosive sublimate.—This substance dissolved 1 part in 1,000 parts of water is one of the best general disinfectants. It is an easily available material for treatment of tools when pruning diseased wood. It is also convenient and effective for use against organisms borne on the surface of seed. A good example of this type is the organism (*Bacterium campestre*) causing black rot of cabbage, a very serious disease in this island and elsewhere. Care must be exercised with this treatment as some seeds are injured by soaking in corrosive sublimate solution. A few minutes' treatment is usually sufficient.

Carbolic acid.—Crude carbolic acid and water are used in varying proportions, as 1 to 3, or in equal parts, as a wash for wounds caused by foot rot or mal di gomma in citrus. In the treatment of this disease the kind of disinfectant is less important than proper drainage and the removal of soil and dead wood from the crown of the diseased tree.

Lime.—When applied as a spray, lime has comparatively small fungicidal value. In combination, however, it is used widely to neutralize the acid elements of other spray materials. When applied to the soil lime not only acts as a direct fungicide, as in the treatment of root disease of cane with quicklime, but it produces a reaction in the soil which retards the development of many fungi.

Sulphur.—Sulphur in dry form has long been used to combat certain superficial mildews such as are frequently seen in Porto Rico on beans and other garden crops. At this station equal parts of sulphur and lime have been used for powdery mildew of beans (Erysiphe) with good results. Dry sulphur in various combinations is coming into prominence for the treatment of some fruit diseases in

[1] Bessey, E. A. U. S. Dept. Agr., Bur. Plant Indus. Bul. 217 (1911).

[2] Cobb, N. A. Hawaiian Sugar Planters' Sta., Div. Path. and Phys. Bul. 5 (1906), pp. 75–81.

the Northern States. As a treatment for citrus scab, it has given little promise in tests made in Porto Rico.

Lime sulphur.—Directions for preparing and diluting this solution are given in the first part of this circular. Lime sulphur has replaced Bordeaux mixture in some instances as a fungicide, principally for the reason that it is both fungicide and insecticide. It is not, however, as active a fungicide as Bordeaux mixture. At present, the principal use of this solution in Porto Rico is in conjunction with Bordeaux mixture in the control of citrus scab. The control of this disease by lime-sulphur solution alone, as reported elsewhere,[1] has not proven satisfactory in Porto Rico, where the disease is unusually severe. This material, in the applications toward the end of the spraying program, is of value in preventing the too rapid increase of scale insects.

Copper sulphate.—Copper-sulphate solution, 2 to 4 pounds in 50 gallons of water, is one of the best washes for trunks of trees, trellises, etc., for removing lichens and mosses. At this station it has been applied at the rate of 3 pounds to 50 gallons of water to trunks, branches, and leaves of young grapefruit trees with no apparent injury except on very young leaves. However, considerable care should be exercised in applying this solution to trees with new growth. It should also be borne in mind that the action of copper sulphate would be similar to that of Bordeaux mixture in the reduction of the beneficial entomogenous fungi.

Ammoniacal copper carbonate.—This solution is frequently used to replace Bordeaux mixture toward the close of the fruit-growing season in order to avoid the spotting produced by the latter. The following is a good formula[2] for the preparation of the carbonate:

Copper carbonate	ounces	6
Ammonia	pints	3
Water	gallons	50

Make the carbonate into a thin paste with 1½ pints of water and then add the ammonia slowly. This should produce a clear blue solution. When all the copper carbonate is dissolved add water to make 50 gallons. The copper carbonate may be bought at drug stores or prepared as follows: Dissolve 10 pounds of copper sulphate and 12 pounds of sodium carbonate each in 10 gallons of water. When the solutions are cool, pour the solution of sodium carbonate slowly into the copper sulphate solution, stirring the mixture meanwhile. Allow the mixture to settle 12 to 24 hours, pour off the liquid, and add an equal amount of water to the remaining precipitate. Stir up the precipitate and allow it to settle as before. Repeat this once or

[1] Fawcett, H. S. California Sta. Bul. 262 (1915), p. 178.
[2] Stevens, F. L., and Hall, J. G. Diseases of Economic Plants. New York, 1910, p. 33.

twice and dry the blue precipitate. This is the copper carbonate. Home preparation greatly reduces the cost of this material.

Bordeaux mixture.—A good general formula for Bordeaux mixture is:

Copper sulphate	pounds	4
Quicklime	do	5
Water	gallons	50

The chemicals are used in amounts varying from 2 to 6 pounds of each. The method of preparation usually recommended is as follows: Dissolve the copper sulphate in 25 gallons of water in a wooden vessel. The action can be hastened by suspending the material in a bag in the upper part of the liquid. Add to the lime just enough water to cause slaking and when the slaking is complete add water to make 25 gallons. Pour the two solutions together and stir well. The solution should be applied within a few hours. It may be kept without deteriorating for some time by the addition of cane sugar at the rate of ½ pound to 50 gallons of solution.[1]

This solution mixes[2] well with arsenate of lead but should not be used with kerosene or tobacco extract.

Bordeaux mixture may be obtained in powder or paste form on the market. The powder is not recommended. The paste form, although expensive, may be used to advantage when only a small amount of spraying is to be done.

The use of this mixture on citrus is sometimes discouraged for the reason that it destroys the entomogenous fungi and results in an increase of scale insects. The condition may be avoided by timely application of paraffin-oil emulsion or lime-sulphur solution. In spraying for scab (Cladosporium) on citrus the Bordeaux mixture should be applied only to the new growth, thus allowing the beneficial fungi to retain a foothold on the trunk and larger branches.

PLANT QUARANTINE.

Porto Rico is particularly fortunate in that a number of the most serious diseases of leading tropical plants have not up to the present time been found in the island. Among these diseases are citrus canker (Pseudomonas), coconut bud rot (Bacillus), anthracnose (Calospora) of vanilla, and leaf spot (Hemileia) of coffee. The importance of keeping the island free from these diseases can not be overemphasized. Each of the above diseases has threatened in other countries to wipe out the industry affected by it. Assistance may be obtained from the experiment stations at Rio Piedras and Mayaguez in handling any suspicious cases of disease in the above or other crops.

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[1] Lutman, B. F. Vermont Sta. Bul. 196 (1916), p. 15.

[2] See table first part of this circular on Compatibility of spray materials (p. 23).

MISCELLANEOUS PESTS.

BOOK PROTECTION.

Books in Porto Rico often have irregular areas eaten off the covers by book lice and cockroaches which are attracted by the starch with which the books are pasted. Protection lasting for from several months to a year or more, depending on the amount of handling the books receive, can be obtained by painting the back and covers inside and out with the following solution:[1]

Corrosive sublimate	ounce	1
Carbolic acid	do	1
Alcohol	quart	1

The books should not be handled until they are thoroughly dry.

BAITS FOR CRABS.

Phosphorus and corn meal mixtures are commonly used in Porto Rico for combating crabs. These mixtures should contain only 1 to 3 per cent of phosphorus as higher percentages are apt to cause spontaneous fires which may be destructive to buildings or standing crops.

Stir a stick of phosphorus into a 5-gallon can half full of corn meal and water. Bring the mixture to a boil over a fire and stir constantly until the phosphorus is entirely mixed. With enough water added to prevent undue smoldering, the mixture is ready for use. It is preferable to introduce it into crabholes rather than to leave it exposed where poultry or other animals might find it.

RAT POISONS.

The following information regarding rat poisons[2] may be found useful:

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate. This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible they usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in rat runs, about a teaspoonful at a place. If a single

[1] Ballou, H. A. Imp. Dept. Agr. West Indies Pamphlet 71 (1912), p. 167.
[2] Lantz, David E. U. S. Dept. Agr., Farmers' Bul. 896 (1917), p. 16.