U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

IMPORTANT INSECTICIDES.

DIRECTIONS FOR THEIR PREPARATION AND USE.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., June 20, 1894.

SIR: I have the honor to transmit herewith, for publication as a Farmers' Bulletin, a condensed account of the more important insecticides for farm and garden use, prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. Circular No. 1, new series, of this division, and Farmers' Bulletin No. 7 contained information of this character, but these documents are out of print and since they were published some advance has been made in the matter of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of this bulletin in large edition.

Respectfully,

L. O. HOWARD,
Entomologist.

HON. J. STERLING MORTON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Throwing aside, for the present purpose, the innumerable special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

BITING INSECTS.

Under this head comes the injury resulting from the actual consumption by the mastication and swallowing of the solid substance of some portion of the plant, as the wood, bark, leaves, flowers, or fruit. This is done by the biting or gnawing insects, such as various larvæ and certain beetles and locusts, causing an injury at once apparent and readily observed and understood.

For all these insects poisons such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked and which will be swallowed by the insect with its food, furnish the surest and simplest remedy. A direct poison should, therefore, be employed for all biting insects which feed externally, except where the parts attacked are themselves to be shortly used for the food of other animals or of man.

SUCKING INSECTS.

Under the second head is grouped the injury due to the gradual extraction or absorption of the juices of the plant, either from the bark, leaves, or fruit by such sucking insects as plant-bugs, plant-lice, scale-insects, Thrips, and also plant-feeding mites, as the red spider. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

It is evident that for this class of injury the application of external poisons, which penetrate little, if at all, into the plant cells, will be of trifling value, and, in fact, for all these insects it is necessary to use substances which will act externally on the bodies of the insects, either as a caustic or to smother or stifle them by closing their breathing pores or to fill the air about them with poisonous fumes. Of value also are deterrent or obnoxious substances which repel the insects. In the cases also, referred to above, where it is not desirable to use poisons for the biting insects, the use of caustic or smothering washes is always advisable.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portions or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root-maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem-borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

In brief, the classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

I. External feeders:
  (*a*) Biting insects.
  (*b*) Sucking insects.
II. Internal feeders.
III. Subterranean insects.
IV. Insects affecting stored products.
V. Household pests.
VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

The arsenical compounds have supplanted all other substances for the insects falling under this heading. Two compounds are in common use, viz, Paris green and London purple.* The use of powdered white arsenic is not recommended, on account of its great liability to scald foliage and on account of its color to be mistaken for harmless substances. Of the two first mentioned Paris green is the stronger insecticide, acting quickly, and is less liable to burn foliage. London purple has the advantage of cheapness, and, being more finely powdered, is kept more easily suspended in water. The former can be had in 14-pound or larger cans at 20 cents per pound, and the latter at 10 cents per pound by the barrel.

HOW TO APPLY ARSENICALS.

For all ordinary cases, the use of these poisons in water in the form of a spray is advisable. In the cotton fields of the South, where prompt and economical action against the cotton worm is essential, the dry application of these poisons is more popular. The latter form of treatment is feasible also for low-growing crops, such as the potato, but can not be employed in the case of orchard and shade trees, and is less satisfactory than the use in a spray, in being wasteful, in lacking uniformity, and in being more apt to injure foliage. The cheapness and rapidity of the dry method gives it a value, however, against the cotton worm, and the usual mode of application is as follows:

The dry method.—A pole 5 to 8 feet long, and about 2 inches in diameter with a three-fourths inch hole bored through it within 6 inches of either end is used. To each end is securely tacked a bag of "8-oz. osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that

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* A third arsenical which promises well, arsenate of lead, has lately been experimented with by the Gypsy Moth Commission. While not urging that this insecticide has advantages over Paris green, it is held that it has the merit of showing on the leaves, indicating at once which have been sprayed, remains much more easily suspended in water, and may be used in large proportions without danger to foliage. It has recently been extensively tested at the Department, and a strength as great as 1 pound to 2 gallons of water has been used on tender foliage of the peach and Osage orange without injury. Good results have attended its use also against the imported elm leaf-beetle. The insecticide results were not better, however, than with Paris green; but for such sensitive foliage as that of the peach, or where no risk of scalding may be taken, I am inclined to believe that it will prove useful.

This insecticide is prepared by combining, approximately, 3 parts of arsenate of soda with 7 parts of acetate of lead. These substances unite chemically and form a fine, white powder which remains easily in suspension. As now used by the commission, 10 pounds of the arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause the insecticide to adhere longer to the leaves. Prof. Fernald's experience and our own would indicate that from one-fourth to one-half this strength will answer for most larvæ—the larvæ of the gypsy moth proving to be unusually resistant to the action of poisons. The arsenate of lead costs the commission 7 cents a pound wholesale, and glucose $16 a barrel.

the powdered poison can be introduced into the bag with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried, on horse or mule back, through the cotton fields, dusting 2 or 4 rows at once. The shaking induced by the motions of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in the early morning or late evening when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains will necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the larger machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres can be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from $30 to $60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this, or similar means from bags, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime; and for application to vegetables which may soon be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or lime, and dusted merely enough to show evenly over the surface.

The wet methods.—Either Paris green or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The greater dilutions are for the tender foliage of the peach, and an average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water, and a more than equal weight of powdered lime added to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees, Paris green may be applied

at the strength of 1 pound to 150 gallons of water without danger; with London purple it is always better to use the lime.

If it is desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture* may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic, and makes it an excellent medium for the arsenical.

TIME TO SPRAY.

For the codling moth, the apple and pear should receive the first application as soon as the blossoms fall, which is also the time for the treatment of the scab fungus; the second spraying should be given one or two weeks later, just before the fruit turns down on the stem or when it is from one-fourth to one-half inch in diameter. The first spraying reaches the eggs laid by the moth in the flower end of the fruit about the time of the falling of the blossoms, and the second the later egg-laying by the more belated moths, and when the first coating of poison will probably have been washed off by rains. The young larva, eating its way from without into the fruit gets enough of the poison to destroy it. This treatment reaches, at the same time, a large number of leaf-feeding enemies of these fruit trees.

For the Curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made: the first before the trees bloom or as soon as the foliage is well started; the second at the time of the exposure of the young fruit by the falling of the blossoms, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent Curculio instead of the young larvæ which, hatching from eggs placed beneath the skin of the fruit are not affected by the poison on the outside. The adult Curculio, however, as soon as it comes from its winter hibernation feeds on the foliage before the trees bloom, and later on the young fruit also and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general such as the potato-beetles and larvæ, blister-beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury. Fruit trees should never be sprayed when in bloom on account of the liability of poisoning honey bees or other insects useful as cross-fertilizers.

*The Bordeaux mixture is made by combining 6 pounds of copper sulphate and 4 pounds of quick lime, with water to make 50 gallons. The copper sulphate is dissolved in water (hot, if prompt action is desired) and diluted to about 25 gallons. The fresh lime is slaked in water, diluted to 25 gallons, and strained into the copper solution, after which the whole is thoroughly stirred with a paddle. Both the copper and the lime mixtures may be kept in strong solution as stock mixtures, but when combined should be promptly used, as the Bordeaux mixture deteriorates on standing.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous, and should be so labeled. If ordinary precautions are taken there is no danger to man or team attending their application, and the wetting of either, which can not always be avoided, is not at all dangerous on account of the great dilution of the mixture, and no ill results whatever have resulted from this source.

The poison disappears from the plants almost completely within 20 to 25 days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

Two classes of insecticides have proven themselves far superior to all others for this group of insects, viz, (1) the kerosene emulsions and resin washes, and (2) the gas treatment. The simpler remedies, such as soap and lye washes, tobacco decoction, etc., need no special explanation. The Pyrethrum powders, Persian insect powder, and Buhach are effective, but too expensive for any but limited applications or indoor use.

THE KEROSENE WASHES.

Pure kerosene is very destructive to p[illegible]e, but diluted it may be safely applied, and the emulsions made by combining it with either soap or milk are so far the most satisfactory means of diluting it discovered.

The kerosene and soap emulsion.—This is made after the following formula:

Kerosene	gallons	2
Soap	pound	½
Water	gallon	1

The soap, first finely divided, is dissolved in the water by boiling, and then added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After about five minutes' pumping, the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk, and assumed the consistency of cream. It should adhere to glass without oiliness. Well made, the emulsion will keep indefinitely, or may be diluted for immediate application.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions or where the water is very hard some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before using, such water should be broken with lye, or rain water used, but better than either, use the milk emulsion, with which the character of the water whether hard or soft does not affect the result.

The kerosene and milk emulsion.—The formula is as follows:

Kerosene	gallons.. 2
Milk (sour)	gallon... 1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsion.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same with the addition of 1 ounce of powdered sulphur to the gallon; for scale-insects, the larger plant-bugs, larvæ, and beetles, dilute with 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees, in the dormant and leafless condition, to destroy scale-insects, stronger mixtures may be used even to the pure emulsion, which may be applied with brush or sponge. This latter is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the 9-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should usually be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger wash.

Pure kerosene.—The pure oil may be applied as a winter wash to the older parts of plants either in a spray or with a sponge, using the least possible quantity. Its use is not advised except in exceptionally bad

cases of infestation and during the dormant period, and should never be attempted after the first sign of spring growth appears.

In many cases plant-bugs and beetles may be jarred into cloths saturated with kerosene or into pans with water and oil and destroyed, where it would be unsafe or inadvisable to spray the plants themselves.

As a remedy against the mosquito, kerosene has proven very effective (Howard). It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water, and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of one ounce to 15 square feet of water surface, and forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

THE RESIN WASHES.

These washes have proved of greatest value, particularly against red scale (*Aspidiotus aurantii*) in California, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale-insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the northern States, the quicker-acting and stronger kerosene washes are preferable. The resin washes act by contact, having a certain caustic effect, but principally by forming an impervious coating over the scale-insects, thereby smothering them. The application may be more liberal than with the kerosene washes, the object being to thoroughly wet the bark.

The wash is made as follows:

Resin	pounds..	20
Caustic soda	do....	5
Fish oil	pints..	2½
Water to make	gallons..	100

The ordinary commercial resin is used and the caustic soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories. These substances should be finely broken up to hasten action and placed, with the oil, in a large kettle with sufficient water to cover them. Boiling should be continued for one or two hours with occasional additions of cold water, or until the compound will mix perfectly in water instead of breaking up into yellowish flakes. The undiluted wash is pale yellow; intermixed with water it becomes dark reddish-brown. It may be kept in concentrated form and diluted as required.

A stronger wash is necessary for the more resistant San José scale (*Aspidiotus perniciosus*), and for this the dilution should be one-third less or to 66⅔ gallons instead of 100. This stronger mixture is a winter wash, and is only to be applied during the dormant period; in the growing season it will cause the loss of foliage and fruit.

MEANS OF APPLYING THE FOREGOING INSECTICIDES.

For the dry use of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about $2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a strong force pump, one-half inch cloth-reinforced hose, and a suitable spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of small plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about $14 and the latter from $6 to $9.

Ready fitted pumps, knapsack and others, for the application of insecticides are now made by all the leading pump manufacturers of this country and also large reservoirs with pump attached for extended orchard operations, the cost of these latter ranging from $25 to $75. This outlay may be greatly reduced by the purchase of a strong pump with nozzle and hose, all costing from $15 to $20, and, combining it with a strong tank of 150 or more gallons' capacity, to be mounted on a wagon or cart or mounting the pump on the end of a strong barrel.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this end in view, and the use of such is recommended.

In spraying the object is to coat every leaf and part of the plant as lightly as feasible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

THE GAS TREATMENT.

The hydrocyanic acid gas treatment of scale-infested trees has hitherto been exclusively confined to California, but recently has been introduced in the East by the Department to combat the San José scale. Briefly it consists in inclosing the tree with a tent and filling the lat-

ter with the poisonous fumes generated with potassium cyanide and sulphuric acid.

The outfit.—The tents are made of blue or brown drilling or 8-ounce duck and painted, or oiled with linseed oil, to make them as near air-tight as possible. They are placed over the trees by hand or with poles in case of small trees, but with trees over 10 feet high some sort of a tripod or derrick is used. The outfit for medium-sized trees—tent and derrick—will cost from $15 to $25. A tent for trees 26 feet tall by 60 feet in circumference costs as much as $60.

The chemicals.—Commercial fused potassium cyanide (costing in bulk 40 cents per pound), commercial sulphuric acid (at 3½ cents per pound), and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of the acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed.

The method.—The generator, which may be any glazed earthenware vessel of 1 or 2 gallons' capacity, is placed within the tent under the tree and the water, acid and cyanide, the latter broken up, put in in the order named, after which the operator withdraws from the tent. The tent is allowed to remain on the tree for one-half hour for large trees or fifteen minutes for small ones. The treatment is best made on cloudy days, early in the morning, late in the evening, or at night. Bright, hot sunlight is liable to cause injury to the foliage, which, however, may be largely avoided by using tents of dark material or painted black.

Three or four men can operate six tents at once, and the expense under such conditions, not counting the cost of the outfit, need not be more than 10 cents per tree.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wire-worms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash, the former preferable, the potash fertilizers, muriate and kainit, and bisulphide of carbon. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proven of the greatest service against the phylloxera.

Kerosene emulsion and resin wash.—Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil

about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant, and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring when the more frequent rains will take the place of the waterings.

For root maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably following after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

Potash fertilizers.—For white grubs, wire-worms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either the kainit or muriate of potash, the former better, are broadcasted in fertilizing quantities, preferable before or during a rain so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and stronger resistant power of the plant, which latter of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wire-worms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple work the fertilizers into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for winter hibernation or to undergo transformation.

Bisulphide of carbon.—This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide and closing the hole with the foot. These injections are made about 1½ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors

and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

For root maggots a teaspoonful is poured into a hole at the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed, or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

Submersion.—This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced, otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which at this season are very susceptible to the action of water.

To facilitate the operation vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the walls being protected by coverings of reed grass, etc., during the first year, or until they can be seeded to some forage plant.

This treatment will reach other root-attacking insects or those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such

as the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitation or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual however, is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisuphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover the top with a blanket to prevent the too rapid dissipation of the vapor.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphide should be first distributed in the lower story, working upwards to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight chest or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling grain than that intended for seeding, since used excessively it is liable to injure the germ. It must always be remembered that the vapor is highly inflammable and explosive and that no fire should be in the building or lighted cigars, etc., during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable to their multiplication than to destroy them after they are once in possession; and in controlling them methods and systems of farm and orchard culture have long been recognized as of the greatest value—more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them in a measure distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land, year after year to the same staple, is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the ene-

mies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice, it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop, spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from $1 to $2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at $2,500. The saving to the plum crop, and other small fruits, frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured. An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats was made to alternate with corn, the owner of a large farm in Indiana made a

saving of $10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm, was estimated to be injured to the extent of $30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit or a loss in agricultural operations.