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×GARDEN AND SMALL-FRUIT INSECTS
WITH NOTES ON SPRAYING IN GENERAL*

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Economic Zoology

GENERAL PRINCIPLES OF INSECT CONTROL

It is well said that it may cost us more to feed our insect enemies than it does to clothe, feed, and educate our children. Much of this great loss may be reduced by studying conditions and applying remedial measures. Spraying is one of the remedial measures, but it must not, by any means, be considered the "cure-all."

It is safe to say that the garden receiving the most careful cultivation and care will usually suffer the least from insect injury. Frequent cultivation, weeding, and watering when necessary, will tend to keep the plants growing rapidly and make them more resistant to the attacks of both insects and diseases. Destroying weeds, removing rubbish, and otherwise cleaning up will destroy the breeding and hiding places of many pests. When it is possible changing the location of a vegetable garden from year to year will help to control the ravages of certain insects.

These good cultural methods are of primary importance, but there are some insect pests which are injurious even when the best cultural methods are practiced. These must be controlled by artificial means. Leaf feeding forms may be controlled by spraying, the stalk borers may best be destroyed by pruning and burning infested shoots, and subterranean insects may be held in check by special methods of culture, soil fumigation, or poisoned baits.

There are three points to be considered in spraying:

1. The materials used;
2. The machinery and accessories necessary to properly place the mixture where it will be most effective;
3. The proper time to make the spraying applications.

MATERIALS

Spraying materials are of three kinds. One kind is used against insects that chew their food; another, against those that receive their nourishment through a sucking tube, or beak; and the third, against plant diseases. The first is called an internal, or stomach insecticide; the second, a contact insecticide; and the one that acts against plant diseases is known as a fungicide.

* Published as State Entomologist's Circulars 47, 48, 49, and 50.

Stomach Insecticides

Stomach insecticides containing arsenic should not be used on lettuce, cabbage, or other vegetables or fruits when nearly ready for use.

Arsenate of lead.—Arsenate of lead is probably one of the best stomach insecticides yet discovered. Of the ordinary prepared paste found on the market, use 3 pounds to 50 gallons of water; of the commercial powdered form, use 1½ pounds to 50 gallons of water. It may be combined with either of the fungicides, bordeaux mixture or lime-sulphur.

Paris green.—Paris green is another standard stomach insecticide, and is usually used at the rate of 1 pound to 50 gallons of liquid. As it contains a high percentage of arsenic soluble in water, it often burns tender foliage. It may be combined with bordeaux mixture, but never with lime-sulphur.

Hellebore.—Hellebore is the ground roots of a plant. It is not so poisonous as the arsenical materials, but is of value in spraying or dusting fruits or vegetables which are nearly ready for use. As a dust, it may be used in the pure form.

Poison baits.—Stomach insecticides in the form of baits are often attractive to insects.

The formula for an attractive bait for the cabbage and radish maggot adult is: ¾ ounce lead arsenate, ½ pint molasses, 1 gallon water. This is sprinkled on the plants during the first three weeks in May for the first generation, and during the first three weeks in July for the second generation. If rains wash the mixture off, the sprinkling must be repeated.

The formula for cutworm bait is: 10 pounds bran, 1 pound white arsenic, sweetened with 1 quart molasses. Water is added to make a wet but not sloppy mash. Apply in the evening along infested rows of plants.

Freshly cut clover dipped in a mixture of paris green and water is also effective for cutworms.

Slices of potato dusted with paris green and distributed about beds in greenhouses are attractive to sow-bugs.

Contact Insecticides

Soap solution.—An excellent contact spray for soft-bodied insects like plant lice is soap solution. It is made by dissolving 1 pound of whale oil or laundry soap in 15 gallons of water.

Tobacco extracts.—Several commercial products made from tobacco are effective contact insecticides. These products, like Nicoticide, Nicofume, and Black Leaf, contain from 20 to 45 per cent of nicotine in different forms. When put up by reliable firms, the percentage given on the container may be depended on. The dilution necessary for spraying varies with the percentage of nicotine in the compound. If 40 per cent nicotine, use ½ pint in 50 gallons of water. These make excellent sprays for plant lice on leaves or stems of plants. In the commercial product Black Leaf 40, the nicotine is in the form of nicotine sulphate. In Nicofume, the nicotine is in the free state and readily evaporates. Hence, the latter is the only form to use against plant lice on such leaf plants as lettuce. The insecticidal value is increased if a small quantity of dissolved soap at the rate of 1 pound to 50 gallons is added.

Lime-sulphur.—Commercial lime-sulphur diluted with 8 or 9 parts water makes the best scale insecticide yet discovered. Unfortunately this can be used only when the trees are dormant, otherwise the leaves would be destroyed.

A Promising New Contact Insecticide

Mr. Moore, of the Division of Entomology and Economic Zoology, has perfected a new contact insecticide, called Nicotine Oleate, based upon recent experiments. Experiments have shown this material to be more effective as a contact insecticide than any of the commercial tobacco compounds now on the market. It can easily be made at home by using a combination of *free* nicotine extract like Nicofume with commercial oleic acid often called "red oil." Two and a half parts of a 40 per cent free nicotine solution thoroly mixed with $1\frac{3}{4}$ parts of "red oil" will unite to form this material. One-third of a pint of Nicotine Oleate is sufficient for 50 gallons of spray. The Nicotine Oleate will cost not more than a dollar for a hundred gallons of spray, while the free nicotine spray used at the same strength will cost \$2.20. **In all sprays where this material is used the water must be soft, rain water or distilled water.**

Nicotine oleate emulsions.—Nicotine Oleate alone is more effective than the nicotine extracts now on the market, but it can be made still more effective by emulsifying an oil with it. These emulsions may not be desirable when the trees are in foliage. An emulsion can be made as follows: 10 parts of an oil, such as cottonseed or kerosene, mixed with $1\frac{3}{4}$ parts of "red oil" to which is then added $2\frac{1}{2}$ parts of 40 per cent free nicotine solution. Shake thoroly. Then add ten parts more of water, shaking again. For mealy bug, white fly, and soft scale, dilute with soft water to make 500 parts.

A patent for these compounds has been applied for. They may be made by any one for his own use, but must not be sold.

Fungicides

Bordeaux mixture.—Bordeaux mixture is a fungicide used to a large extent in orcharding and potato-growing. One formula is: 4 pounds copper sulphate (blue vitriol), 4 pounds good stone lime, 50 gallons water. Dissolve each in 25 gallons of water; then pour the two together into a 50-gallon barrel, stirring thoroly. Some leaves, like those of the plum, are very tender and only 3 pounds of the blue vitriol should be used in the formula. Dissolve the copper sulphate in a burlap sack suspended just beneath the surface of the water. The container must be of wood, never of iron.

Lime-sulphur.—Lime-sulphur is both an insecticide and a fungicide. It was first used as a sheep-dip, and then came into use as a scale insecticide. Many different formulas for its manufacture have been suggested, but there are two that stand out prominently—the self-boiled and the concentrated. The self-boiled is a homemade product, and is primarily a fungicide. It is used when trees are in foliage. The following is the formula: 8 pounds good stone lime, 8 pounds flowers of sulphur, 50 gallons water.

Put lime and sulphur together in a barrel and add cold water to slake the lime. Stir thoroly, adding enough water to prevent burning, but not enough to "drown" the lime. When slaking has stopped, add enough water to make 50 gallons and strain through a fine mesh to work out all the lumps. All the lime should be worked through the strainer. The process usually requires from five to fifteen minutes. This mixture can be applied immediately to trees in foliage.

The concentrated lime-sulphur is both an insecticide and a fungicide. At the rate of 1 gallon to 9 gallons of water, it is used only when the trees are dormant, at that time killing principally the scale insects. At the rate of 1 gallon to 40 gallons of water, it is a fungicide and can be combined with arse-

nate of lead and sprayed when trees are in foliage. The following is the formula, altho it is usually much better to buy the commercial product on account of its constant chemical properties: 40 pounds fresh unslaked lime, 90 per cent pure; 80 pounds sulphur, thoroly and finely pulverized; water to make 50 gallons. After proper mixing, this must boil from forty-five to fifty minutes.

DILUTIONS FOR CONCENTRATED LIME-SULPHUR

Baumé reading	Water required for one gallon of lime-sulphur	
	Dormant spray	Summer spray for apples and plums
Degrees	Gallons	Gallons
35	9	45
34	8 $\frac{3}{4}$	43 $\frac{1}{4}$
33	8 $\frac{1}{4}$	41 $\frac{1}{2}$
32	8	40
31	7 $\frac{1}{2}$	37 $\frac{3}{4}$
30	7 $\frac{1}{4}$	36 $\frac{1}{4}$
29	6 $\frac{3}{4}$	34 $\frac{1}{4}$
28	6 $\frac{1}{2}$	32 $\frac{3}{4}$
27	6	31
26	5 $\frac{3}{4}$	29 $\frac{1}{2}$
25	5 $\frac{1}{4}$	27 $\frac{3}{4}$
24	5	26
23	4 $\frac{1}{2}$	24 $\frac{1}{4}$
22	4 $\frac{1}{4}$	22 $\frac{3}{4}$
21	3 $\frac{3}{4}$	21 $\frac{1}{4}$
20	3 $\frac{1}{2}$	19 $\frac{3}{4}$

Resin-bordeaux mixture.—A resin mixture makes bordeaux mixture or other spray compound stick better to a smooth surface, such as that of raspberry canes, when spraying for anthracnose. The mixture is made as follows: 5 pounds pulverized resin, 1 pound concentrated lye, 1 pint fish oil (or other animal oil), 5 gallons water.

Put the oil, resin, and 1 gallon of hot water in an iron kettle and heat until the resin softens. Then add the lye and stir thoroly. Add 4 gallons of hot water and boil until a little will mix with cold water, giving a clear amber-colored liquid. If any water is lost in boiling, add enough to bring the total back to 5 gallons and keep as stock.

In using this in bordeaux mixture, dilute 2 gallons of this resin stock with water to make 10 gallons, and add to 40 gallons of bordeaux mixture, made according to the formula given.

Combined insecticide and fungicide.—Several insecticides can be combined with a fungicide, so that in one spraying, insects as well as diseases may be killed. Insecticides containing arsenic, such as paris green and arsenate of lead, are particularly adaptable to this combination, the amount of arsenical poison recommended being used in the fungicide at the rate given for its use with water. The following combinations are recommended: Arsenate of lead, 3 pounds of paste or 1 $\frac{1}{2}$ of powder, or paris green, 1 pound, with 50 gallons of bordeaux mixture; arsenate of lead, 3 pounds of paste or 1 $\frac{1}{2}$ pounds of powder with 50 gallons lime-sulphur. Never use paris green with lime-sulphur.

How to Spray

The method of applying the spray is often just as important as the nature of the material used. Spray thoroly, giving special attention to the hardest places to reach. See that every surface, the bottom of every crack, and the space behind the buds is wet with the spray. This can be done only by using high pressure and good nozzles. For all orchard spraying run the pump at not less than 150 pounds pressure; 200 pounds may be preferable.

Price of Spray Materials

The following may be considered fair prices for insecticides and fungicides, for 1918. Paris green is very scarce and may not be available later in the season.

Material	In large quantities	In small quantities
Arsenate of lead (paste).....	25 cents per pound	35 cents per pound
Arsenate of lead (powder).....	45 cents per pound	60 cents per pound
Black Leaf 40 (nicotine sulphate) and Nicofume	\$10.50 per gallon	20 cents per ¼ pt.
Copper sulphate (blue vitrol).....	12 cents per pound by the barrel	15 cents per pound
Dust mixtures—15 per cent arsenate of lead; 50 per cent superfine sulphur; 35 per cent bolted lime	\$9.50 per 100 in carload lots	\$10.50 for 100 lbs.
Dust mixtures—15 per cent arsenate of lead; 85 per cent superfine sulphur		
Dusting sulphur alone.....	\$3.75 per 100-pound sack	
Lime-sulphur	21 cents per gallon by the barrel	45 cents per gallon
Paris green.....	48 cents per pound	60 cents per pound

Dust Sprays

If not convenient to use wet sprays, dry insecticides are often used with good results. It is well known that paris green or powdered arsenate of lead dusted on plants kills biting insects. In the last few years experiments have been conducted with dusts having a combined insecticidal and fungicidal value. Apparently some good results have been obtained. It can safely be said, however, that up to this time no material that can be put on in the dust form is as good a fungicide as the liquid bordeaux mixture or lime-sulphur.

In dusting it is necessary to procure the materials in as finely ground form as possible and many firms are now putting on the market poisons that are adapted for this purpose. When the insecticide is used alone, it is often wise and economical to mix it with a carrier of 5 to 10 parts of air-slaked lime or other cheap neutral substance.

MACHINERY AND ACCESSORIES

In Minnesota, April is the month to prepare for spraying. The spraying apparatus should be taken from storage and the necessary repairs made. Fittings should be gone over carefully and the parts which need oiling should be well cleaned and then oiled. The hose should be tested and clamps and connections examined thoroly for leaks. If the nozzles were not put away carefully last summer they should be overhauled and freed from all dirt or rust particles. The pressure tank should be very carefully cleaned as it may contain much

residue from last year's spraying. In spraying with even the simplest spray pump, there is no satisfaction so great as that of knowing that your spray material is being put on the trees with the greatest efficiency possible for the sprayer used.

For those who have not yet purchased a spraying machine, the illustrations here given may be of value.

A bucket pump is always a handy sprayer. One should be purchased that is "double acting," that is, should pump when the handle is pulled up as well as when pushed down.

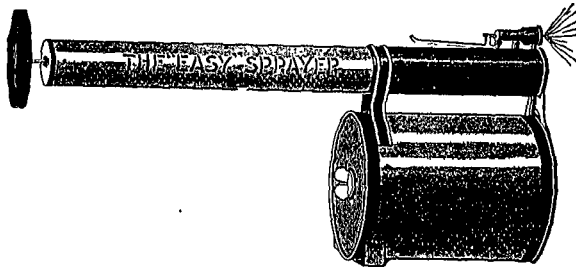


Fig. 1. Small Compressed Air Sprayer

This small sprayer can be used on house plants or on small plants and shrubs in the garden. The capacity is one gallon. The cost is from \$2 to \$3.



Fig. 2. Bucket Pump

Small trees and garden plants can be sprayed efficiently with this sprayer. The objection to it in spraying large areas is the difficulty of carrying and refilling the bucket and the need of stopping to stir the mixture. The cost is about \$5.



Fig. 3. Compressed Air Sprayer

As a rule the compressed air sprayers are not very satisfactory when an arsenical insecticide or bordeaux mixture is used. If care is used, small trees and garden plants can be sprayed fairly well with this sprayer. The cost is from \$5.75 to \$7.50.

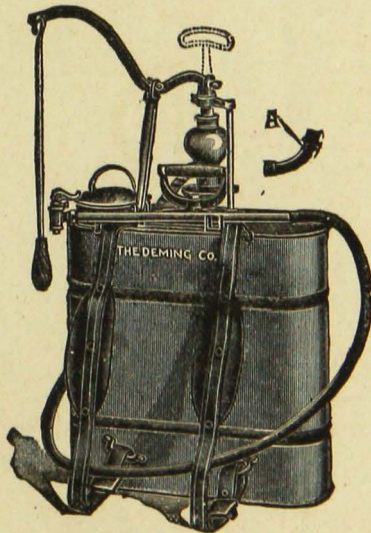


Fig. 4. Knapsack Sprayer

These sprayers are very good for spraying small gardens. While pumping, the mixture in the tank is agitated mechanically. The cost is from \$10 to \$18.

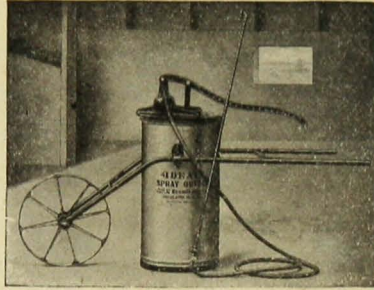


Fig. 5. Wheelbarrow Sprayer

This outfit is light and easy to work. The tank holds fifteen gallons and therefore can be operated over a larger area than the preceding sprayers. Trees of good size can be sprayed with this outfit as well as garden plants over an acre or more. The cost is about \$20.

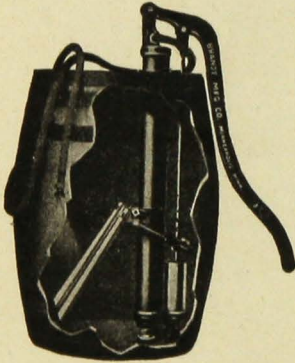


Fig. 6. Barrel Pump, Upright

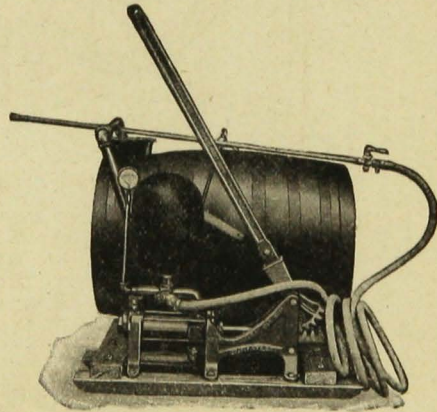


Fig. 7. Barrel Pump, Horizontal

One of these barrel pumps is needed by anyone having an orchard more than an acre and a half in extent. The barrels hold fifty gallons of spray material and with these properly mounted on low-bodied wagons or stone boats a small orchard can be sprayed very efficiently. Of the two, the horizontal type is preferred, because the pump works easier and 150 pounds pressure can be maintained without trouble. The cost is from \$15 to \$35.

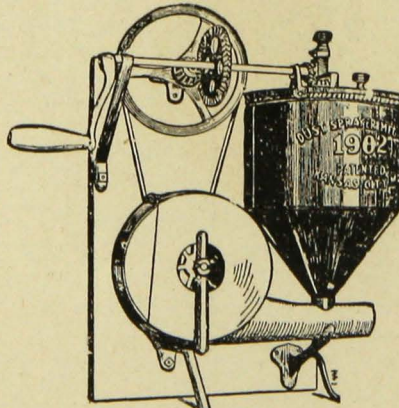


Fig. 8. Portable Dusting Machine

The cost is about \$15.

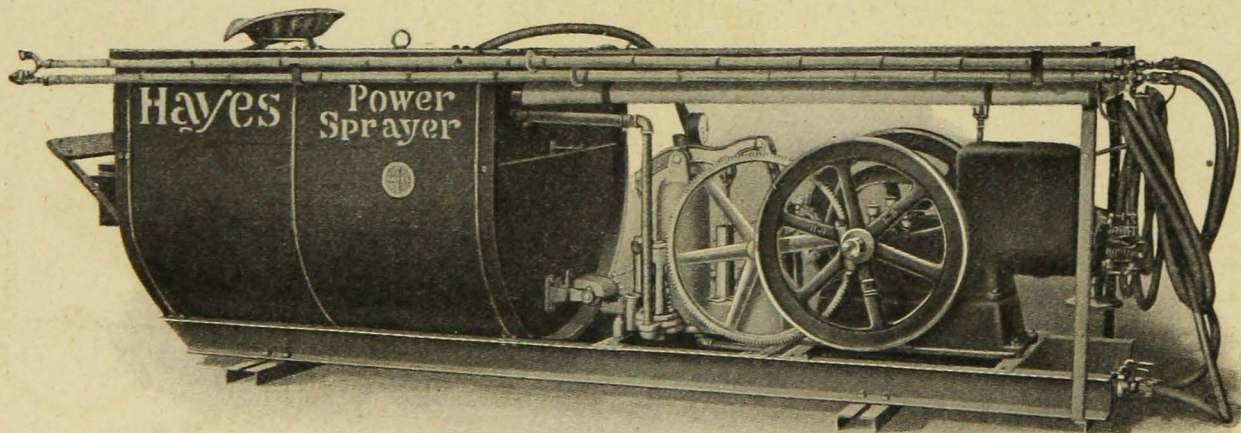


Fig. 9. Small Power Sprayer

This represents the type of a power sprayer that solves the labor problem of spraying. One man can run the machine and spray more trees in a day than two men with an ordinary barrel outfit and at the same time know that the pressure at the nozzle is uniform throughout the operation. The cost is \$240 and up.

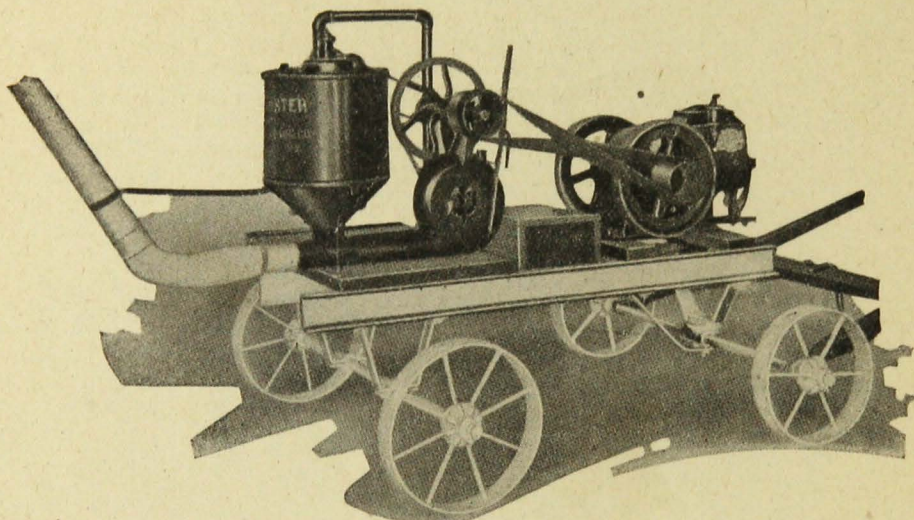


Fig. 10. Power Dusting Outfit

The price is about \$160.

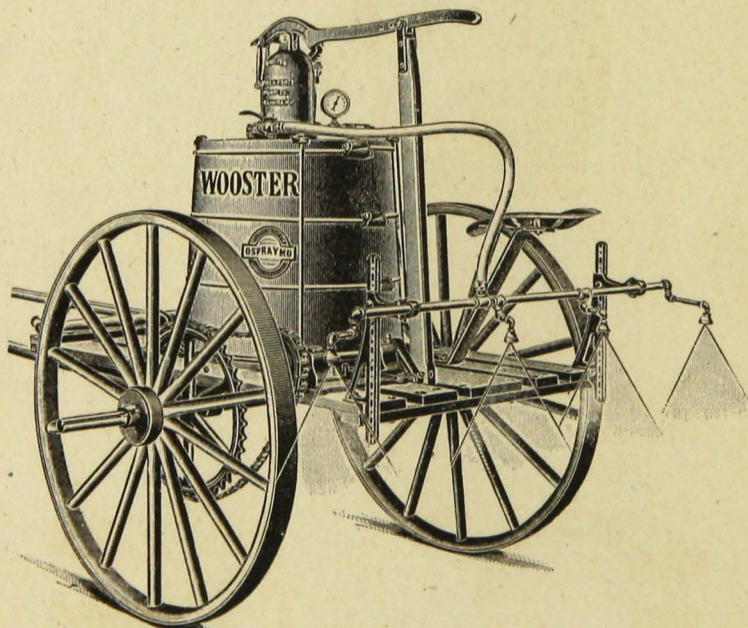


Fig. 11. Potato Sprayer

This machine runs automatically, but can be worked by hand. It has automatic agitator and brushes for stirring liquid and keeping suction strainers clean. It holds 100 gallons. The cost is about \$80.

Nozzles

We recommend, for all sprayers larger than the knapsack, the purchase of large nozzles giving a spray of the inverted cone shape, and especially those that are perfectly plain, as shown in Figure 12. The nozzle should be at an angle of forty-five degrees from the line of the spray rod so that by turning the rod the twigs or leaves can be sprayed from all sides. In all of our orchard spraying work we prefer to have two nozzles attached to one pole by means of a "Y." The 45-degree angle may be either in the "Y" itself or in the nozzle.

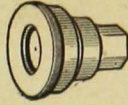


Fig. 12. A Good Type of Nozzle



Fig. 13. A Straight "Y"

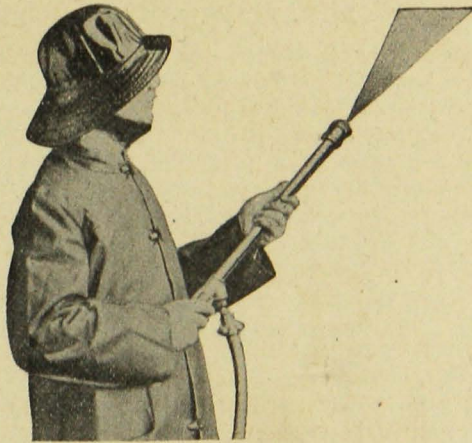


Fig. 14. New "Fog" Nozzle

Within the last two or three years a spray gun has been developed which will eventually displace the long spray rod with its smaller nozzle. By a turn of the handle, it will deliver the full capacity of the machine or any part thereof. These are made now by several firms and cost from \$12 to \$18 each.

Couplings, Clamps, and Hose

The hose couplings should be long enough that the hose may be attached by two clamps instead of one, or for one long clamp like the "Stayon." Very convenient and satisfactory clamps are shown in the illustrations.

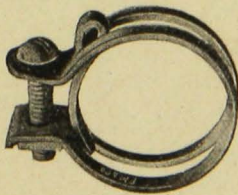


Fig. 15

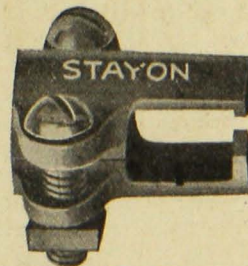


Fig. 16

Good Types of Clamps

The hose should be of the best. When high pressure is used, even the best is none too good. A 5- or 7-ply hose is usually satisfactory. Good spray hose costs from .25 to 30 cents a foot and should last at least two seasons.



Fig. 17. High Pressure Coupling

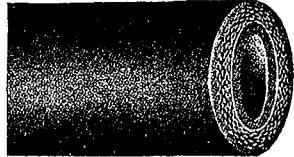


Fig. 18. Hose for Spraying

Names of firms selling spraying machinery may be obtained from the State Entomologist, University Farm, St. Paul.

POTATO INSECTS¹

The commonest and most generally known insect attacking the potato is the Colorado potato beetle. Altho in many sections this is apparently the most injurious insect attacking the crop, it is by no means the only one. The potato is subject to the attack of insects from the time of planting until it is served on the table. The seed pieces when planted are sometimes injured by the burrowing larvae of a fly and are often attacked and partially or wholly destroyed by wireworms, cutworms, or white grubs. The young plants are often attacked and destroyed by cutworms and the leaves are injured by Colorado potato beetles, blister beetles, flea beetles, leaf-hoppers, plant bugs, aphids, and several others of lesser importance. Fly, moth, and beetle larvae often are found boring in the stalk. The roots and ripening tubers are injured by flea beetles, wireworms, and white grubs, and finally the tubers in storage are sometimes injured by fly larvae, wireworms, or other tuber-feeding insects brought in from the field. Approximately one hundred species of insects are known to attack the potato in one stage or another, but fortunately a large proportion of them are not sufficiently numerous or destructive to be of primary importance. Pests attacking the upper parts of the plants are most commonly observed, but those attacking the underground parts are often as injurious and are much more difficult to control.

COLORADO POTATO BEETLE

Leptinotarsa decemlineata Say

Order—Coleoptera Family—Chrysomelidae

The Colorado potato beetle is frequently and improperly called the "potato bug." The adult beetle is about two-fifths of an inch long and a little more than half as broad. The wing covers are marked with ten longitudinal black stripes on a yellowish brown background and the thorax is somewhat spotted with black. The larvae are red soft-bodied creatures with black heads and a double row of black spots along the sides, and are often called "slugs."

Life History

The winter is passed in the adult stage in the ground. About the time the potatoes are up these adults make their appearance and, after feeding for some

¹For potato diseases see Agr. Exp. Sta. Bull. 158, Potato diseases and their control, by E. C. Stakman and A. G. Tolaas.

time upon the leaves and stems, lay their yellow or orange eggs in clusters of from ten to fifty on the under side of the leaves. In from four to eight days these eggs hatch and the larvae feed on the leaves and grow rapidly. In from nine days to two weeks they reach their full growth, leave the plants, and go into the soil for the pupal or resting stage, which lasts from ten days to two weeks. Following the pupal stage they transform to the adult stage and again appear on the potatoes. The fecundity of the beetle is high, single females being known to lay from 1,500 to 4,000 eggs during a period of two months, so the importance of controlling the first brood is evident. In Minnesota there are two generations each season.



Fig. 19. Colorado Potato Beetle and Larvae Feeding (From Chittenden.)

Natural Enemies

The Colorado potato beetle is subject to the attacks of several natural enemies, but in most seasons these are not in sufficient numbers to hold the beetles in check. The most important of these enemies are the ladybird beetles and the larvae of the lacewing flies which attack the potato beetle eggs and "slugs." A few wild birds destroy the larvae of the potato beetle, the rose-breasted grosbeak being the species most commonly observed. Some domestic fowls, particularly the guinea, turkey, and duck, when allowed to run in the potato fields, are valuable in cleaning the plants of "bugs."

Control

The most certain method of controlling the potato beetle, and the one usually depended on in potato-growing sections, is the treating of the plants with an arsenical spray. Bordeaux mixture, as a fungicide, is frequently mixed with the arsenical spray. The material which has been most commonly used in the past is paris green, which is an effective poison for the beetle when used at the rate of 1 pound to 50 gallons of water or bordeaux mixture. For

the first spraying one pound should cover about one acre. Arsenate of lead is not so strong a poison as paris green, but owing to its sticking power it has been recommended and has proved satisfactory when used at the rate of from $1\frac{1}{2}$ to 2 pounds of the powder to 50 gallons of water. The secret of success in using arsenate of lead against the potato beetle is to get the material on the vines early, since the young "slugs" are much more susceptible to poisons than those which are fully grown. Put on the first spray as soon as the eggs begin to hatch and repeat as often as necessary.

THE POTATO FLEA BEETLE

Epitrix cucumeris Harr.

Order—Coleoptera Family—Chrysomelidae

Altho the potato flea beetle has been an important pest in the eastern states for many years, it has been practically unknown in Minnesota until recently.

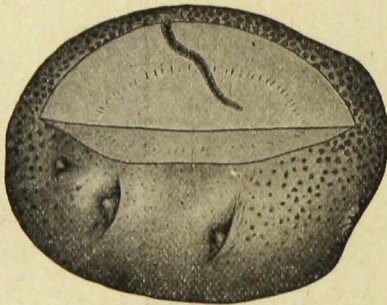


Fig. 20. Tuber Injured by Larvae of Potato Flea Beetle (From Webster.)



Fig. 21. Adult Potato Flea Beetle Enlarged 24 Times (From Webster.)



Fig. 22. Larva of Potato Flea Beetle Enlarged 20 Times (From Webster.)

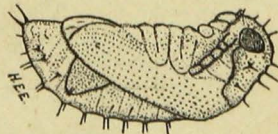


Fig. 23. Pupa of Potato Flea Beetle Enlarged 30 Times (From Webster.)

Last summer this insect was responsible for considerable injury in limited areas, but it bids fair to establish itself and become one of the pests which must be fought each year.

The beetles are about one-twelfth of an inch in length, black, somewhat hairy, and have the hind legs well developed for jumping. It is this habit of leaping away when disturbed that gives the insect its common name.

Life History

Flea beetles pass the winter in the adult stage, hidden away beneath leaves or other litter. In the spring the adults leave their hiding places and as soon as the potatoes are up begin to feed upon the leaves, usually from the under side. They eat almost through the leaf from below, leaving the upper epidermis untouched. Later this usually dries and drops out, making a hole through the leaf. This injury to the leaves is usually the first indication of an infestation, since the beetles themselves are seldom noticed.

The eggs are laid singly in the soil and the larvae, which are tiny, elongate, and worm-like in form, attack the roots and finally burrow into the developing tuber, causing pimply potatoes. When full grown the larvae transform to the pupal stage and in midsummer emerge as adults. There is apparently but one generation a year.

Control

The flea beetle is a much more difficult insect to control than the Colorado potato beetle owing not only to the fact that it is resistant to poisons, but also to the habit of feeding on the lower surface of the leaves, making it difficult to put the poison on the foliage where it will be eaten. So far as our knowledge goes, good results cannot be expected from stomach poisons.

The material which has given the best results in the eastern states is bordeaux mixture, which has a repellent effect upon the beetle. When the plants were well covered by the spray the results were very satisfactory, but when the material was applied unevenly and the under sides of the leaves were not sprayed, little deterrent effect was noticeable. Bordeaux mixture has given very imperfect control of the flea beetle in Minnesota, owing perhaps to the fact that the type of sprayer commonly used in this state sprays the plants only from above. If the nozzles were so arranged as to drive the spray in from the sides, much better results could be obtained in the control of both insects and diseases. Such machines are on the market but are seldom seen in this state.

THE APPLE LEAF-HOPPER

Empoasca mali Le Baron

Order—Hemiptera Family—Jassidae

The apple leaf-hopper is usually considered a pest of apples, but it also attacks many field and truck crops and is particularly injurious to potatoes. The leaf-hoppers are sucking insects, i.e., they do not eat the leaves, as do

Colorado potato beetles, but feed on the juices of the plant by inserting their probosces into the tissues of the leaf or stem and sucking the sap. The evidences of injury are usually slight, and consist of a curling of the injured leaves and more or less dwarfing of the plant except in dry seasons, when the tips are often killed. The real injury is the reduction of the crop due to the stunting of the plants caused by the loss of sap.

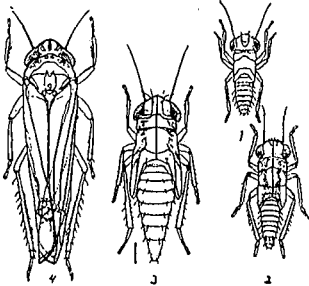


Fig. 24. Leaf Hopper, Adult and Nymphs (From Washburn.)

The adult hoppers are small, pale green insects, about one-eighth of an inch long. The wings fold over the back like the sides of a tent. The nymphs, or immature forms, are wingless. Both the nymphs and adults are very active and jump or fly away quickly when disturbed, the adults being much more active than the nymphs.

Life History

Leaf-hoppers usually pass the winter in the adult stage, hidden beneath leaves or other trash. They do not usually make their appearance on the pota-



Fig. 25. Injury to
Potato Leaves by Leaf-
Hoppers

toes until late June, when the adults lay eggs in the stems. These eggs hatch and the wingless nymphs suck the juices of the plants and in about a month reach maturity. There are probably only two generations a year, altho there may be a partial third. The hoppers may be found on the potatoes as long as the plants are green in the fall. Two or more other closely related hoppers with slightly different life histories may occur on potatoes with the apple leaf-hopper and complicate control measures.

Control

Like that of the flea beetle, the control of the leaf-hopper is still in the experimental stage, owing largely to the fact that they have only recently come to be regarded as very injurious to potatoes. Their habit of feeding precludes any possibility of success with arsenicals or other stomach poisons and their rapid movements make them difficult to hit with a contact spray. The contact spray, however, is the best measure that can be suggested at present. When the spray is applied at the time most of the hoppers are in the wingless stage, fair results have been obtained. The proper time for spraying will vary with the season, but will usually come about the middle of July. The best material for this spraying is a tobacco extract to which at least 1 pound of soap has been added for every 50 gallons of liquid. A free nicotine extract such as "Nicofume" is better than the extracts such as "Black Leaf 40," containing nicotine sulphate. As these commercial tobacco extracts are standardized, they are much to be preferred to the home-made products. The usual dilution for a 40 per cent nicotine extract is $\frac{1}{2}$ pint to 50 gallons of water, to which at least 1 pound of soap has been added. Soft liquid or fish oil soaps are, as a rule, much more effective for this purpose than the hard soaps. These nicotine extracts can be used at double this strength without danger of injury to the plants. Do not mix bordeaux mixture with the nicotine spray or the value of the spray as a contact insecticide will be much reduced. In spraying with a contact insecticide it should be remembered that the insects must be hit by the spray if the treatment is to be successful. Altho widely recommended as a contact insecticide, recent investigations have shown that kerosene is so variable in composition as to make its use undesirable.

THE POTATO APHID

Macrosiphum solanifolii Ashm.

Order—Hemiptera Family—Aphididae

Another insect which in some seasons causes considerable loss to potato growers and every year causes some injury is the potato aphid, or plant louse. The aphids, like the leaf-hoppers, are sucking insects and do not eat the leaves, therefore their injury has an effect upon the plants similar to that caused by the leaf-hopper.

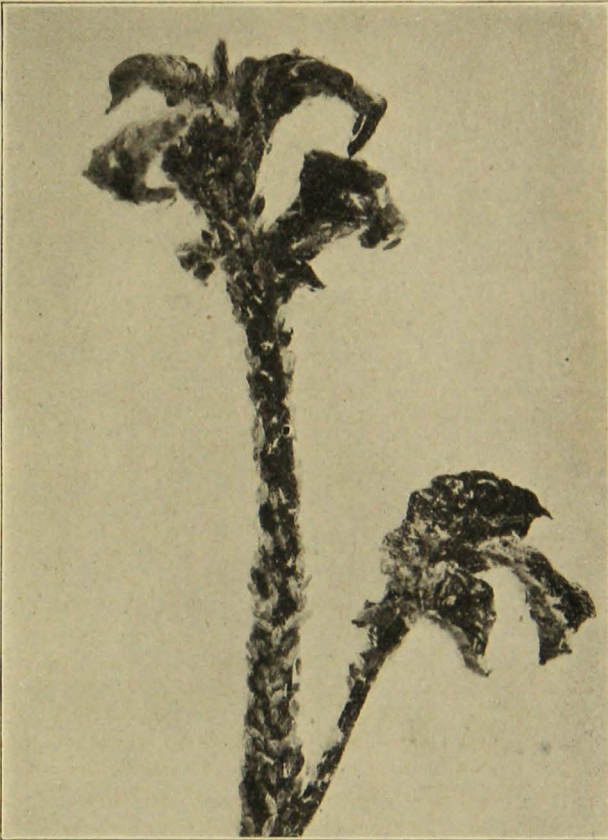


Fig. 26. Potato Shoot Infested With Potato Aphids (From Patch.)

Life History

The potato aphids pass the winter in the egg stage, usually on some plant other than the potato, the rose being a favorite. In the spring the eggs hatch and the young aphids feed and multiply on the plant on which the eggs were laid. In late June or July they migrate to the potato, where they spend the

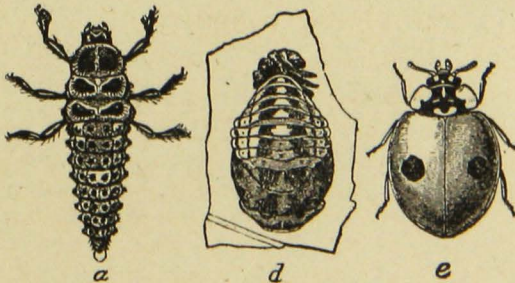


Fig. 27. Ladybird Beetles a. Larva d. Pupa e. Adult (From Riley.)

remainder of the summer. In the fall they scatter to other food plants, altho some will remain on the potatoes as long as the plants are green. On the potato plants the aphids reproduce rapidly, a single female giving birth to more than fifty young in two weeks. The young begin to reproduce two weeks after birth, which explains the sudden appearance of some infestations.

Natural Enemies

It is only the extreme fecundity of the aphids which makes it possible for them to survive the attacks of their enemies and remain a serious pest. They are attacked by the larvae of the ladybird beetles, the syrphids, and the lacewing flies, as well as by several tiny wasp-like parasites.

Control

The Colorado potato beetle, the potato flea beetle, the apple leaf-hopper, and the potato aphid are the most universally injurious potato insects, but occasionally there are outbreaks of other less common pests. These will be briefly discussed and the best methods recommended to date for their control will be given.

OTHER POTATO INSECTS

Frequently the natural enemies of the aphids will keep the pest in check, but this is not always the case. When artificial methods of control are necessary the use of a nicotine and soap spray as mentioned for leaf-hoppers is the best remedy. This material should be applied thoroly so as to hit the aphids. A sprayer which throws the spray in from the sides is much better than a machine which sprays only from above.

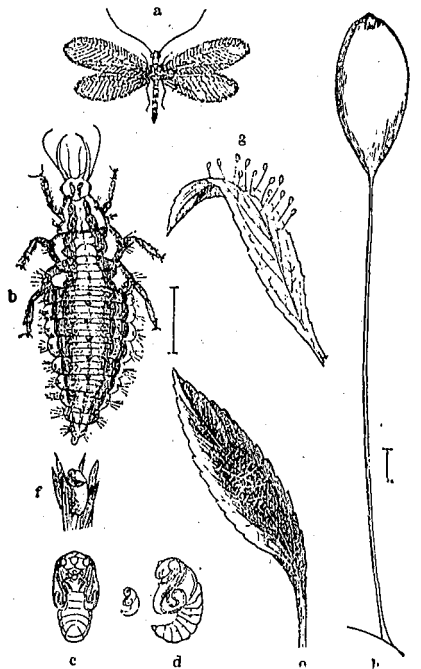


Fig. 28. Lacewing Fly a. Adult b. Larva c. and d. Pupa g. Eggs on Leaf h. Single Egg and Stalk Much Enlarged (From Luggier.)

BLISTER BEETLE OR "OLD FASHIONED POTATO BUG"

Epicauta pennsylvanica DeG.

Occasionally slender gray or black beetles, from one-third to one-half an inch in length, with soft wing covers, will attack and sometimes strip a field of potatoes. These are blister beetles and can be controlled by using arsenate of lead as for the Colorado potato beetles. The larvae of these insects are beneficial, living on the eggs of grasshoppers.



Fig. 29. "Old-Fashioned Potato Bug" or Blister Beetle (From Washburn.)



Fig. 30. Blister Beetle Larva in Grasshopper Egg Capsule (From Washburn.)

PLANT BUGS

Several plant bugs attack and injure the potato by sucking the juices in much the same manner as the leaf-hoppers. If they threaten to become abundant, the application of a tobacco and soap spray, applied when the nymphs are in abundance, should keep them within bounds.

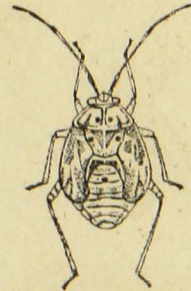
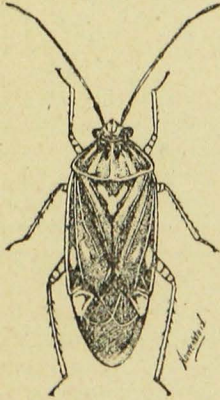


Fig. 31. Tarnished Plant Bug a. Adult b. Nymph (From Luggler.)

CABBAGE LOOPER

Autographa brassicae Riley

Occasionally there is found in potato fields a small green measuring worm which may vary considerably in shade, the darker being usually marked with longitudinal white lines. This is the cabbage looper, and may do considerable damage in unsprayed fields, but can easily be controlled with an arsenical spray.



Fig. 32. Injury to Potato Leaves by Tarnished Plant Bug

STALK BORER

Several insects bore into the potato stalks, injuring or killing the vines. These can only be controlled by cutting out and destroying the infested stalk and by keeping down weeds, particularly ground cherry and burdock, in and around the potato field.

WHITE GRUB

White grubs are the larvae of the May beetles and are among the most injurious of the subterranean insects. They feed upon the roots of grasses and

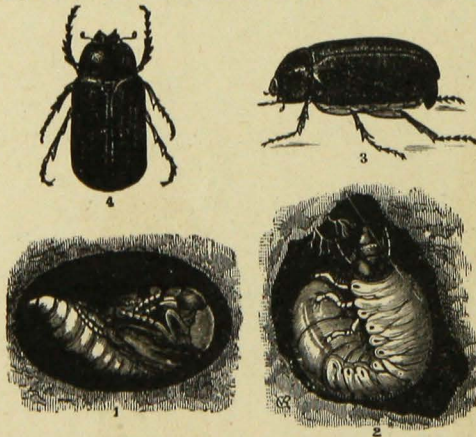


Fig. 33. White Grubs 1. Pupa 2. Larva 3 and 4. Adults (From Riley.)

other plants and frequently attack the roots and tubers of the potato. Since the eggs are usually laid in grass land they are likely to be most injurious when potatoes are planted on sod. In Minnesota the most common white grubs require three years for the completion of their life cycle and as they increase in size their powers of destruction also increase. The adult beetles were out and laying eggs last year (1917) and since the majority of beetles appear in cycles of three years, this season (1918) is a moderately bad white

grub year and next year will probably be still worse, so that potatoes should follow some cultivated crop wherever possible. If it is necessary to plant on sod land, the ground should be plowed and disked in the early fall preceding planting and hogs turned into the field to pick up the grubs.



Fig. 34. White Grub Working in a Potato Tuber (From Davis.)

WIREWORM

Another group of subterranean insects which normally feed on the roots of grasses, but which also attack the potato roots and tubers, is the wireworms. These are the larvae of click beetles and are slender and worm-like in form, with a hard body covering from which the name is derived. The greatest injury caused by this insect is the scarring of the surface and the boring into

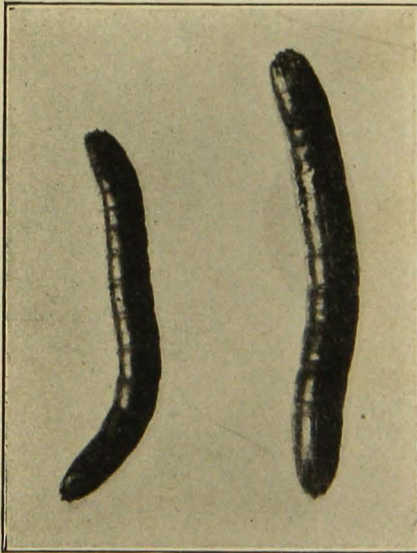


Fig. 35. Wire Worms, Larvae of Click Beetle (From Williamson.)



Fig. 36. Click Beetle, Adult of Wire Worm. (From Forbes.)

the tuber. If potatoes in which wireworms are working are put in the bin, the worms will continue to work through the winter, and going from one potato to another may cause great loss. Do not follow sod with potatoes and do not store potatoes infested with wireworms.

GENERAL RULES FOR SPRAYING POTATOES

1. For leaf-eating insects, use a stomach poison, either paris green or arsenate of lead, the latter being preferable. Poison while the larvae are small.
2. It is advisable to mix the fungicide bordeaux mixture with the arsenical sprays and apply at the same time.

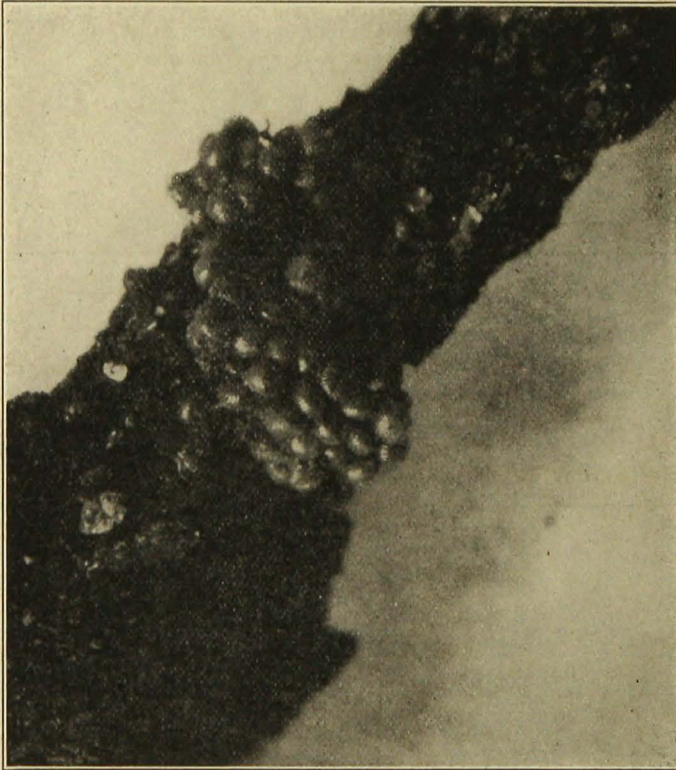


Fig. 37a.



Fig. 37c.



Fig. 37b.



Fig. 37d.

Fig. 37. One of the Stalk Borers a. Eggs b. Adult c. Larva d. Pupa

3. For sucking insects, use a contact insecticide, the best being a commercial nicotine solution to which has been added at least 2 pounds of soap to each 50 gallons of the material diluted for spraying. An extract such as "Nicofume," which contains free nicotine, is better than solutions containing nicotine sulphate, such as "Black Leaf 40." A 40 per cent extract should be diluted at the rate of $\frac{1}{2}$ pint to 50 gallons. The addition of soap is important.

4. Do not mix bordeaux mixture with nicotine sprays as the insecticidal value will be reduced.

5. For leaf-hoppers and plant bugs, spray with nicotine and soap when the nymphs are in the greatest abundance.

6. Apply sprays thoroly to all parts of the vine, particularly where a contact insecticide or a repellent is used. This may necessitate the remodeling of the old spray boom, which can be successfully done for a small outlay, provided the machine has sufficient surplus power to carry the extra nozzles, or it may mean the purchase of a machine with the nozzles so arranged as to drive in the spray from the sides as well as from above.

VEGETABLE GARDEN INSECTS

CUTWORM

Order—Lepidoptera Family—Noctuidae

Cutworms are the larvae, or caterpillars, of certain moths. They normally feed on the roots of grasses, but in the spring they attack a wide variety of garden plants, usually chewing off the stem just above the surface of the ground.

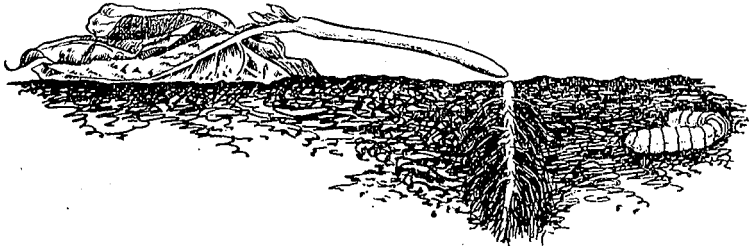


Fig. 38. A Cutworm and Its Work (From Washburn.)

Control

The worms may be killed by a poisoned bran mash which is made by mixing 1 pound of white arsenic with 10 pounds of bran and sweetening with a quart of cheap molasses. The mixture should then be moistened with water until it holds together, but does not drip, and scattered near the infested plants about sundown. After drying out this bait loses its attractiveness.

If only a few plants are to be protected from the worms, collars of heavy paper or other material four inches high and extending one inch below the surface of the ground, may be placed around the plants an inch and a half from the stem and will serve as effective barriers. Hand collecting is sometimes the best method to follow in a very small garden.

WHITE GRUB

See under Potato Insects.

COLORADO POTATO BEETLE

See under Potato Insects.

PLANT LICE OR APHIDS

Order—Hemiptera Suborder—Homoptera Family—Aphididae

Almost every plant in the garden has its own species of aphid, but since the treatment is the same for all they will be considered together. Aphids are small, soft-bodied, green or reddish-brown sucking insects, which feed upon the juices of plants. They are usually found on the under side of the leaves or along the stems. They breed very rapidly and occur frequently in numbers sufficient to stunt or even kill the plant upon which they are feeding.

Control

Aphids may be killed by a contact spray. Soap used at the rate of 1 pound to 15 gallons of water is often sufficient. Do not use "Ivory" soap, as it is not strong enough. The best spray for these insects is a solution of one of the commercial tobacco extracts such as "Nicofume." This can be used at the rate of 1 or 2 tablespoonfuls to a gallon of water. In each gallon of water dissolve about a cubic inch of soap to make the spray stick and spread over the insect. The addition of soap is important. In garden work it is advisable to use a nicotine extract containing *free* nicotine, such as "Nicofume," which evaporates quickly, and not a nicotine sulphate compound such as "Black Leaf 40," as the sulphate remains on the plants for a long time and may make them dangerous for human consumption. Spray for aphids as soon as they appear. Do not wait until the leaves are curled, as it is then hard to reach the insects with a spray.

STRIPED CUCUMBER BEETLE

Diabrotica vittata Fab.

Order—Coleoptera Family—Chrysomelidae

Frequently small yellow and black striped beetles $\frac{3}{16}$ of an inch in length attack the leaves and stems of young cucumber plants, often killing them. These are striped cucumber beetles. The larvae feed upon the tender roots of cucumbers, causing the vines to turn yellow and die.

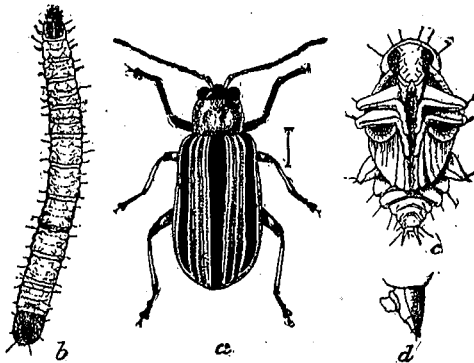


Fig. 39. Striped Cucumber Beetle a. Adult b. Larva c. Pupa
(From Div. of Ent., U. S. Dept. of Agr.)

Control

This insect cannot be successfully controlled by spraying. The best method is to protect the plants with cheesecloth covers supported by a frame of some sort until they are well started. A barrel hoop cut in two and crossed makes a

good frame. The larvae on the roots can be killed by use of a nicotine extract. Mix 2 tablespoonfuls of "Nicofume" in a gallon of water and pour a cupful about the stem of each plant.

CABBAGE WORM

Pontia rapae Sch.

Order—Lepidoptera Family—Pieridae

The green cabbage worms are the larvae of the white cabbage butterfly. These insects feed upon cabbage and other related plants, often making them inedible.

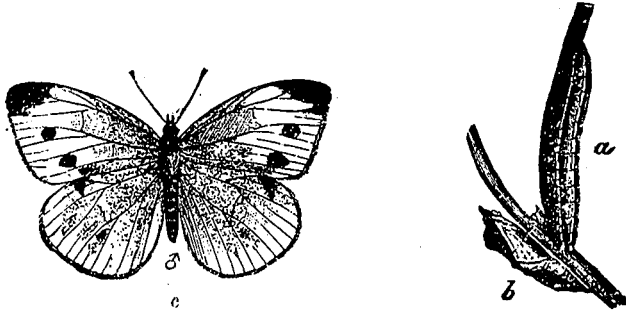


Fig. 40. Cabbage Butterfly and Cabbage Worm (From Riley.)

Control

Arsenate of lead powder dusted or sprayed on the plants as recommended for the Colorado potato beetle is effective against the cabbage worm.

CABBAGE MAGGOT

Pegomyia brassicae Bouche

Order—Diptera Family—Anthomyidae

Cabbage, cauliflower, radishes, turnips, and other related plants are frequently attacked and killed or rendered worthless for food, by small maggots working upon the roots. The adults are flies which look somewhat like the housefly. The larvae are particularly injurious where their food plants have been grown on the same ground for several years:

Control

Plants like cabbage or cauliflower may be protected by discs of tar paper, fitted around the stems close to the ground. A poisoned bait has proved very satisfactory in killing the adult flies before they lay their eggs. This bait consists of $\frac{3}{4}$ ounce of lead arsenate, $\frac{1}{2}$ pint of molasses, and 1 gallon of water. This should be sprinkled on the plants at the time the flies are out, a few drops on each leaf is enough. This bait should be kept on the plants from the time they are set out until May 20 and for the second generation of flies from July 1 to 20. Renew the bait once a week during fair weather and two or three times a week in rainy weather.

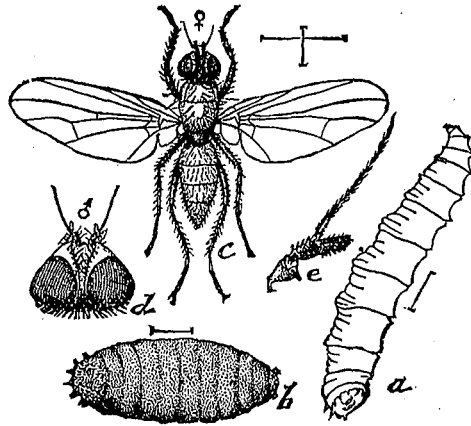


Fig. 41. Cabbage Maggot a. Larva b. Pupa c. Adult d. Head of Male Fly
e. Antenna Enlarged (From Riley.)

PEA AND BEAN WEEVIL

Order—Coleoptera Family—Bruchidae

Peas and beans are often infested before harvesting by one or more of the weevils. The bean weevils continue to work and often destroy the whole crop after it is stored for the winter. Beans or peas which are suspected of being infested should be heated in an oven to 180° F. and stored in a dry place, or better, in tight tins. Beans or peas for seed should not be subjected to this treatment.

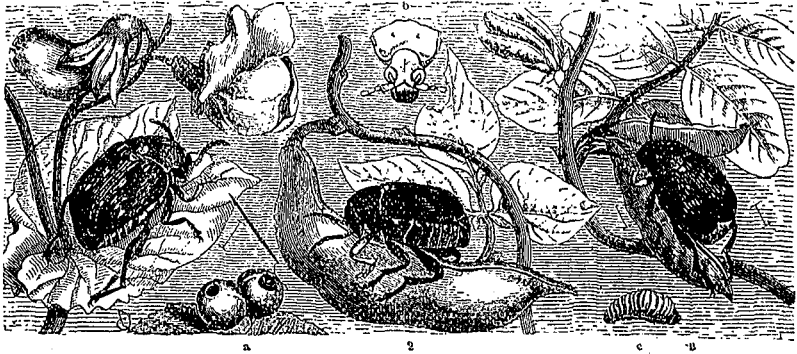


Fig. 42. Bean and Pea Weevils (From Brehm.)

SMALL FRUIT INSECTS

IMPORTED CURRANT-WORM

Pteronus ribesii Say

Order—Hymenoptera Family—Tenthredinidae

The imported currant-worm is the larva of a sawfly. It is greenish in color and is marked with numerous black dots. It feeds upon the leaves of currants and gooseberries. The currant-worms usually work outward from the center of the plant where they are inconspicuous, and often almost strip the

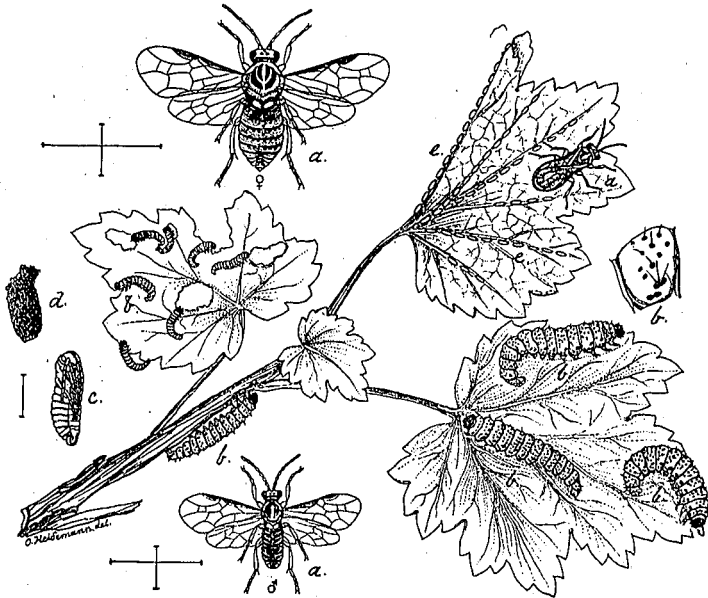


Fig. 43. Imported Currant Worm a. Adult b. Larvae c. Pupa d. Cocoon e. Eggs
(From Luggler.)

bush before they are noticed. There are two generations, one appearing in the early summer and the other about six weeks later.

Control

These worms are easily controlled by the use of paris green, arsenate of lead, or hellebore. When the fruit is ripening, hellebore should always be used. As a liquid spray use arsenate of lead powder at the rate of 10 level teaspoonfuls to 1 gallon of water. Use paris green at the rate of from 1½ to 2 level teaspoonfuls to 1 gallon. It is often more convenient to apply these materials in the form of a dust than as a liquid spray. Hellebore can be used pure, but arsenate of lead and paris green should be diluted with 10 parts of air-slaked lime or road dust for every part of the poison. Dusting should be done when the plants are wet with dew.

CURRANT BORER

Sesia tipuliformis Clerck

Order—Lepidoptera Family—Sesiidae

Currant or gooseberry stems which looked unthrifty last summer and do not leaf out or only leaf out partially this year are likely to be found infested by the currant borer. This is the larva of a moth, which burrows into the stems, eventually killing them.

Control

Since the larva remains in the stem over winter, transforming to the adult in June, it may be controlled by pruning and burning all injured stems before June 1.

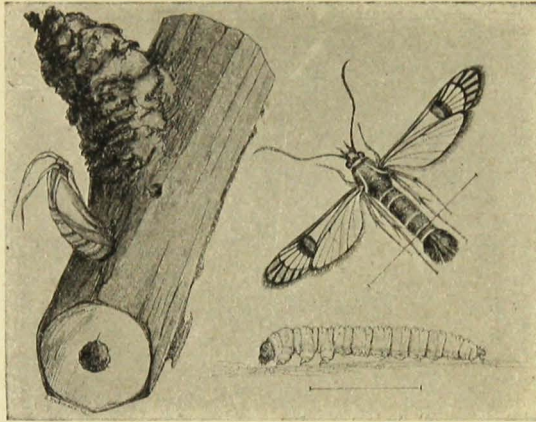


Fig. 44. Currant Borer (From Luggier.)

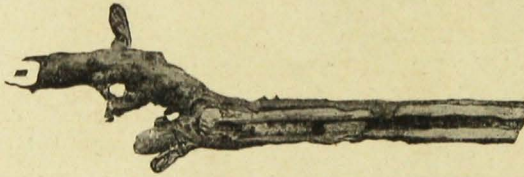


Fig. 45. Work of Currant Borer (From Washburn.)

CURRENT APHID

Myzus ribis Linn

Order—Hemiptera Suborder—Homoptera Family—Aphididae

The bright red spots on the upper surface, together with the curling and puckering so often seen on the leaves of currants are caused by the currant aphid or plant louse. These insects injure the plants by sucking the juices from the leaves. If the under sides of the leaves are examined, the lice will be found lying in little pockets. These insects multiply very rapidly and frequently cause considerable injury.

Control

After the leaves become curled, it is almost impossible to hit the aphids with a contact spray, so that if they are to be controlled, the spraying must be done early. "Nicofume" at the rate of 1 or 2 tablespoonfuls to 1 gallon of water, in which a cubic inch of laundry soap has been dissolved, applied in the spring just after the leaves begin to unfold, should prove satisfactory.

RED-NECKED CANE-BORER

Agrilus ruficollis Fab.

Order—Coleoptera Family—Buprestidae

Raspberry canes which show spindle-like swellings and appear unthrifty or dying, are usually found to be infested by the larva of the red-necked cane-

borer. This is the larva of one of the flat-headed or metallic wood-borers. It burrows spirally around the cane in these gall-like swellings, girdling and killing the shoot. In late summer it makes its way into the pith, where it passes the winter.

Control

Cut out and burn all infested canes before May 1.

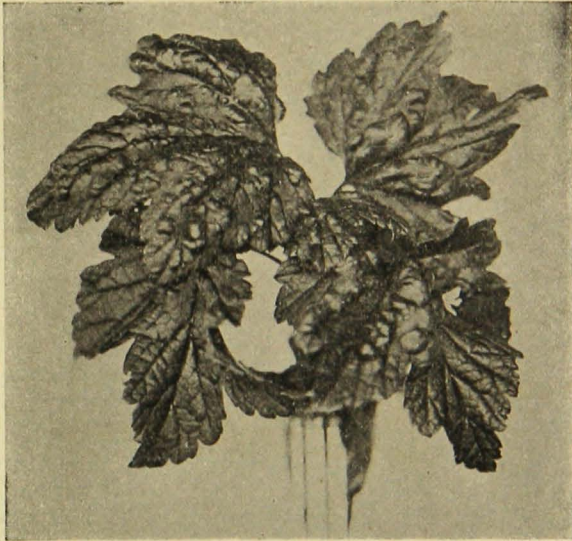


Fig. 46. Currant Leaves Infested With Plant Lice (From Luggler.)

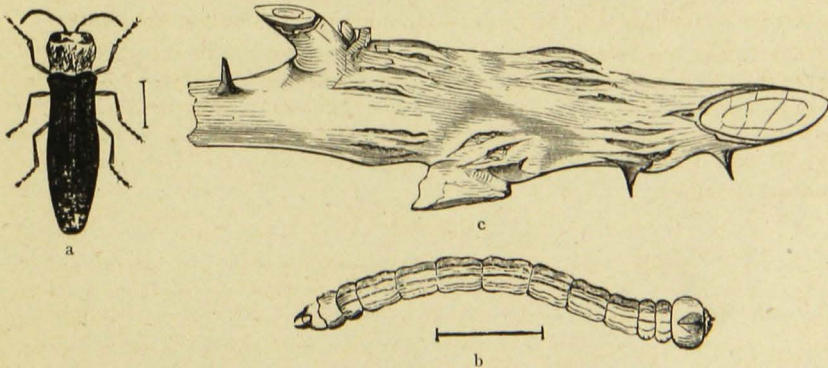


Fig. 47. Red-Necked Cane-Borer a. Adult b. Larva c. Work (From Riley.)

RASPBERRY FRUIT WORM

Byturus unicolor Say

Order—Coleoptera Family—Dermestidae

In the spring small brown beetles are often observed feeding upon the leaves of raspberries. These are adults of raspberry fruit worms. Later the eggs are laid in the flower buds and the larvae live upon the developing fruit.

Control

As the larvae go into the ground to pupate, thoro cultivation of the raspberry patch during the summer and as late as is compatible with good culture will help to keep this insect within bounds. The adults are difficult to kill with a stomach poison. Paris green appears to be more effective than arsenate of lead; but is not entirely satisfactory. In small patches, careful hand-picking and destroying of the adults is effective.

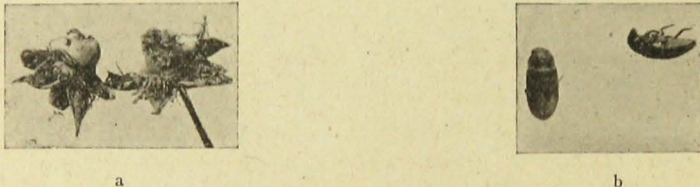


Fig. 48. Raspberry Fruit Worm a. Larvae b. Adults

SNOWY TREE CRICKET

Oecanthus nigricornis Walker

Order—Orthoptera Family—Gryllidae

The canes of raspberries and the tender shoots of shrubs and trees are sometimes severely injured by the egg punctures of the snowy tree cricket. The eggs are deposited in a row running lengthwise of the stem during the late summer and fall and hatch in the spring.

Control

Prune and burn injured canes or twigs in winter or early spring.

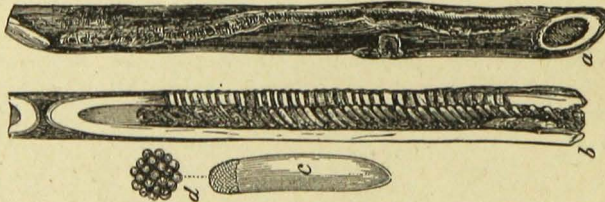


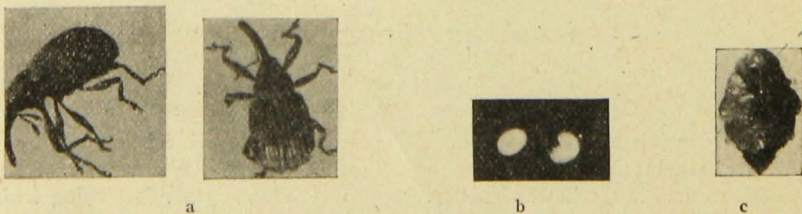
Fig. 49.. Eggs of Snowy Tree Cricket (From Riley.)

STRAWBERRY WEEVIL

Anthonomus signatus Say

Order—Coleoptera Suborder—Rhynchophora Family—Curculionidae

In the spring a small gray snoutbeetle may be observed feeding on the under side of strawberry leaves. Altho the adults feed upon the leaves, the



(From Marcovitch.)

principal injury is done to the blossoms. They cut off the flower buds after laying eggs in them. The greatest injury is to the June crop; the everbearing varieties, coming on later, suffer little.

Control

The best measure which can be recommended for the control of this pest is systematic rotation. Take only one or two crops from a bed and set out the new bed at some distance from the old one. The plowing under of the old beds, according to the latest work, destroys most of the weevils which are in hibernation. Burning over the beds after the crop is off and careful renewal will tend to keep the pest down, but are not so satisfactory as a rotation system.

GOOSEBERRY FRUIT-WORM

Zophodia grossulariae Pack

Order—Lepidoptera Family—Pyrilidae

The fruit of the gooseberry is sometimes eaten into and destroyed by small green caterpillars. When bushes infested with this insect are shaken, the worms drop on a thread of silk until the disturbance is over and then climb back to their former place by means of the thread. There is but one generation a year. After becoming full grown, the caterpillars drop to the ground and pupate beneath the litter.

Control

Thoro cultivation, cleaning up and burning trash and litter will usually serve to keep this pest in check.

NOTICE

Let us know about your insect problems as they arise. We can often help you. Send living specimens and injured plants when possible. Living insects can be sent through the mail in a tight wooden box. No holes need be made for ventilation. Address:

STATE ENTOMOLOGIST,
University Farm,
St. Paul, Minnesota.

SPRAYING CALENDAR

Pest	Spray	First Spraying	Second Spraying	Third Spraying	Remarks
Codling moth Curculio Scab Black rot Bitter rot Aphids or plant lice Scale insects	Arsenate of lead (3-50) plus concentrated lime-sulphur diluted (1 to 40), or bordeaux mixture (4-4-50)	APPLE As center bud in flower cluster begins to show pink	Just after petals fall	Three weeks later	Spraying just after the petals fall, getting as much of the liquid into the calyx cups as possible, is most effectual for codling moth. Give a fourth spraying three or four weeks later if codling moth, black rot, or bitter rot is present. Destroy fallen leaves and all rotted fruit; prune out and burn all cankers; disinfect wounds. Trees should be thoroly covered.
	Nicotine sulphate or Nicofume	When insects appear			
	Lime sulphur (1-9)	Before buds burst in spring			
Cabbage worm	Arsenate of lead (3-50) or paris green (1-50) Dust with the powdered form or with wood ashes	CABBAGE Whenever worms appear	Repeat when necessary		The poison will stick better to the leaf if used in soapy water.
Cabbage maggot	Sweetened arsenate of lead	May 1-20	July 1-20		
Cucumber beetle Larvae or grubs	Arsenate of lead or air-slaked lime or ashes Nicofume on roots	CUCUMBER Dust as soon as insects appear	Repeat when necessary		The adult insects do not seriously injure cucumbers in cold frames, nor do larvae under field conditions.
Currant worm Leaf spot Currant leaf louse	Arsenate of lead or hellebore Bordeaux mixture Nicotine sulphate	CURRENT A few days after blossoming Just as leaf buds are breaking As buds are breaking	As young leaves appear		When berries begin to turn, use hellebore to prevent discoloration.
Brown rot Curculio	Arsenate of lead (3-50) plus concentrated lime-sulphur diluted (1 to 40), or bordeaux mixture 3-4-50	PLUM Just before flower buds break	When plums are size of small peas	When fruit begins to color	Destroy all mummies (fruit shriveled by rot). Prune and burn affected branches in the fall. If whole tree is affected, cut down and burn.
Plum pocket Scale insects	Copper sulphate Bordeaux mixture Same as for apple	Copper sulphate before any growth starts in spring	Bordeaux mixture as soon as growth starts		
Blight (early and late) Beetle	Bordeaux mixture (5-5-50) Paris green (1-50) or arsenate of lead (3-50)	POTATO When plants are 8 inches high As soon as beetle eggs hatch	Repeat when necessary		Vines should be well covered with bordeaux mixture throughout the season. This usually involves spraying every ten days or two weeks.
Anthraxnose	Resin-bordeaux mixture	RASPBERRY Before leaves open			Cut out and burn diseased canes; keep old canes cut out. Protect with bordeaux until canes are at least two-thirds grown.
Fruit worms	Arsenate of lead (4-50)	When young shoots are 6 inches high			Cultivate close to plants in fall.
Tomato worms Leaf spot Black rot	Arsenate of lead (3-50) Bordeaux mixture	TOMATO When worms appear Just after the fruit sets	Repeat when necessary		Vines should be well covered with bordeaux throughout the season. Provide good ventilation.

NOTE.—Never spray when trees are in bloom. From Special Bull. No. 1, Spraying Calendar, by E. C. Stakman and A. G. Ruggles. (Out of print.)