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Connecticut Agricultural Experiment Station
New Haven

Control of the Japanese Beetle

J. Peter Johnson

The Japanese beetle, *Popillia japonica* Newman, is indigenous to the principal islands of Japan and at times causes some damage in localized areas. Prior to 1912 many plants with balls of soil about their roots were imported from Japan, and it is very probable that grubs or larvae were present in the soil of some of this nursery stock and started the infestation in this country.

The beetle was first discovered in a nursery at Riverton, New Jersey, during the summer of 1916. Since that time it has become widely distributed throughout an area of over 100,000 square miles in the northeastern part of the United States. In Connecticut federal scouts first found a few beetles in Stamford on September 1, 1926. The beetle now occurs in more than 73 towns and cities of this State.

BEETLE DAMAGE TO FOOD PLANTS

At the present time beetles are very numerous in all of the large cities: Bridgeport, Hartford, New Haven, New London, Greenwich, Stamford, Danbury, Waterbury, Willimantic and Putnam. They have done considerable damage by feeding upon the foliage of many preferred food plants, skeletonizing the leaves. The adult beetle is known to feed upon more than 250 species of plants, not all of them of economic importance. The following list names the more common ones including economic species. Those marked with an asterisk are particularly attractive to the beetles.

Plants Often Attacked by the Japanese Beetle

Small fruits:
- Blackberry, foliage and fruit
- Blueberry and huckleberry, foliage and fruit
- Currant, red varieties
- *Grape, foliage
- *Raspberry, foliage and fruit

Orchard fruits:
- *Apple, foliage and especially fruit of early ripening varieties
- *Cherry, foliage
- Peach, injury severe on fruit of early ripening varieties and occasionally severe on foliage
- Plum, foliage and fruit
- Quince, foliage

Truck and garden crops:
- Asparagus, Beans, Rhubarb } foliage
- *Sweet corn, foliage, silk and ear

Field crops:
- Alfalfa
- Clover, foliage and flowers
- *Field corn, foliage, silk and ear
- *Soybean, foliage

Ornamental shrubs and vines:
- Barberry
- Butterflybush, flowers only
- Crapemyrtle, foliage and flowers
- Lespedeza
- Oriental flowering cherry
- *Rose, foliage, buds and flowers
- *Shrub-althea, flowers
- *Virginia creeper, foliage

Flowering garden plants:
- Canna, foliage and flowers
- *Dahlia, foliage and flowers
- *Hollyhock, foliage and flowers
- *Marshmallow, foliage and flowers
- Rosemallow, foliage and flowers

Flowering garden plants:—*Continued*
- Snapdragon, especially flowers of dark-colored varieties
- *Zinnia, flowers and foliage

Shade trees:
- *Elm, *Horsechestnut, *Linden, *Lombardy poplar, Norway maple, Pin oak, Sycamore, White birch, *Willow } foliage

Weeds and other non-economic plants:
- Alder
- *Bracken
- Dock
- *Elder
- *Evening primrose, foliage and flowers
- *Indian mallow or velvetleaf
- *Sassafras, foliage
- *Sensitive fern
- *Smartweed, foliage and flowers
- Tear thumb
- *Wild fox grape, foliage
- *Wild summer grape, foliage

Japanese beetles are spreading rapidly and becoming more abundant each year. If they are not checked their damage will increase and they will attack many crops, trees and ornamental plants that are now untouched.

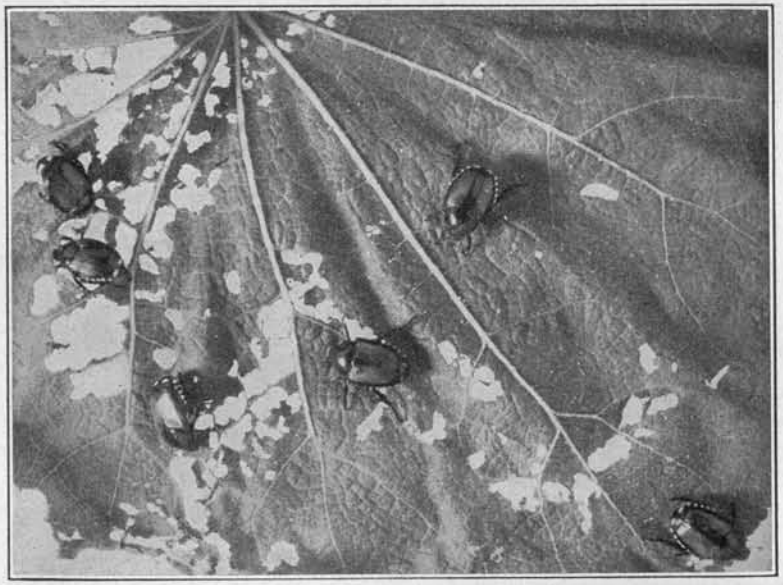

FIGURE 1. Japanese beetles feeding on hollyhock. Natural size.

INJURY BY GRUBS OR LARVAE

Lawns, golf greens and pastures are injured by the grubs or larvae of the Japanese beetle which devour the roots of grass just beneath the soil surface. As a result the finer and perennial grasses are usually destroyed and are replaced by unsatisfactory annual grasses or weeds. Feeding has

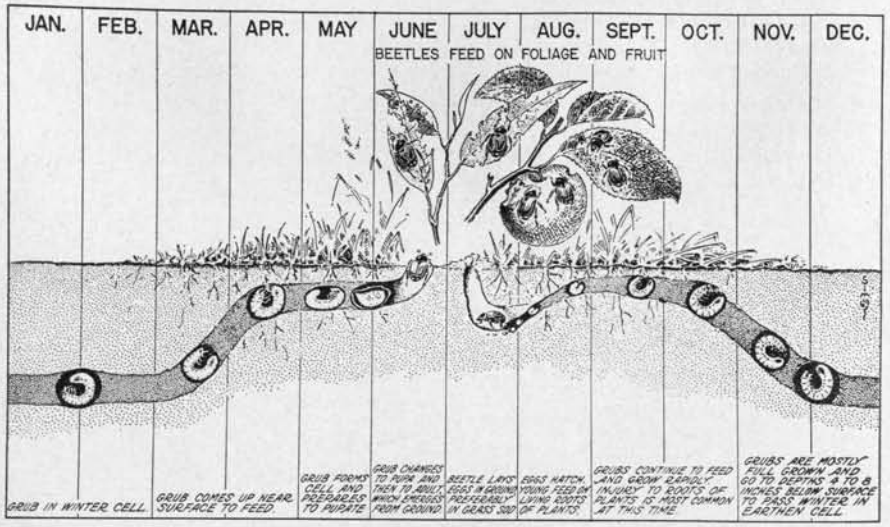

FIGURE 2. Diagram showing the seasonal life cycle of the Japanese beetle. (After Bureau of Entomology and Plant Quarantine, U. S. Dept. of Agriculture).

been recorded on the roots of bean, corn, strawberry, tomato and other vegetables, field and flowering plants. Grubs have numbered as many as 1,531 in one square yard of golf green. Under normal conditions 100 grubs per square yard may kill the grass in spots, especially during dry periods. Before the turf is infested to such an extent, it should be treated.

LIFE HISTORY AND DESCRIPTION

The entire life cycle of the Japanese beetle usually requires one year, with most of that period spent in the larval or grub stage. As all the individuals do not mature at the same time there is some overlapping of the stages. The seasonal life history is shown in Figure 2.

Egg. The female beetle lays her eggs in the soil, mostly within two inches of the surface. At first she deposits from one to four, then emerges from the ground and feeds for a day or two before laying a few more. This continues until she has laid a total of 40 to 60 eggs. Although the larger amount of oviposition occurs in July, it extends over the season while the adults are present.

When first laid, the eggs are translucently white or cream in color, somewhat elliptical and about one-sixteenth of an inch in greatest diameter.

They soon increase to nearly twice that size and become almost spherical, hatching in about two weeks.

Larva. When first hatched, the larva is about one-eighth of an inch in length. It has three pairs of legs and is whitish in color. Immediately the tiny larvae begin to feed upon the roots of grasses and other plants and upon organic matter in the soil. They pass through three distinct stages or instars, molting or shedding their skin at the end of each. When fully grown (usually in September) they are about one inch in length, in general resemble other white grubs and are usually found curled up in the soil. The head is light brown and the body white with a bluish tint, much darker at the anal end. The grub may be identified by examining the ventral surface of the anal segment. In the Japanese beetle the last rows of spines occur in a V-shaped arrangement as shown in Figure 3a[1]. Characteristic structures also occur on the epipharynx, as shown in Figure 3b.

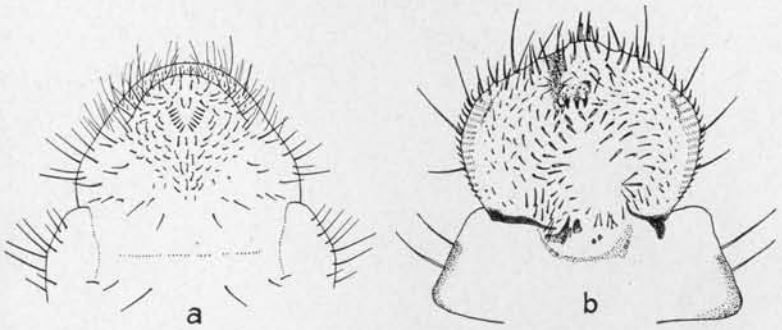

FIGURE 3. a. Ventral aspect of the anal segment of the larva, showing crescent-shaped anal slit, and V-shaped arrangement of straight setae. b. Epipharynx, showing specific arrangement of striae, spines, setae and pores. Greatly enlarged.

The larvae usually feed in the upper two inches of soil. On the approach of cold weather they descend to a depth of 2 to 6 inches, where they hibernate until the following spring. Then they work their way to the surface and resume feeding. The fully grown larva is shown in Figure 4. Larval development is completed by June. There follow about 10 days in the prepupal stage, when the insect is pale in color, shrunken and inactive. Certain changes take place before the grub transforms to the true pupa.

Pupa. The pupa, which occurs in a cell in the soil at a depth of about 1.5 to 3 inches, is approximately half an inch in length, light yellow in color at first, later changing to tan. This stage lasts 8 to 20 days, depending upon temperature and moisture.

Adult. The adults begin to emerge the last week of June, are at their peak of abundance in July and early August, and decrease until October,

[1]The drawings in this circular were prepared by Elizabeth Kaston.

when they disappear altogether. They are slightly less than half an inch in length and about one-fourth of an inch in breadth. The head, thorax, abdomen and legs are bright, shining green, and the wing-covers are copper brown. The wing-covers do not entirely conceal the abdomen. Two patches of white hairs at the apex and five additional patches along each side, appear like distinct white spots edging the wings when viewed from above. The sexes are similar in color and marking but the males are usually smaller than the females. Mating occurs soon after emergence.

The adults are very active on warm, sunny days and usually quiet in stormy, cloudy or cool weather. They are strong fliers and will congregate in large numbers on preferred host plants. Their adult life lasts from 30 to 45 days.

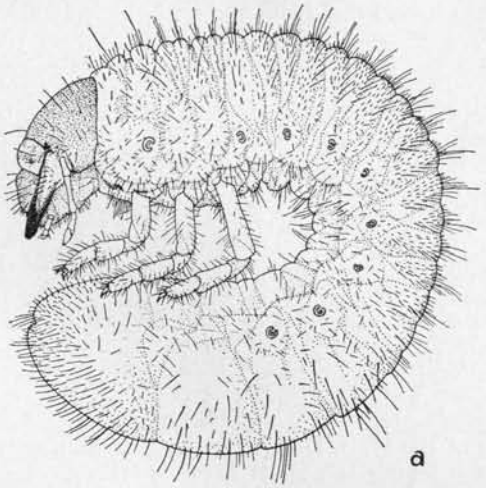

FIGURE 4. a. Grub or larva, lateral aspect. About five times enlarged.

DISPERSION

As the Japanese beetle is a strong flier, infestations may spread from 5 to 10 miles each year through normal flight. Beetles may be carried on clothing, in crates of fruit, vegetables and other produce, and even on machinery, hardware and structural steel. They often fly into motor cars and railroad trains, and may travel many miles before they escape.

The grubs or larvae may be transported through the movement of plants with soil about their roots, or in turf, soil, manure and even sand.

NATURAL ENEMIES

Domestic fowls, birds, toads, predaceous insects and even spiders devour adult beetles. Certain birds, skunks, moles, pine mice and the short-tailed shrew eat the grubs.

Numbers of three different species of imported parasites have been released by the U. S. Department of Agriculture at centers of infestation within the State. One of these, a tachinid fly, *Centeter cinerea* Ald., attacks adults, while the spring tiphia wasp, *Tiphia vernalis* Roh., and the summer tiphia wasp, *Tiphia popilliavora* Roh., attack the grubs. Several years may be required to demonstrate the value of these parasites.

ARTIFICIAL CONTROL OF THE ADULT BEETLES

The Japanese beetle may be present in tremendous numbers in its adult stage and is such an important pest that any reasonable method employed to reduce its population may be considered a good control. It devours leaves and blossoms as well as certain early ripening fruits. Because it is a general feeder on such a great variety of plants, successful control is difficult and protective measures must be extended to include many host plants.

Jarring

One of the quickest and easiest methods of control is to jar the beetles from trees and shrubs under which a sheet or canvas has been spread. The catch is then placed in a container holding water covered by a thick layer of kerosene. This should be done in the early morning before seven o'clock, as the beetles are very sluggish during the cool part of the day. Jarring the individual branches of infested trees and shrubs in this manner is much more efficient than hand-picking and large numbers of the insect may be disposed of cheaply and effectively. After the beetles have been killed, immediate burial is recommended as they decompose rapidly and give off very offensive odors.

Trapping

Entomologists of the U. S. Department of Agriculture have developed a baited trap for capturing the adult beetles. The most effective bait is a liquid consisting of one part eugenol and 10 parts geraniol. One and one-half ounces of this liquid in a trap should last five to seven weeks, depending on the weather conditions.

The traps, as illustrated in Figure 5, together with the bait, may be purchased from dealers in agricultural commodities. The outside of the funnel should be light green in color, with the inside, the baffle and bait container white. The paint should have a luster, as this increases the efficiency of the trap.

The attractive odors are given off by evaporation from a wick extending through the cork of the bottle containing the liquid. The wick should not come into contact with the side of the bait container or trap as the material will be dispersed too rapidly by capillary action and lost.

A Mason jar of one pint to two quarts' capacity is attached to the bottom of the trap as a beetle receptacle. This is a necessary part of the trap, and the pint size is suggested for use in a lightly infested area. A quart jar will hold approximately 3,300 beetles. It should be emptied regularly into a bucket of water on which there is a thick film of kerosene oil, and the dead beetles should be buried.

Millions of Japanese beetles have been captured in traps throughout the infested area. The traps are exceedingly valuable in light infestations. Many female beetles are captured before egg laying has been completed, and this assists in keeping the local infestation at a minimum. The adult beetles in Connecticut begin to emerge from the soil during the last week of June and are present until cold weather. The traps should be placed in position about June 20 and left until October.

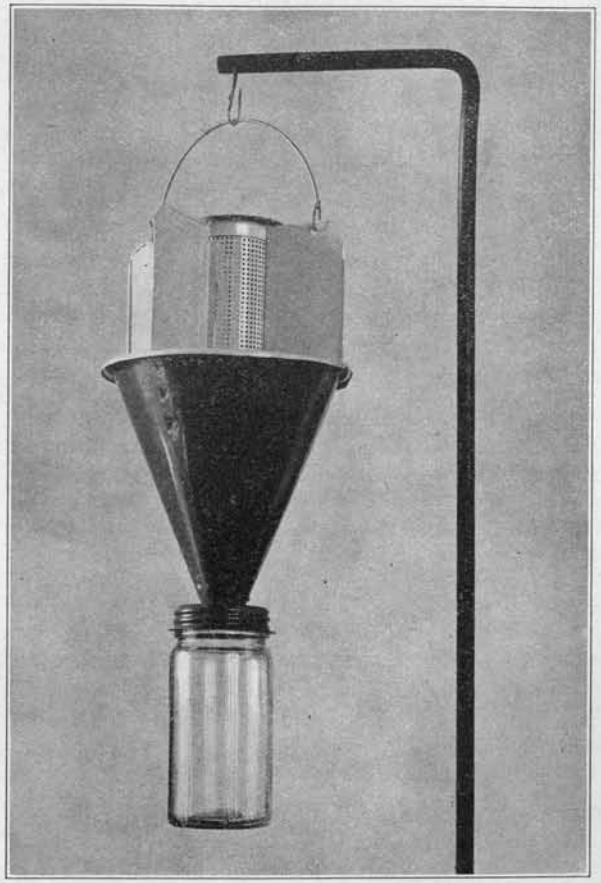

FIGURE 5. A Japanese beetle trap.

When set in the vicinity of the average home, traps will probably draw beetles only from the immediate surroundings. Buildings, trees and shrubs have a tendency to deflect or impede air currents which carry the attracting odors. In open fields or large expanses of lawn, and under favorable weather conditions, beetles may be drawn from a distance of 500 yards.

As they migrate in search of favorite food plants or to lay eggs, an influx from adjoining areas may be expected. Thus it is possible for traps to

operate efficiently without any noticeable decrease in the beetle population. The beetles will not all be caught in the traps, and if excessive feeding is observed on nearby plants, such traps should be removed 10 or more feet distant. The efficiency of the traps decreases greatly when they are moved more than 25 feet from plants and shrubbery.

Traps should be placed 3 to 4 feet above the ground in the open where they are exposed to the sun for the greater part of the day. Special standards from which they should be suspended may be purchased or made. One or two placed in the proper locations in the average property of 50 feet frontage will assist greatly in reducing the numbers of beetles. The use of only a dozen traps in a large city would not be very successful, but coöperative campaigns are of great value.

Traps alone will not solve the Japanese beetle problem. Their effectiveness varies depending upon the conditions under which they are used. In heavy infestations traps cannot be depended upon to protect favored food plants. In general, they will reduce the numbers of beetles and this is a distinct advantage. In fact, many property owners probably will adopt no other control measures and the use of traps should be encouraged. If traps are placed in the garden as early as June 10 they will also catch many rose chafers (*Macrodactylus subspinosus* Fabr.).

Spraying

The intensity of the Japanese beetle population has a decided effect upon the method of spraying as a means of control. Small numbers of beetles are readily repelled from host plants by protective sprays. However, when an area is heavily infested protective sprays must be applied before the adult beetles appear. On the other hand, when an area is lightly infested protective spraying may be delayed until the beetles begin to emerge. The sprays described in this circular are those recommended by the U. S. Department of Agriculture and were all tested or developed in New Jersey. The infestation in Connecticut is now of such intensity that experimental work and tests may be carried out here. The federal recommendations have changed from time to time as new methods have been developed and no doubt they will continue to change until the problem has been fully solved.

Spray Materials

Lead arsenate may be used at the rate of 6 pounds to 100 gallons of water in combination with a good sticker. Wheat flour used at the rate of 4 pounds to each 6 pounds of lead arsenate is very effective for this purpose. Other stickers and spreaders generally used with lead arsenate in the regular spray schedule may be substituted for flour. In heavily infested areas it may be necessary to make a second application of the lead arsenate spray. This insecticide serves primarily as a repellent but also has a killing action, giving excellent results with complete coverage. Lead arsenate may be used in small amounts at the rate of 2 rounded tablespoonfuls to 1 gallon of water, together with flour (1.5 tablespoonfuls) as a sticker.

A non-poisonous repellent, consisting of 1 pound of hydrated lime and one-quarter pound of aluminum sulfate to 5 gallons of water may be used around the home grounds and elsewhere as desired. This spray leaves a

very white residue upon the plants and is objectionable in some cases for spraying ornamentals. As the adult beetles are repelled from host plants covered with a white spray residue, the material is very effective. The mixture should be agitated continuously to prevent the lime from settling to the bottom of the container. The spray residue withstands rains very well, but additional applications are necessary in areas of heavy infestation, while new growth must also be sprayed. The use of the non-poisonous lime-aluminum sulfate spray, when fruits and vegetables are ripening, eliminates some of the objectionable features of using a poison spray at such periods.

A mixture of 3 pounds of derris (containing 4 percent rotenone) and 3 pounds of rosin residue emulsion in 100 gallons of water is very effective as a repellent in protecting foliage and fruit from beetle injury. This spray does not leave an objectionable residue. The residue breaks down through oxidation when exposed to the sun and is rendered non-toxic in approximately one week. Because of this it is necessary to make additional applications to obtain adequate protection while the beetles are present.

Emergency measures are employed when tremendous numbers of beetles infest early fruit. At such times derris, cubé, or timbo (containing approximately 4 percent rotenone) may be used as contact sprays, at the rate of 6 pounds to 100 gallons of water. One of several suitable sticking or spreading agents, such as rosin-residue emulsion, a sodium salt of water-soluble sulfonic acids derived from petroleum, sodium sulfonate of orthophenyl phenol or sodium lauryl sulfate, manufactured under various trade names, should be used with the insecticide. These agents should be used in the quantities and under conditions as recommended by the manufacturers.

Pyrethrum contact sprays are very effective in killing the beetles. Such contact sprays are useful in controlling the adult Japanese beetle, but under conditions of heavy infestation they may not afford satisfactory protection. Several commercial contact sprays can be purchased in the open market. It must be remembered that in order to kill the adult Japanese beetle with such an insecticide, a coarse drenching spray must be used to wet the insect. The most effective contact spraying is done when the beetles are most active in the late morning and early afternoon of a sunny day.

A commercial fish oil soap or a good grade of household soap used at the rate of 1 pound to 3 or 4 gallons of water may also be effective as a contact spray but should not follow or precede an application of lead arsenate. In order to avoid soap injury, care must be taken not to make too many applications on any one plant and not to spray on very hot, humid days.

As it is necessary to protect a great variety of plants under many conditions, the adaptation of the various sprays to individual problems will afford protection from beetle injury. **It must be remembered, however, that all objectionable spray residue on fruits and vegetables must be removed by brushing or washing before consumption or marketing.**

Flowering Plants

The rose is one of the primary host plants of the adult beetle and may be damaged severely. Hollyhocks, dahlias, altheas, and zinnias are also important hosts. As a protective spray for flowering plants, derris powder (4 to 5 percent rotenone), one-third pound in 10 gallons of water, will not leave an undesirable residue and gives a fair degree of control. Desirable

flowering plants can be protected by covering them with cheesecloth or wire screening. If spray residue is not objectionable, hydrated lime and aluminum sulfate may be used.

Non-flowering Plants

Lead arsenate in combination with a good sticker or the hydrated lime-aluminum spray may be used to protect large trees, shrubs and vines. Linden, horsechestnut, elm, willow, Lombardy poplar, European white birch, Norway maple and its varieties, sycamore, pin oak, chestnut oak, larch and sassafras trees, are all susceptible to Japanese beetle attack. When the trees and shrubs are large and cannot be covered properly by a hand sprayer, it is best to use a high-pressure machine.

Vegetable Plants

As the adult beetle feeds upon the foliage of lima and string beans, rhubarb, asparagus, etc., the hydrated lime and aluminum sulfate spray may be applied to these plants for protection. Sweet corn is injured by the adult beetles feeding on the immature silk, which prevents proper pollinization and development of the kernels. This can be prevented by dusting very fine (300-mesh) hydrated lime on the tips of the ears with a hand duster. The material should be applied before the beetles attack the silk, and at least two additional applications should be made at three-day intervals.

Small Fruits and Grapes

Ripening blackberries, blueberries and raspberries cannot be satisfactorily protected from the adult beetles as it is next to impossible to remove spray residue without damaging the fruit. The foliage alone can be protected by spraying with the hydrated lime-aluminum sulfate spray. This material may also be applied to grapevines to prevent injury by the adult beetles because this is one of the most important host plants. Fruit of early ripening varieties may be severely damaged by the insect and the foliage is very susceptible to attack. Grape leaves may also be protected by using the lead arsenate spray. A thorough job is necessary to protect every leaf and the spray should be directed downward from above to avoid excessive residue on the fruit. New growth must be protected by additional applications through the season.

Protection of Fruit Trees

Apples and peaches that ripen in July or early August are very susceptible to adult beetle injury and it is difficult to protect them satisfactorily. Ripe fruit is usually the first to be attacked but if the beetle infestation is heavy, the ripening fruit will also be damaged.

The foliage and fruit of early apples may be protected by spraying with lime-aluminum sulfate. Diseased or prematurely ripening fruit and that lying on the ground should be removed from the orchard because the beetles will feed upon it even though it is heavily coated with the spray residue. Early ripening peaches and plums may be protected by spraying with the derris-rosin residue spray.

Cherries are usually harvested before the adults emerge in great numbers. The foliage of apples, peaches, plums and cherries can be protected by thorough coverage with the hydrated lime-aluminum sulfate spray. It is extremely important that all spraying be done thoroughly to avoid defoliation during a period of heavy infestation, as unsprayed portions of plants will be eaten.

ARTIFICIAL CONTROL OF GRUBS

Turf Treatment with Lead Arsenate

As mentioned previously in this bulletin, Japanese beetle larvae feed on the roots of grasses and other plants. A small number of larvae present in the turf does not indicate that the grass will be completely killed. However, it does mean that an infestation is present and it will only be a matter of time before the larvae will occur in sufficient numbers to injure the grass severely.

Under *life history* were described the life cycle and feeding habits of the grubs. In the autumn a drop in soil temperature to 65 or 60° F. sends them to winter quarters, 2 to 6 inches below ground level. A rise to about 50° F. in spring brings them up again and they have been observed feeding just below the surface in April.

Lawns may be examined for infestation by cutting through the turf and rolling it back to expose the under surface. The exposed soil may then be examined by digging, and that in the turf shaken out or loosened with a knife.

Brown or dead patches in turf areas do not necessarily indicate that grubs are injuring the grass. Dry weather, other insects and grass diseases are often responsible for such conditions. Therefore, it is desirable to make a thorough examination before remedial measures are taken. If grubs are found in numbers, lead arsenate may be applied. If there are no grubs and the soil below the turf is very dry, the lawn may merely need watering. Damage to lawns by other insects and grass diseases is described, together with remedies, in Station Circular 113.

The larvae can be controlled by using acid lead arsenate, the kind normally used in spraying operations, at the rate of 1 pound to 100 square feet. Other white grubs are commonly mistaken for the Japanese beetle larvae but the control measures for these are similar. The grubs of the Asiatic garden beetle, *Autoserica castanea* Arrow, and the Asiatic beetle, *Anomala orientalis* Waterhouse, both introduced species, are approximately the same size as the Japanese beetle larvae, while the grub of the *Ochrosidia borealis* Burm., a native species, is slightly larger.

The lead arsenate soil treatment is not recommended for vegetable gardens, flower beds or shrubbery borders. Many vegetables will grow in the treated soil but the lead arsenate absorbed by the plants through their roots may be detrimental to health. Some of the flowers and shrubs react unfavorably to the lead arsenate treatment and it is advisable to leave them untreated. To avoid injury and soil complications the lead arsenate should not be used in amounts greater than those recommended.

Under average conditions it is possible for lead arsenate applied at the rate of 1 pound to 100 square feet of area to be effective for five years. This depends on several factors such as type of grass, soil structure and constituents, drainage, amount of organic matter, soluble salts present, fertilizer used, and others.

It is considered an excellent practice to top-dress turf annually with a good compost high in organic matter, not to exceed one-fourth inch in depth. Lead arsenate should be thoroughly mixed with such top-dressing in alternate years at the rate of 2 pounds to 1 cubic yard, before application. This treatment will prevent the accumulation of a non-poisonous layer above the original treated soil. Fertilizers such as well-rotted manure, ammonium sulfate, sodium nitrate, potassium chloride, superphosphate, bone meal, activated sludge and tankage, as usually recommended, have been used successfully on treated turf. As lime has a tendency to reduce the effectiveness of the lead arsenate, it should be used only when necessary to correct the acidity of the soil.

Methods of Application

In treating turf areas the lead arsenate may be applied in dry form mixed with carriers, or as a spray with water. Any method of application which insures an even distribution over a given area is satisfactory but the methods employed are usually those adapted to the size of the area to be treated.

For small areas, the use of large expensive equipment may be avoided by applying the chemical in the dry state. This can be done by thoroughly mixing the lead arsenate with about 25 times its volume of slightly moist sand or soil and broadcasting by hand. It can also be applied by using a hand fertilizer-distributing machine. When such a machine is employed, the lead arsenate mixture should be dry and finely ground to avoid clogging.

It is best to prepare mixtures just before their application to avoid lumps that may clog the distributors. Upon completing the application it is advisable to wash off the material remaining on the grass. Do not flood the turf while washing, as this will cause the insecticide to run off or be washed into depressions.

Small areas may also be treated by suspending lead arsenate in water and applying it with a watering can. When this method is used the insecticide should be diluted at the rate of not less than 2 gallons of water to 1 pound of lead arsenate. It is necessary to stir the mixture from time to time during the application. If any lead arsenate remains in the bottom of the watering can, add more water and sprinkle the same area. One should be certain that the proper amount of lead arsenate is applied evenly to each area treated.

It is most economical to use high-pressure power sprayers to apply the lead arsenate to large areas of turf. The arsenate of lead may be used at the rate of 1 pound to 2 gallons of water in the tank. Various nozzles have been employed successfully in making applications at this concentration. It is advisable to hold the nozzle nearly parallel with the surface of the turf so the liquid will hit the grass at a narrow angle some distance ahead of the operator. This will enable a more uniform application and prevent injury

to the grass which may occur from a close-up pressure delivery. Before it dries, the lead arsenate should be washed off the grass blades and into the soil where it is needed.

FIGURE 6. Applying lead arsenate spray to the turf.

LAWN SEEDING AND TREATMENT WITH INSECTICIDES

It is often necessary to re-seed a lawn that has been severely injured by grubs or to build a lawn around a new home in an area of heavy infestation. Such lawns may be treated with lead arsenate in the powder form at the rate mentioned previously for turf treatment. The area should be prepared for seeding and the dry lead arsenate applied evenly over the surface. It should then be mixed thoroughly into the upper 2 or 3 inches of soil, leveled and seeded. When this method is used the lead arsenate is incorporated into the actual area where the grubs do their feeding and is immediately ingested, causing death.

Used before seeding, lead arsenate will slightly delay germination. However, if the soil treatment and seeding are made together early in September, a good stand of grass can be obtained. Annual bluegrass is retarded in its growth by lead arsenate and is not a satisfactory grass to be grown in treated areas. Redtop, Kentucky bluegrass, Italian and perennial ryegrass, red fescue, rough-stalked meadowgrass, velvet bent, creeping bent, metropolitan bent, Washington bent, colonial bent and Rhode Island bent, all grow well in soil treated with lead arsenate.

Many seedings of grass have failed because of the poor germinating qualities of the seed. In case of failure the first time, it is well to re-plant with seed that has been tested for germination. If an area of heavy in-

festation is treated and seeded too late in the fall, the retarded germination may result in the loss of the grass stand during the winter. However, if it is necessary to seed a heavily infested area late in the season the ground may be treated before seeding with a 70 percent carbon disulfide emulsion diluted at the rate of 1 quart to 50 gallons of water. Three pints of the material should be applied to each square foot of area. The grubs must be in the upper 1 or 2 inches of soil if this treatment is to be effective.

FIGURE 7. Applying water to wash the lead arsenate off the grass.

As such a remedy is only a temporary measure, it can be followed by a lead arsenate treatment late in the following spring or early summer, after a good stand of grass has grown. Occasionally late-sown grass may escape injury because the grubs have already gone down to winter quarters. It is well to remember, however, that very late seeding is a questionable procedure because the results are so uncertain. *The best results are obtained by treating with lead arsenate during July and August, when the grubs are small.* But the poison may be applied at any time when turf injury is present and the grubs are feeding near the surface. If used late in the fall it will last over, killing the grubs in the spring. A late spring treatment will do little harm to the current brood, but will be available against the newly-hatched grubs in midsummer.