Tomato Diseases and Insect Pests

Identification and Control

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COLLEGE OF AGRICULTURE : AGRICULTURAL EXPERIMENT STATION AND EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS

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Many other diseases of tomatoes than those mentioned in this circular are present in Illinois, but most of them seldom, if ever, are of commercial concern. . . . All inquiries concerning plant diseases sent to the Horticultural Department, University of Illinois, should be accompanied by an entire plant, adequately illustrating the trouble, in order that a positive diagnosis can be made. . . . For control methods for insect pests not discussed herein, write direct to the Illinois State Natural History Survey, and include a damaged plant and at least one of the insects.
Tomato Diseases and Insect Pests: Identification and Control

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The importance of the tomato as a vegetable crop in Illinois has been increasing rapidly in the past few years, until it now ranks second in value as a truck and garden crop. Altho grown largely for market and canning, practically every home garden has a sizable planting. Like most other crops, the tomato is subject to a number of diseases and is attacked by many insects. Fortunately not all of them cause serious losses, but there are a few which, once established, require special attention if the crop is to be grown with profit.

The purpose of this circular is to place in the hands of the tomato grower information designed to help him identify and control the most important tomato diseases and insects.

General Control Measures

Aside from special control measures which pertain to specific troubles, there are several general practices that all tomato growers should follow in order to keep losses from diseases and insects at a minimum. These general practices are listed and discussed below.

1. The first step in the production of disease-free tomato plants is the selection of disease-free seeds. If seeds are saved from only healthy plants, heavy losses as well as soil contaminations may often be avoided. When seeds of uncertain origin must be used, they should be treated for 5 minutes in a solution of corrosive sublimate 1 part in 3,000 parts of water, and then rinsed with running water and dried. This material (poison) may be obtained at any drug store and should not be mixed in metal containers. If bought in tablet form, it should be used at the rate of 1 tablet to 3 pints of water. The same solution should not be used more than once.
2. Many serious field troubles originate from infested seed-bed soil. *Clean soil* which has not grown tomatoes or related crops should be used, but if it is not known to be disease-free it should be thoroughly sterilized (page 32).

3. If a grower has been using tobacco in any form, or has been handling any kind of plants, he should *wash his hands thoroughly* in soap and water before touching tomato seedlings. This practice is especially valuable in combating tomato virus diseases (see *Mosaic*, pages 5 to 7).

4. If soil sterilization is not practiced, the seeds should be *dusted with red copper oxide or copper carbonate* before they are planted. This treatment reduces materially the losses from the damping-off disease, but is not necessary if the soil has been sterilized.

5. The importance of *general field sanitation* in preventing losses from plant diseases and insects cannot be overemphasized. It is much easier, more effective, and less expensive to prevent heavy losses from plant pests than to control them once they become established. For vegetable culture in general it is a wise practice to *destroy all debris* after the crop is harvested, rather than to plow it under as is usually done. A special effort should be made to destroy plants which died during the growing season, since it is highly probable that they were killed by diseases or insects and would build up the soil infestation if left to decay. The safest way to destroy vegetable debris is to *burn* it. If animals eat it or if it becomes mixed in other ways with manure, the diseases which have been present will again be returned to the fields when the manure is used for fertilizer. *Weeds* should be eradicated in and near plantings, since they often harbor plant pests during the winter and account for their liberation in the spring.

6. *Crop rotation* is already in general practice because most growers have learned by experience that continued cultivation of a given crop on the same land soon becomes unprofitable and in many instances impossible. Tomatoes should not be grown on the same land more often than once every three years, nor should they be grown in rotation with potatoes, peppers, and other closely related crops.

7. No general recommendation can be made as to the *spraying practices* to be followed. The grower should be on the alert, however, to detect disease and insect pests and apply the proper control measures promptly.
TOMATO DISEASES

Mosaic

Mosaic is the most common tomato disease encountered under Illinois field conditions. It is often a serious trouble in greenhouse culture. Few growers recognize the importance of mosaic, since its symptoms are not always conspicuous and the losses it produces are usually ascribed to other causes. If infections occur before or during transplanting, yield is often reduced as much as 50 percent. There are very few fields of tomatoes grown in Illinois which do not have some degree of mosaic infection before the growing season is over. It has been reliably estimated that the losses to the tomato industry in Illinois from this disease range from 5 to 15 percent yearly. It is common wherever tomatoes are grown.

Cause.—Tomato mosaic belongs to a group of plant troubles known as "virus diseases." The causal agents of virus diseases have never been seen, altho their existence may be demonstrated in many ways.

Symptoms.—Any description of the symptoms of tomato mosaic is likely to be incomplete because of the many varied forms the disease has been known to assume. Temperature, rate of growth, and the age of the plants when infected are all factors which greatly influence the expression of the symptoms. The disease may be detected first and is always most evident on the young leaves at the tips of the growing branches. Infected plants never recover, altho the symptoms may become less conspicuous as the plants grow older, or when cooler temperatures prevail.

The most characteristic index of mosaic is its production of mottled areas of light and dark green upon the foliage. The dark green areas usually appear raised and puckered. The leaves at the tips of growing branches tend to be bunched and to unfold unevenly. They also may be distorted and crumpled, or reduced to narrow ribbons (Fig. 1). General stunting of growth and a yellowish cast are typical of mosaic-infected plants.

Ordinarily the fruit does not exhibit any marked effect from this disease, but in cases of severe infections it seldom reaches normal size and is generally irregular in shape and color. The reduction of yield so common in the case of mosaic-infected plants is largely due to reduced quantity rather than reduced quality, altho both conditions may exist.

Introduction and Spread.—Apparently mosaic is not seed-borne and does not persist in the soil. Initial tomato infections usually occur
from such weeds as perennial ground cherries and horse nettle, or from such hothouse crops as tomatoes and cucumbers. Oftentimes the use of tobacco by the grower, or his help, is responsible for initial infections and subsequent serious outbreaks. The disease is so extremely infectious that merely touching healthy plants after having touched diseased ones is sufficient to transmit it. Transplanting, cultivating, weeding, and attacks of insects (see *Aphids*, page 28) are all possible ways of disseminating mosaic. Greenhouse outbreaks may

FIG. 1.—TOMATO MOSAIC

Note distortion and crinkling of the leaves. The leaf at the lower left is normal.
often be directly correlated with plant pruning and the harvesting of the fruit.

*Overwintering.*—So far as is known, the mosaic disease does not overwinter in tomato seed or in the soil. Perennial ground cherries and horse nettle seem to be the chief weeds responsible for the wintering of the factor causing mosaic. Seedlings and field plantings are often infected from hothouse plantings of petunias, tomatoes, or cucumbers.

*Control.*—1. All weeds should be eradicated from seed beds and field or greenhouse plantings, especially perennial ground cherries and horse nettle.

2. If a grower has been working with other plants, he should never handle his tomato seedlings until his hands have been thoroly washed in soap and water.

3. Recommendation No. 2 applies also to growers who use tobacco in any form. Tobacco should never be used when working with tomatoes, especially cigars or chewing tobacco.

4. Early pulling and destroying of diseased seedlings and diseased plants in greenhouse culture is a very important and valuable practice. It is also worthwhile under field conditions when the number of infected plants is low, but it is of doubtful value if infections exceed 4 or 5 percent.

5. Tomatoes should not be grown next to crops such as potatoes, petunias, cucumbers, tobacco, and related plants, which are likely to carry a virus capable of infecting them.

6. If tomato insects are abundant, it often pays well as one means of preventing the spread of mosaic to fumigate, dust, or spray to control them (see *Aphids*, page 28).

**Streak**

Streak, like mosaic, is a virus disease of tomatoes, but fortunately it is seldom of economic importance in Illinois. Purplish-black streaks on the stems and petioles of infected plants are characteristic of this trouble. Young leaves usually show irregular spots of dead tissue appearing brown or black. Diseased fruits are small and show sunken discolored areas and are seldom marketable. The control measures recommended above for mosaic apply also to this trouble.

**Bacterial Canker**

Bacterial canker is one of the most destructive diseases of the tomato encountered under Illinois field conditions. It may also cause
serious damage in greenhouse plantings. Investigators in other states have reported cases of complete crop losses from this disease. Eighty-percent losses in individual fields are not uncommon in Illinois during some seasons. When the disease is general in a given field, it usually causes much greater damage than serious outbreaks of mosaic, but so far it has not been nearly so prevalent. Over a period of years this disease may prove to be the tomato growers' greatest problem if control measures are neglected. It has been reported from practically all important tomato-growing regions.

**Cause.**—The disease is caused by a bacterium (*Aplanobacter michiganense*) and so far as is known tomatoes are the only plants of commercial importance that it affects.

**Symptoms.**—The first sign of bacterial canker is usually drooping of the lower leaves accompanied by curling of the leaflets. Soon wilting becomes pronounced, progressing from the bottom of the plant upward. As the disease progresses, the leaves wilt and die, although the petioles usually remain green and firm. Unlike Fusarium and Verticillium wilts, to be described later, the petioles are very difficult to remove from the main stem, which fact aids materially in field diagnosis of this trouble. Yellowish to yellow-brown streaks usually appear on the stems of infected plants. If an infected stem is cut lengthwise, it will be noticed that close to the edge on one or both sides are lines of creamy white, yellow, or yellowish-brown discoloration. These are due to the presence of the causal bacterium in the water-conducting tubes and its subsequent spread to adjacent tissues (Fig. 3). The discoloration is generally much lighter than that typical of Fusarium or Verticillium wilt.

There are two distinct types of fruit infections from this disease, internal infection and external infection, or fruit spot. Internal infection through the vascular, or food-conducting, channels of the plant is by far the most important. The discolored tissue typical of the disease may often be traced directly through an infected plant into fruit and seeds produced thereon. This type of fruit infection does not affect materially the marketability of the fruit, but is largely responsible for outbreaks of the disease the following year.

Fruit spot, or bird's-eye spot, as it is often called, is a very common form of bacterial canker under Illinois weather conditions. The spots appear as tiny light dots which soon show a rough brownish center surrounded by a white halo (Fig. 2). Fruits may have only a few spots or they may be literally covered with them. The most serious aspect of this phase is its effect upon the market value of the fruit.
Introduction and Spread.—Bacterial canker furnishes an outstanding example of the importance of obtaining clean, disease-free seed. The causal bacterium is transmitted on and in the seed, or by the distribution of seedlings from diseased seed, or seedlings which have been grown in infested soil. Wind, rain, and cultural practices account for local spread once the bacterium is established in plants or soil.

The exact length of time the organism will survive in the soil has not yet been determined. Experience in Illinois indicates that the organism is not virulent after the land has been in some other crop one season. In general, this is in agreement with the results obtained in other states, altho the organism has been shown, in a few instances, to live two and one-half years.

Secondary spread from diseased to healthy plants has never been considered a very serious aspect of bacterial canker, since most of the infections caused in this manner are usually local in nature. Fruit spot is a good example of secondary infection.

Fig. 2.—Typical Bird's-Eye Spot of Tomato Fruit
This disease is caused by the bacterial canker organism. The light border around each point of infection is typical of this disease on tomato fruit. (Courtesy Mich. Agr. Exp. Sta.)
FIG. 3.—TOMATO STEMS INFECTED WITH FUSARIUM WILT, VERTICILLIUM WILT, AND BACTERIAL CANKER

These longitudinal sections of tomato stems show discolorations caused by Fusarium wilt (top), Verticillium wilt (middle), and bacterial canker (bottom). These three diseases are often confused because of the similarity of their symptoms. The discoloration from bacterial canker is usually more yellow and creamy in appearance than are the other two. Fusarium wilt cannot be distinguished from Verticillium wilt except by laboratory examination.

Overwintering.—The organism which causes the disease overwinters in infected seeds and infested soil. If tomato vines or fruit are mixed with manure in any way, the bacteria may also overwinter in the manure pile.

Control.—1. Seeds should never be saved from fields known to have bacterial canker.
2. If the soil of the seed beds is not known to be free from the disease, it should be sterilized or replaced with soil known to be disease-free (see page 32 for sterilization methods).

3. Tomatoes should not be planted on infested soil until it has been in other crops for at least one year, and preferably for two years.

4. Tomato vines should always be burned after the crop is harvested. This is a very wise practice whether the vines are infected or not. There are many diseases of tomatoes which this recommendation, if practiced, would tend to hold in check.

**Fusarium Wilt**

Fusarium wilt is still one of the most important field and greenhouse diseases of tomatoes in Illinois in spite of the fact that several desirable resistant varieties have been available for some time. The advent of varietal resistance has made continued tomato culture possible on over 2,000 acres of wilt-infested soil in Illinois. Without these varieties, Fusarium wilt would undoubtedly be the most damaging tomato disease in this state. It is present in all important tomato-growing regions of the United States, but does its greatest damage in the southern states and in northern states during excessively hot seasons.

*Cause.*—Fusarium wilt (*Fusarium lycopersici*) is caused by a soil fungus which enters the roots and, like bacterial canker, does its damage by growing in the water and food channels of the infected plants. It may cause the death of plants directly by plugging of these channels or indirectly by the secretion of a "toxic substance."

*Symptoms.*—Many growers know this wilt disease as "yellows." They have applied this name because of the characteristic yellow appearance constantly associated with this trouble. The first sign of the disease is a slight wilting and drooping of the lower leaves. If a section of the stem close to the base of the plant is examined at this time, or later, a distinct brown discoloration of the water- and food-conducting channels may be seen (Fig. 3).

As the disease becomes more acute, the wilting leaves and the petioles turn yellow and wither until finally the entire plant withers and dies. Shortly after a petiole and the leaflets thereon become infected and appear slightly yellow, they may be removed from the main stem by merely touching them. In the case of bacterial canker, the infected petioles seldom turn yellow and are very difficult to remove from the main stem. This fact aids materially in differentiating these diseases under field conditions.
Fusarium wilt infections may occur any time during the life of the growing plants. Seed-bed infections are very common and usually result in severe losses. Seedlings grown on infested soil usually do not show the disease until after they have been transplanted for some time. This fact illustrates the importance of sterilizing the seed-bed soil unless it is known to be disease-free.

The first symptoms of Fusarium wilt generally occur about the time of bloom or shortly after the set of the first fruit. The disease is favored by hot weather, and the high summer temperatures so common in Illinois cause infections to progress very rapidly. Plants are usually dead within two to four weeks after the first symptoms appear. Oftentimes the small side roots of infected plants show a black-rot condition typical of this disease. In damp weather a pinkish-white growth of the causal fungus may be seen protruding from wounds and leaf scars on plants killed or severely infected by the wilt organism.

**Introduction and Spread.**—Fusarium wilt may be introduced into a new area in or on the seed, by the distribution of seedlings grown in infested soil, by dust and rain storms, by cultural practices, and by farm implements. Seed is often considered responsible for the introduction of the disease into widely separated areas, while the other methods account largely for local spread. Once wilt is established in the soil it may persist there for many years, making any reasonable rotation impractical.

**Overwintering.**—The wilt fungus overwinters in infested soil, in manure piles containing tomato refuse, and on and in seeds saved from infected plants. It may infect the plant at any time during the growing season.

**Control.**—1. The most satisfactory control measure is the use of resistant varieties. The Pritchard and Break-O’Day are apparently the only early resistant varieties now generally available. Of the later varieties, Marglobe is the most popular. The Horticultural Department of the University of Illinois is developing several new wilt-resistant varieties which will be released as soon as sufficient quantities of seed are available. For greenhouse culture on wilt-infested soil, the Lloyd Forcing and Blair Forcing varieties are recommended at the present time.

2. Sterilization of seed-bed soil is advisable if it is not known to be disease-free, even tho wilt-resistant varieties are to be grown, since there are other diseases besides Fusarium wilt which may originate in seed-bed soils. If the fungus is present in greenhouse soil, resistant
varieties may be used, or the soil may be sterilized (see sterilization methods, page 32).

3. Seed should never be saved from plants that are not absolutely healthy.

4. A very important practice, seldom followed at the present time, is to destroy tomato plants after harvest, especially diseased ones.

**Septoria Leaf Spot**

The severity of Septoria leaf spot is governed by the frequency of rains and warm temperatures. As a general rule, the disease is slow in getting started and is not much in evidence before the first or middle of July. If frequent showers and warm temperatures occur during the early growing season, the disease may become established shortly after the plants are set in the field. When such conditions prevail very serious losses may result from blighting and dying of infected plants. The trouble is most serious under field conditions, but damage may occur in seed-bed and hothouse plantings.

*Cause.*—Septoria leaf spot is caused by a fungus (*Septoria lycopersici*) which may attack all varieties of tomatoes as well as horse nettle, nightshade, jimson weed, and ground cherry.

*Symptoms.*—This trouble is first evident as small gray spots, with black or brown borders. These may remain small or enlarge to about one-fourth inch in diameter (Fig. 4). If the spotting is severe, the leaves soon die and drop. The lower leaves in the damper situations are attacked first and if the weather is damp and rainy, infections spread rapidly. It is not unusual for plants to be completely defoliated; in which case exposed fruit may be severely sun-scalded and greatly reduced in size and quality.

The fungus may also attack the petioles and stems, causing small black spots which may be so abundant as to form long blackish-brown streaks and to cause subsequent killing of the plant. Fruit spotting is seldom of importance, but occasionally this form of trouble may seriously affect the market value of the infected fruits.

*Introduction and Spread.*—Spring infections of Septoria leaf spot come from the debris of plants that were infected the year before. The destruction of diseased weeds and tomato plants is very important in this connection. Occasionally tomato seedlings become infected from nearby weeds and carry the disease to the field when transplanted. Wind may carry fungal spores great distances under some conditions.
FIG. 4.—TOMATO LEAF INFECTED WITH SEPTORIA LEAF SPOT

The spotting caused by this disease may occur on leaves, stems, and fruit. When severe, it completely defoliates the plant and renders the fruit unmarketable. It seldom causes extreme damage in Illinois.
Overwintering.—The Septoria fungus overwinters on the debris from infected weeds and tomato plants.

Control.—1. The best and most effective control measure for Septoria is to prevent it by practicing general sanitation. Tomato vines should be raked in piles and burned after the growing season is past. The debris from horse nettle, ground cherry, nightshade, and jimson weed should be treated likewise and an effort made to eradicate these weeds from tomato plantings.

2. When field infections occur, they may be controlled by spraying with a 4-4-50 bordeaux mixture at 10- to 14-day intervals. The bordeaux mixture should be made of high grade hydrated lime (4 pounds), copper sulfate (4 pounds), and 50 gallons of water. Directions for mixing bordeaux are given on pages 34 and 35.

Verticillium Wilt

This disease in many respects is similar to Fusarium wilt. It is caused by a soil organism \((\text{Verticillium alboatrum})\) which may be seed-carried. This fact probably accounts for its introduction into widely separated areas. Unlike Fusarium wilt it thrives best under cool moist conditions and is more serious in the northern states and Canada than in the southern states.

Altho this disease has been identified on plants from many localities in Illinois, it is not as yet a serious problem. Very little is known as to the resistance of various varieties to this trouble. It is definitely known that varieties resistant to Fusarium wilt are not necessarily resistant also to Verticillium wilt, but a few of them may be (Fig. 5).

The control measures are exactly the same as those described for Fusarium wilt except that No. 1 is not applicable. If this disease becomes established in the greenhouse or seed bed, the soil must be sterilized if tomatoes are to be grown (see page 32 for sterilization methods).

Bacterial Spot

Bacterial spot is widely distributed in Illinois and is particularly serious in warm seasons with frequent rains or heavy dews. The disease is commonly known as "scab," because of the scab-like appearance of the spots upon the fruit. The development of these spots is the most serious aspect of the disease in Illinois (Fig. 6).

Bacterial spot is caused by a bacterium \((\text{Bacterium vesicatorium})\) and is carried upon the seed from year to year. It may be controlled by treating the seeds with a 1 to 3,000 corrosive sublimate solution for 5 minutes and then thoroly washing them in running water.
Once the disease is established in the soil, tomatoes or peppers should not be grown thereon for at least three years. Altho losses to individual growers are sometimes rather large, the disease has not as yet caused major concern. The seedling and leaf-spot stages have not been observed in serious form. If the general control practices listed on pages 3 and 4 are followed, this disease can be controlled.

![Image of Pritchard Tomatoes Infected With Verticillium Wilt](image)

**Fig. 5.—A Field of Pritchard Tomatoes Infected With Verticillium Wilt**

Pritchard tomatoes, tho resistant to Fusarium wilt, are subject to attack by Verticillium wilt. Note the complete defoliation of the infected plants. Seed should never be saved from a field known to have this disease.

**Blossom-End Rot**

Blossom-end rot is a physiological disease caused by extreme fluctuations in the water supply of the growing plants. It may be a very serious trouble in field or hothouse culture. The fruits seem most susceptible when they are one-half to two-thirds grown, but the disease may appear at any stage of development. A small water-soaked spot around or near the blossom-end is the first sign of the disease. As the trouble advances, the spot enlarges and soon becomes sunken, brown, and leathery (Fig. 7). It may be very small or in severe cases may involve more than half the affected fruit. Rotting of
fruits affected with blossom-end rot by other organisms is very common.

Any practice which tends to conserve moisture and give a uniform supply will help to reduce losses from blossom-end rot. Under field conditions all weeds should be destroyed and in dry weather cultivation should be limited to that absolutely necessary for weed control. In the greenhouse this disease can be completely controlled by maintaining a uniform supply of soil moisture.

![Fig. 6.—Scab or bacterial spot on tomato fruit](image)

The common name, scab, is very descriptive of this disease of the tomato fruit. The spots are usually quite large. (Courtesy Mich. Agr. Exp. Sta.)

**Damping-Off**

Damping-off is common wherever tomato seedlings are grown. Several soil organisms may cause this trouble, which is characterized by the toppling over of infected seedlings. Infections usually occur at the ground level and the infected tissue appears soft and water-
The lesion caused by blossom-end rot may vary from a tiny spot to a very large one involving over half the tomato.
soaked. As the disease advances the infected stems become constricted and the plants collapse (Fig. 8).

Damp, cloudy weather, along with over-watering, brings about ideal conditions for severe damping-off of the young tender seedlings. Over-crowding of plants should be avoided, as well as over-watering. Soil sterilization of the seed bed is the most satisfactory way of controlling damping-off, since it also controls several other important tomato diseases if they are present (see page 32 for sterilization methods). Dusting the seed with red copper oxide or copper carbonate has given good results in experimental tests, but if the soil is badly infested, soil sterilization is the safest practice. Both the above chemicals may be purchased at drug stores and usually also from seedsmen. Damping-off is important only as a seedling disease, altho new transplants may be killed under cool, wet conditions.

**Leaf Mold**

Leaf mold is principally a greenhouse trouble which is of fungous origin (*Cladosporium fulvum*). The development and spread of this disease depend upon high humidity and poor ventilation. All above-ground parts of the plant may be affected, altho generally the greatest damage occurs to the leaves. Infections usually progress from the

![Fig. 8.—TOMATO SEEDLINGS SHOWING TYPICAL DAMPING-OFF INJURY](image-url)

Note the shriveled stems of the seedlings affected with damping-off disease. The plant on the left is healthy. (Courtesy Mich. Agr. Exp. Sta.)
lower leaves upward, and if control measures are not practiced, the entire plant may be involved, causing complete losses.

Yellowish or light green spots on the upper side of infected leaves are the first evidence of the disease. On the under side of the leaf, directly beneath the above discoloration, the infection appears as a grayish-purple spot with a velvet cast.

If a greenhouse is known to have the leaf-mold fungus present, it should be thoroly fumigated by burning 1 pound of sulfur to every 1,000 cubic feet of space before any tomato plantings are made in it. *No plants should be left in the greenhouse during this operation.*

Practices which reduce humidity should be carefully observed. Forced ventilation by electric fans often gives beneficial results. Proper adjustment of ventilators and watering are also very important factors in controlling greenhouse humidity. During cold, damp, cloudy weather, if leaf mold is present, the temperature of the greenhouse should be maintained without fluctuation day and night to prevent the precipitation of moisture on the leaves.

Other methods of control than those given above are possible, depending upon the peculiarities of individual cases. The disease, however, is not ordinarily serious enough to merit their inclusion here. If leaf mold is a problem in your greenhouse, details of other control measures may be had by writing to the Horticultural Department, University of Illinois, Urbana.

**Hollow Stem**

Hollow stem is a physiological tomato disease which may be observed in practically all stages of plant development. If care is exercised in producing and selecting seedlings, this disease is of little importance.

The best single practice to prevent losses from hollow stem is to avoid the use of “spindly” transplants. All seedlings should be properly hardened off before they are set in the field and should not be transplanted into dry soil. A well-balanced seed-bed soil is also very essential.

**Collar Rot**

This disease may apparently be caused by at least four fungi (*Verticillium lycopersici, Macrosporium solani, Rhizoctonia solani*, and *Phytophthora cryptogea*), which attack the plants in the seedling stage. The plant is attacked at or near the ground level. The tissue becomes brittle and in many cases the plants topple over. The diseased area appears as a brown, sunken lesion which may partially or completely
girdle the infected stem. The extent of the injury on any given plant is directly correlated with the amount of girdling.

Collar rot has been observed only on seedlings shipped in from other states. A careful examination of the stems of the plants to be set and prompt disposal of diseased ones is sufficient to avoid subsequent heavy losses. This trouble should not be confused with damping-off, described on page 17.

TOMATO INSECTS AND THEIR CONTROL

The most important of the insects attacking tomatoes are flea beetles, tomato worms, garden slugs, cutworms, and aphids, or plant lice. In the greenhouse, the tomato may also be attacked by whiteflies, nematodes, and symphylids.

All the tomato insects are more or less general feeders, attacking potatoes, eggplants, peppers, and such weeds as ground cherry, horse nettle, and buffalo bur. Preventing these plants from becoming heavily infested with insects is often of considerable value in reducing injury to tomato.

Types of Injury.—Insects attack the tomato in a number of ways. They may eat the foliage and fruit, destroy the roots, suck sap from the plants, or transmit harmful disease organisms. The type of injury depends largely upon the feeding habits of the insect.

Two general types of injury occur: (1) that done by chewing insects, such as the tomato worms and flea beetles, and (2) that done by sucking insects, such as aphids and whiteflies. The chewing insects eat away parts of the plant and are usually controlled by a stomach poison. Sucking insects secure their food by piercing the plant with their needle-like beaks and sucking out the sap. For their control, a contact poison is most effective. Stomach poisons are of no value against sucking insects on plants.

Flea Beetles

Tomatoes are attacked by several species of flea beetles. The most important of these are the potato and eggplant flea beetles. The adults of these insects are about $\frac{1}{16}$ inch long, brownish-black to black, and very active when disturbed.

Injury.—Flea beetle injury to the tomato is usually most severe during the early growing season. Severely injured plants look as if

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1Epitrix cucumeris Harr. and Epitrix fuscula Crotch.
they had been peppered with fine shot, the leaves being filled with small holes where the beetles have fed (Fig. 9). The margins of these feeding punctures usually dry out and cause the death of an entire leaf or plant. The young of flea beetles attack the roots and lower stems of some crops, but are not of much importance on tomatoes.

Control.—Young tomato plants should be closely watched, especially after they are transplanted, and control measures applied upon the first appearance of injury. Either a dust or spray may be used effectively to control flea beetles on tomato plants if the plants are thoroly covered. Untreated parts of a plant are quickly detected and fed upon by the beetles.

Barium fluosilicate, calcium fluosilicate, or arsenate of lead may be used against these insects on small plants, but should not be used after the fruit has set.

Arsenate of lead mixed with hydrated lime, at the rate of 1 pound of the poison to 4 parts of lime, and heavily dusted on the plants will give satisfactory control of flea beetles. If fluosilicates are used, they should be mixed with talc or flour according to the directions of the manufacturer.

Arsenate of lead at the rate of 1½ to 2 pounds to 50 gallons of 4-4-50 bordeaux mixture (page 34) will also give good control of flea beetles on tomatoes.

Life History and Habits.—Flea beetles spend the winter in the adult stage under trash and rubbish in or near the tomato field. In the spring they emerge and feed for a while upon wild host plants and

![Fig. 9.—Flea Beetle Injury on Young Eggplant](image-url)

Note the numerous small holes eaten in the leaves. Injury to the tomato has the same appearance.
later upon the tomato and other cultivated crops. The eggs are laid in the soil around plants upon which the adults feed. They hatch after a few days, producing small white or yellowish-white larvae which feed upon the roots and lower stems. One or two generations are produced each year.

**Tomato Worms**

The largest and best known of the tomato insects are the hornworms (Fig. 10). These worms when full grown are 3 to 4 inches long, are green to brown in color with diagonal white stripes along the sides, and have a prominent horn on the rear end of the body.

*Injury.*—Hornworms are ravenous feeders. During the two or three weeks spent on tomato plants, hornworms consume large quantities of foliage and occasionally attack the fruits. Injury usually becomes apparent about the middle of the summer and continues until the end of the growing season unless the worms are controlled.

*Control.*—Hand-picking is an effective method for ridding a small garden of these worms.

In larger fields hornworms are usually held in check by small wasp parasites. The young parasites feed until full grown, within the body cavity of hornworms, after which they work their way to the outside where they spin their small white cocoons (Fig. 10-B). Worms bearing these, altho not dead, will not feed and should not be destroyed. In a short time, adult parasites emerge from the white egg-like cocoons to attack other hornworms.

The derris dust recommended for control of tomato fruit worms (page 25) may be of some value against newly hatched hornworms, but will not give a satisfactory kill of the larger worms. Arsenicals and fluosilicates should not be used on account of the danger from poisonous residues on the fruit.

*Life History and Habits.*—Hornworms spend the winter as dark brown, inactive pupae several inches below the soil surface. In the spring they emerge as large, dark gray hawk moths. These are often seen hovering over petunia, jimson weed, and other flowers from which they sip nectar. The greenish yellow eggs are laid on the underside of tomato leaves where they hatch in about a week. About three weeks are required for the worms to become full grown. At least a fully first and a partial second generation occur during the growing season.

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1*Protoparce sexta* Johan. and *P. quinquemaculata* Haw.
FIG. 10.—HORNWORMS AND HORNWORM PARASITES

Hornworms are voracious feeders; one is shown in A stripping a plant of foliage. Hornworms with cocoons of parasites attached to the backs of their bodies (B) should not be destroyed, since they do no further feeding. Parasites emerging from these cocoons attack other hornworms.

Tomato Fruit Worms

The corn earworm and several species of cutworms attack tomato fruit. Of these, the corn earworm is by far the worst offender. This worm ranges in color from a flesh pink to green or dark brown, with longitudinal stripes along the body. Full-grown worms are usually about 1½ inches long.

¹The corn earworm, *Heliothis obsoleta* Fab., and several species of cutworms.
Injury.—Unlike hornworms, the fruit worms feed mainly on tomato fruit. The corn earworm attacks fruit of all sizes and usually does considerable damage when abundant. It does not confine its feeding to a single fruit, but moves from one to another, destroying much more than it consumes. Damage to the tomato crop (Fig. 11) is greatest when corn earworm moths are abundant and the supply of food plants is more or less limited. In northern Illinois the greatest injury occurs during the latter part of the growing season.

![Tomato Fruit Worm and Injury](image)

**Fig. 11.—Tomato Fruit Worm and Injury**

The injury shown here is typical of this insect. The fruit is ruined by the feeding of these worms.

Cutworms sometimes attack tomato fruit, but they are ordinarily not of much importance as fruit worms.

Control.—The tomato fruit worm is not abundant enough every year to necessitate regular dusting or spraying.

Experiments during 1934 indicate that heavy applications of derris dust containing .5 percent of rotenone will control fruit worms on tomato plants if applied before the infestation becomes heavy. This dust acts chiefly as a contact poison against the newly hatched worms and is not very effective against worms that are half-grown or larger. The first application should be made as soon as the worms appear to be causing injury and should be repeated at intervals of 7 to 10 days, as necessary to hold the worms in check. The dust should be applied late in the afternoon or early in the morning.
Derris is a relatively new poison that is safe to use on tomato fruit at any time. It is not very dangerous to man and can be removed easily by washing. Further work with rotenone must be done before final recommendations regarding its use can be made.

When small quantities of derris dust are needed, a ready-mixed commercial preparation is recommended. Directions for mixing quantities of derris dust can be secured by writing to the Illinois State Natural History Survey at Urbana.

Life History and Habits.—The corn earworm does not overwinter much north of the Ohio river. To the south it spends the winter 2 to 6 inches beneath the soil surface as a brown pupa. The moth which emerges in the spring has a wing spread of about 1½ inches. The wings are dark straw to grayish brown.

When the moths are abundant, they lay their eggs on the fresh silks and tassels of corn, on tomato plants and eggplants, or on other wild and cultivated host plants. One to two weeks are required for the eggs to hatch during the fall months. The worms feed for three weeks or more before becoming full grown. During this time each worm will injure several fruits. Pupation takes place in the ground soon after the worms become mature; however, none of those pupating in the late fall are able to survive the cold winter in Illinois.

Garden Slugs

The presence of slugs may be easily detected by the shiny trails of slime they leave in their paths. These slimy, repulsive creatures resemble snails in general appearance. They range in color from gray to dark blue and are from 1 to 3 inches long.

Injury.—Slugs are most troublesome during seasons when there is an abundance of moisture. They rasp out holes in the foliage and fruit of tomato plants, the principal injury being to the ripening fruit. Blemishes and decay are common on tomatoes that have been attacked.

Control.—Injury from slugs can be prevented by spraying tomato plants with a 4-4-50 bordeaux mixture (page 34) or by dusting with hydrated lime during the late afternoon. These materials irritate the body of slugs that come in contact with them and cause the slugs to avoid treated plants. The poison bran bait recommended for cutworms (page 36) is also effective against slugs.

Life History and Habits.—The eggs of slugs are laid in clusters in the moist soil or other protected places. These hatch in three weeks or more, depending upon the weather. Development depends largely

1Several species.
upon food and living conditions. Slugs are said to live for several years.

**Cutworms**

Most growers are familiar with cutworms and the damage they do. These plump, well-fed worms (Fig. 12) vary considerably in habits and appearance. They are usually from gray to brown or black in color and are from 1½ to 2 inches long when full grown.

**Injury.**—Cutworms are ordinarily most troublesome during the early spring months, cutting off plants in the hotbed or in the field and garden soon after transplanting. They may cut the plants off at or near the ground level, feed on the foliage or fruit, or destroy the roots. The injury caused by the worms cutting off the young plants is usually most noticeable.

**Control.**—Clean cultivation of crops that precede tomatoes is of considerable importance in cutworm control. Sod or weedy ground upon which tomatoes are to be grown should be plowed during late

\[\text{Several species.}\]
summer or early fall and kept clean in order to prevent egg laying by cutworm moths.

In a small garden, cutworms can be collected by hand, or young plants can be protected by means of tin or cardboard cylinders pressed into the soil around the plants.

Cutworms that attack plants aboveground can be successfully controlled by means of the poison bran bait described on page 36. The bait should be evenly distributed at the rate of 8 to 10 pounds an acre after sunset. Bait that is applied earlier tends to dry out and becomes unattractive to the worms. The oil bait is easier to distribute, and dries out less rapidly than that containing molasses and water. Land that is known to be infested with cutworms in the spring should be baited several times before the tomatoes are transplanted, and afterwards if necessary.

The black cutworm and others that feed underground cannot be successfully controlled by means of the poison bran bait.

*Life History and Habits.*—Most of the common cutworms pass the winter in the worm stage. They may be found hibernating in the soil, in clumps of grass, or other protected places. Feeding begins early in the spring and continues until the worms become full grown, at which time they change to brown, inactive pupae underground, from which moths emerge later. Eggs are laid on the ground, on the stems of weeds, grasses, or other plants. Most of the common cutworms have but one generation a year.

### Aphids or Plant Lice

Aphids, or plant lice, are small, soft-bodied insects that secure their food by sucking sap from the plants. They are about 1/6 inch or less in length, and vary in color from solid pink to dark green. Both winged and wingless adults may appear on the same plant.

*Injury.*—Aphids are seldom abundant enough on tomatoes to kill the plants. They may, however, stunt the plants and injure the fruit clusters enough to reduce yields. They also transmit virus diseases of tomato (see page 5).

Aphids prefer the shaded portions of a plant, but may be found on exposed blossom clusters and growing tips. They feed entirely on juices extracted from the plants by means of their small, piercing mouth parts.

Whether grown in the greenhouse or out-of-doors, tomatoes should

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*Macrosiphum gei* (Koch) and other species.
be carefully watched for aphid infestation and promptly and thoroly treated if the insects are abundant enough to cause damage.

Control.—Aphids can be controlled on tomato plants by thoro and repeated applications of a nicotine spray or dust. Applications should be made at intervals of 2 to 3 days until the infestation is cleaned up. Complete coverage is essential if satisfactory results are to be obtained from spraying or dusting.

A spray containing ½ pint of 40-percent nicotine sulfate to 50 gallons of 4-4-50 bordeaux mixture (page 34) will give good control of aphids on tomato plants. The same amount of nicotine sulfate added to 50 gallons of water containing 1 quart of Penetrol, or 2 to 3 pounds of laundry soap, or potash fish-oil soap, will also give good results as a spray.

A 2.4-percent nicotine dust made according to directions on page 35 will give a good kill of aphids and can often be used to better advan­tage than a spray on the larger plants.

Greenhouse tomatoes can be freed of plant lice by dusting or spray­ing as outlined above or by fumigation as for whiteflies (page 30).

Life History and Habits.—The potato aphid, which is commonly found on tomato plants, spends the winter in the egg stage on rose bushes. During the summer, winged females are produced that migrate back to potato, tomato, and other plants, where they feed and reproduce. Both winged and wingless females occur, each being capable of giving birth to as many as 50 young over a period of two weeks. Ten days to three weeks are required for the young to reach the adult stage. During the fall months winged females migrate back to the rose, where a generation of egg-laying females is produced. A num­ber of generations are produced each year.

Whiteflies

Greenhouse tomatoes are sometimes infested with tiny, powdery-white flies that swarm off the plants when disturbed. The adults are about ¼ inch long, have four wings, and may be easily seen at rest on the under side of infested leaves. The young are very small, oval, scale-like creatures. They are light-green and are found on the under side of leaves.

Injury.—Injury from this pest is common on tomatoes and other greenhouse crops. Both adults and young suck sap from the plants, causing them to become stunted and unproductive if the infestation

₁Trialeurodes vaporariorum Westw.
is very heavy. The young excrete a sticky substance which covers foliage or fruit and supports a growth of black fungus.

Control.—Whiteflies can be controlled most easily by repeated fumigation with cyanide. Only the adults are killed by the fumigation, so that it is necessary to repeat applications at intervals of about two weeks until an infestation is cleaned up. Two fumigations are usually sufficient. Calcium cyanide at the rate of ¼ ounce to 1,000 cubic feet of space will kill the adult flies in an average greenhouse.

Fumigation with cyanide should be attempted only by one who is thoroly familiar with the use of this material. Cyanide is a deadly poison which should be kept in air-tight containers out of reach of children or irresponsible persons.

Life History and Habits.—All stages of whitefly may be found at any time in an infested greenhouse. The eggs, which hatch in 10 to 14 days, are deposited on the under side of leaves. After hatching, the nymphs attach themselves and begin sucking sap from the plants. They are then oval shaped, motionless, and light green. About two weeks from the time of hatching, adults emerge and begin at once to lay eggs.

Eelworms or Nematodes

Root-knot of tomato (Fig. 13) is caused by microscopic eelworms, or nematodes. In Illinois these pests are of greatest importance in the greenhouse, but may be found attacking tomatoes in the field, especially if the young plants were grown in infested soil.

Injury.—These very small white worms bore into the roots of tomato and other crops, causing characteristic knots or swellings, as shown in Fig. 13. This enlargement and abnormal growth of the roots prevents the normal transportation of water and food materials, causing the plants to become stunted and eventually to die. If tomatoes show a tendency to wilt or die prematurely, a few plants should be dug up and the roots examined for this trouble.

Control.—Injury from root-knot nematodes can be prevented in the greenhouse by careful and thororo sterilization of infested soil, benches, and walks with steam prior to planting, as outlined on page 32. Every precaution should be taken to prevent infestation in houses that are free of this pest.

Young tomato plants that are to be transplanted to the field should not be grown in soil infested with nematodes.

Field or garden soil that is known to be infested should not be planted to tomatoes or other susceptible crops.

1Heterodera radicicola Mull. and other species.
Symphylids¹

Symphylids are primarily greenhouse pests in this state. The adults are pearly white, about ¼ inch long, and may be found to a depth of 3 feet in the ground.

Injury.—Greenhouse tomatoes cannot be grown successfully in

¹Scutigerella immaculata Newport.
soil that is infested with symphylids. Unlike nematodes, these tiny creatures eat off the young roots, causing the plants to become badly stunted and eventually to die. The larger roots and underground portions of the stems may be attacked, and become warty and rough.

Control.—Prevention is better than cure in the case of these pests. Once an infestation has become well established in a greenhouse, it is hard to clean up. Symphylids are most easily controlled in raised benches, but even this is difficult. Steam sterilization of soil and benches will kill all symphylids and eggs present if properly done. In ground benches, steam sterilization will kill all symphylids in the upper part of the soil. Since some of the eggs and adults survive in the lower subsoil, sterilization will have to be repeated each year in order to prevent serious injury. Walks, as well as benches, must be treated. (For directions for steam sterilization, see below).

Reinfestation is sure to occur in sterilized benches if infested soil is brought in from the outside or other parts of the greenhouse.

Life History and Habits.—All stages of symphylids may be found throughout the year in an infested greenhouse. The eggs, which are almost invisible to the naked eye, are usually laid several inches below the surface of the soil. Four to six weeks are required for symphylids to complete their development from egg to adult. Their entire life is spent below the soil surface.

SOIL STERILIZATION METHODS

Sterilization of the soil by steam, when properly done, affords effective control of all soil-borne diseases, nematodes, insects, and weeds. Other methods of soil sterilization may be employed, but steam is the best all-round method.

Tile Method of Applying Steam.—The most modern and efficient method of sterilizing the soil in greenhouse ground beds is by steaming with tile lines. If the soil is tiled for drainage, the same lines may be used for steaming provided they are close enough together. The best results have been obtained by using 4-inch tile laid in parallel lines 24 inches apart and at a soil depth of about 15 inches. The steam should be turned into the tile lines at 15 to 25 pounds pressure.

The time required to give satisfactory results varies between two and four hours. Covering the soil with such material as canvas or boards will shorten the time required. The process may be considered complete when a medium-sized potato, placed about 3 inches under the surface of the soil between two tile lines, is well cooked.
If the entire area is not simultaneously treated, extra care must be taken to prevent contamination of the sterilized soil by the untreated. The entire area of any given unit, including walks, must be treated in order to prevent contamination.

Pipe Method of Applying Steam.—The pipe method is essentially the same as the tile method and is especially adapted to raised benches, but may also be used for ground beds. Care must be taken to prevent contamination of the treated soil in ground beds when the lines are moved. The piping should be 1½ to 2 inches in diameter and bored with 3/16-inch holes at intervals of one foot. The piping, holes down, is placed in the ground about 15 inches deep and about 18 inches apart. In the case of benches the piping should be placed about 1 inch from the bottom of the bench and 15 inches apart. The length of treatment and method of determining the completeness of the job are the same as in the tile method.

The piping may be installed as a permanent fixture but most growers prefer to remove it after each sterilization, which practice prevents its rapid deterioration. The pipes are removed easily if wires are fastened at 15- or 20-foot intervals when the lines are being laid. The wires should extend above the soil surface far enough to be readily accessible. The soil should be covered with canvas, paper, burlap, or boards. This practice shortens materially the time required to complete the sterilization process.

Pan Method of Applying Steam.—The inverted-pan method is also a reliable method of applying steam to the soil and is especially adapted to sterilizing the soil in benches and flats. It may also be used on ground beds if the area to be treated is small and the soil well loosened before treatment. The pan may be any desired shape in order to fit a given width bench or ground area. It should be at least 8 inches deep and pressed firmly into position before steaming. The total surface area of the pan should not exceed 75 square feet. Five pounds of steam pressure is sufficient for this method.

For the sterilization of soil in flats the material to be treated is placed, flats and all, under the pan. The process in flats and benches is usually complete after 1 to 2 hours of steaming, but almost twice this time is required for ground-bed sterilization. If the potato is used as an indicator, it should be placed on the bottom of the bench or at the required soil depth instead of a few inches below the surface of the soil.

Hot Water Method.—Sterilization with boiling water is often practical and efficient when the total area to be treated is small. It is
especially useful as a sterilization process for benches and flats, but cannot be relied upon to control nematodes. The treatment is most effective if the soil is dried out before the boiling water is added.

At least 7 gallons of boiling water are required to treat one square foot of soil in benches and about half that amount for the average size flat. When benches are treated, they should be sectioned off so that when the 7 gallons of water per square foot are added they will cover the entire area evenly. As soon as the water has seeped thru the soil, the bench should be covered with canvas, paper, burlap, or boards to help hold the heat.

Formaldehyde.—In the event that the above methods are not applicable, a formaldehyde sterilization may be employed, altho it is generally quite expensive and not satisfactory for the control of nematodes. The formaldehyde solution is made by diluting 1 pound of commercial formaldehyde (formalin) in 20 gallons of water. The diluted solution is then applied to the soil until it is saturated. This usually requires about 1 1/2 gallons per square foot. For best results the soil should be dried out and loosened before treatment and covered after treatment with canvas, paper, burlap, or boards.

Seeds or plants must not be placed in the treated soil for ten days or two weeks after applications have been made.

**FUNGICIDES AND INSECTICIDES**

Several fungicides and insecticides are commonly used on tomato plants. Below are given formulas and directions for mixing them.

**Bordeaux Mixture**

When a very small quantity is needed, a ready-mixed commercial bordeaux may be used. It should be used according to the directions of the manufacturer.

For a considerable quantity, bordeaux can be prepared by the grower according to the following formula:

- 4 pounds copper sulfate (blue vitriol)
- 4 pounds hydrated lime
- 50 gallons water

Copper sulfate is available in lump or powdered form. Because of greater ease in handling, the powdered form is preferable.

For mixing bordeaux, *agitation should be provided throughout the operation*. After the spray tank has been partially filled with water, the proper amount of lime should be added in the form of a thin paste.
or sifted directly into the tank as a powder. The copper sulfate, previously dissolved in a small amount of water, should then be poured slowly into the tank and the remainder of the water added.

_Caution._—Copper sulfate should not be dissolved in metal containers. The mixture is most effective if used within a few hours after it is made, since it settles out and changes in composition upon standing.

**Bordeaux Dust With Stomach Poison**

For some pests that attack tomatoes, a copper dust containing a stomach poison gives effective control. The dust can be prepared according to the following formula:

- 16 pounds monohydrated copper sulfate
- 64 pounds hydrated lime
- 20 pounds arsenate of lead

Ordinary copper sulfate should not be substituted for the monohydrated form. Only the best grade of hydrated lime should be used. After the ingredients have been weighed, they should be thoroughly mixed, using the proportions given. This dust should not be allowed to stand in open containers for long periods before using.

**Nicotine Dust**

Hydrated lime is used as a standard base for nicotine dust prepared for use in the home garden.

When making large amounts of dust, place 47 pounds of hydrated lime in a barrel having a tight-fitting cover. Pour 3 pounds 40-percent nicotine sulfate over the lime, add about 30 smooth stones the size of an egg, and roll the barrel back and forth over the floor or rotate by mounting the barrel in a frame with a rod attached to the center of the barrel. This kind of frame has a crank at one end by which it may be turned, and the barrel should be rolled or turned at the rate of 35 or 40 revolutions a minute. If it is turned rapidly, the mixing is not so complete as when it is moved at the suggested rate of speed. A churn may be substituted for the barrel as a container for mixing the dust.

To make the dust in small quantities, place 1 pound of hydrated lime in a small keg or bucket having a tight-fitting lid. Pour 1 ounce of 40-percent nicotine sulfate over the lime. Place 12 to 15 pebbles about the size of a walnut in the container, close the lid, and rotate for about 10 minutes.

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*This section is from Ill. Agr. Exp. Sta. Circ. 391 by C. C. Compton.*
Be careful upon opening the container not to hold the head close to the opening, as a large amount of nicotine is given off, which may cause a severe headache or nausea. It is best to mix the dust just before it is to be applied. If for any reason this is impossible, the dust should be stored in tight containers as soon as it is mixed. If allowed to stand for 3 or 4 weeks it will lose some of its strength, altho if the container is air-tight it may be held for a month or two without any great depreciation in insecticidal value.

Poison Bran Bait

Large or small quantities of poison bran bait may be made according to the following formula:

<table>
<thead>
<tr>
<th>Large quantity</th>
<th>Small quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bran</td>
<td>25 pounds</td>
</tr>
<tr>
<td>Molasses</td>
<td>2 quarts</td>
</tr>
<tr>
<td>Water</td>
<td>10 quarts</td>
</tr>
<tr>
<td>Paris green</td>
<td>1 pound</td>
</tr>
</tbody>
</table>

The dry bran and Paris green should be mixed thoroly, after which the molasses and water, previously mixed, should be added slowly, with constant stirring. The bran should be coated thoroly with the poison and molasses. The finished bait should contain just enough water to make it hold together, and not enough to make it sloppy.

An oil bait has recently been worked out that shows much promise as a substitute for the above bait. It may be prepared from the following formula:

<table>
<thead>
<tr>
<th>Large quantity</th>
<th>Small quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bran</td>
<td>25 pounds</td>
</tr>
<tr>
<td>Lubricating oil (medium heavy)</td>
<td>2 quarts</td>
</tr>
<tr>
<td>Paris green</td>
<td>1 pound</td>
</tr>
</tbody>
</table>

Mix bran and poison and add oil as for the molasses and water above.