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Diseases of Some Vegetable and Fruit Crops and Their Control

by A.G. Plakidas

Bulletin No. 357 (Revised)
Agricultural Experiment Station
Charles W. Upp, Director
Louisiana State University and Agricultural and Mechanical College
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Introduction

This bulletin was first published in 1943. It became very popular because it came to fill a long-felt need for a convenient handbook for reference and use by county agents and farmers. The supply of the original printing has long been exhausted, but even before exhaustion it was felt that a revision was necessary. The organic fungicides, which have displaced to a large extent the copper and sulphur compounds as sprays and dusts, were unknown when the bulletin was first written. The disease situation in certain crops has changed during the past few years. For example, internal cork, which at present ranks as perhaps the most important disease of sweet potatoes, was unknown when the bulletin was first written. The same is true of Tristeza of citrus trees. Bacterial blights of beans, very important then, have been practically eliminated by the use of certified blight-free seed.

No attempt has been made to include all crops growing in Louisiana or all diseases of each crop. The important diseases of only the vegetable and fruit crops are considered. Consequently, some of the most important crops of the State, namely, sugarcane, rice, cotton, and corn, are not included.

Causes of Plant Diseases

It will probably be easier to understand the discussion of the individual diseases and their control if a brief, general account of the causes of plant diseases and troubles is presented first. The different causes of plant diseases and troubles are given in the following outline:

I. Parasitic Diseases
   1. Fungi
   2. Bacteria
   3. Nematodes
   4. Insects

II. Non-parasitic Diseases

1. Unfavorable climatic conditions
2. Adverse soil conditions
3. Noxious gases

III. Virus Diseases

Fungi are the most important plant-disease producing organisms. They are minute organisms composed mostly of a thread-like body (the "mycelium") and of microscopic fruits (the "spores"). The spores may, for convenience, be termed the "seed" of the fungi because it is by means of these organs that fungi are disseminated

1 The injuries caused by insects are not considered in this bulletin. Information on insect pests of different crops can be obtained from the office of Extension Entomologist, Louisiana Agricultural Extension Division, Baton Rouge, Louisiana.
and infect the plants. Fungi cause many different kinds of diseases. They may attack the underground parts of the plant causing various root rots; they may attack the above-ground parts causing various cankers on the trunk and branches, rusts and mildews, leaf spots, blights of leaves and flowers, and various rots and molds of different fruits; or they may invade the vascular system of the roots and stems to produce wilting. The combating of fungous diseases is, therefore, a complicated process. It is necessary to know the life history of the particular fungus involved in order to know when to apply the fungicide to do the most good. Generally speaking, fungous diseases occurring on the above-ground parts of a plant are fairly easily controlled by sprays or dusts. The soil-inhabiting fungi which attack the roots and those that invade the vascular system of the stems are most difficult to control.

Bacteria are microscopic organisms much smaller than fungi. Like fungi, bacteria are capable of causing a great diversity of diseases. They, also, can invade the vascular system of plants and cause wilts. They can attack leaves, stems, shoots, blossoms, and fruit of different plants and cause serious blights (bean blight and fire blight of pears and apples, for example). In addition, bacteria can attack roots and crowns, which results in the formation of swellings and knots (crown gall). They can cause cankers on trunks and branches of trees, and various rots of fruits and vegetables. Bacterial diseases are much more difficult to control by sprays and dusts than are those caused by fungi.

Nematodes are microscopic animals (eelworms). The most common and most destructive species is the one that causes galls or knots on the roots of many plants (root knot nematode). However, not all species of root-feeding nematodes cause the formation of galls or knots on the roots. Some species invade the roots, causing death of the tissue without the formation of galls; others feed on the roots from the outside causing great damage. There are also species of nematodes that prefer to feed inside the crowns or buds of certain plants (see “strawberry dwarf,” p. 109) and still others that attack leaves, stems, and flowers of different plants. The root knot nematode alone can attack a very large number of different plants (over 1200 kinds of plants are known to be affected) and it can survive in the soil outside the plants for a long time. Nematodes are very common in the South, especially in light sandy soils. They are very difficult to control.

Non-parasitic diseases are caused by adverse climatic or soil conditions, such as cold, heat, drought, poor drainage, unfavorable soil reaction (acidity or alkalinity), general infertility of the soil, lack of one or more of the “minor elements” (zinc, manganese, copper, boron, etc.) or excess of soluble salts, or the presence of a toxic substance in the soil, etc. In cities and in the vicinity of industrial plants, smoke and poisonous fumes may cause injury. Some of the herbicides
(weed killers) and defoliants that have come into general use in modern agriculture often cause serious injuries (see Section IV, pages 128-131).

For convenience, virus diseases have been placed in a separate group instead of being included either among the parasitic or the non-parasitic causes, because it is not definitely known whether viruses are living or non-living. In some ways viruses behave like living organisms and in other ways like non-living chemical substances. What is known is that viruses are ultramicroscopic (they cannot be seen even with the strongest microscope) entities which, when introduced into the plant, increase and spread very rapidly, and produce specific diseases which are often very destructive. Virus diseases are spread chiefly by insects (aphids, leaf-hoppers, thrips, etc.) which feed on diseased plants and then on healthy ones, but some can also be spread mechanically during handling operations. Tomato mosaic, for example, is often spread during pruning and staking.

Viruses produce a great variety of symptoms depending on the kind of virus and often on the kind of plant. Some of these symptoms are green and yellow mottling of leaves (mosaic), general yellowing or chlorosis (yellows), dwarfing and stunting of the growth of the entire plant, distortion or rolling of leaves, dead spots on leaves or stems, etc. Often there is a combination of several of these symptoms.
Section 1. Vegetable Diseases
BEAN AND LIMA BEAN

The bean is subject to numerous diseases. The two most destructive diseases of bean in the past were anthracnose and bacterial blight. Neither of these is of economic importance now because satisfactory control of both anthracnose and bacterial blight has been attained by the use of western-grown seed. However, a brief description of both of these diseases is included in this bulletin because there is always the possibility of outbreaks if other than western-grown seed is planted.

Anthracnose

Symptoms. This disease, which is caused by a fungus (*Colletotrichum lindemuthianum*), affects all parts of the bean—seed, stem, leaves, and pods. The spots on the pods are the most conspicuous symptom (Fig. 1). Mature spots on the pods are sunken in the tissue, black with brownish margins. In the presence of moisture the centers of the spots may become flesh-colored. On the stems the cankers are at first brown in color, later becoming black and sunken. The symptoms on the leaves are angular dead areas on the upper surface and blackening and killing of the veins on the under surface. The petioles are also affected.

Control. Control of anthracnose is based on the fact that the disease is seed-borne. The organism causing the disease does not survive the high temperatures of Louisiana summers. Therefore, if disease-free seed is planted in the spring, the beans will be free of anthracnose. In former years, when most of the bean seed planted in Louisiana was grown in the cool, humid, northern states (chiefly Michigan) bean anthracnose was very serious. In recent years, with the planting of western-grown seed (seed grown in the arid, irrigated areas of the West where anthracnose is not prevalent) the disease has been practically eliminated and it has ceased to be of economic impor-
tance in Louisiana. This point should be kept well in mind in connection with the control of another seed-borne disease of beans, bacterial blight, which is discussed next.

Bacterial Blight

Symptoms. Several species of bacteria attack beans, causing blights. The most important ones are *Xanthomonas phaseoli*, the cause of common blight, and *Pseudomonas phaseolicola*, the cause of halo blight. These two blights differ in symptoms somewhat, the chief difference being that the dead spots on the leaf caused by the halo blight organism are surrounded by distinct yellow halos (Fig. 2), while those of the common blight are not. For practical purposes, however, and especially from the point of view of control, the two diseases may be treated as one because both have many things in common. Both are seed-borne. Both may affect all parts of the plant—seed, seedlings, stems, leaves, and pods of the mature plant; and both may be very destructive under conditions favorable for infection and spread. The spots on the leaves have a water-soaked (greasy) appearance at

![Fig. 2. Bacterial blight of beans. Symptoms on foliage and pods.](image-url)
first, and in the case of halo blight, are usually surrounded by a yellow halo. Later the spotted leaf tissue dies and turns brown. When the spots are numerous, there are no distinct halos, but the entire leaf turns yellow. When infection starts early, the entire plant is severely stunted and may be killed outright. The spots on the pods also start as water-soaked (greasy) areas resembling sun-scald, but may become reddish-brown on drying. The spots may be separate and more or less circular, or may run together forming irregular water-soaked areas on the pod (Fig. 2).

**Control.** In discussing control for bean blight, the following facts should be emphasized: (1) The disease is seed-borne; (2) the bacteria occur under the seed coat where ordinary seed disinfectants cannot reach them; (3) sprays have not given satisfactory control; and (4) under Louisiana conditions the blight bacteria do not survive in the soil from one year to the next. With these facts in mind it is apparent that the logical way to control bean blight is to plant blight-free seed. Seed grown in the cool, humid northern states almost invariably contains a large percentage of blight infection.

About 15 years ago, it was discovered that bacterial blights did not occur in the dry areas of Sacramento Valley in California, where there is no summer rainfall and beans are grown under irrigation. The Plant Pathology Department of the Louisiana Agricultural Experiment Station, in cooperation with the University of California, decided to make a practical use of this discovery. Arrangement was made with certain California growers to produce seed of the bean varieties grown commercially in Louisiana for testing. Careful tests showed that California-grown seed was completely blight-free. This led to large-scale production of certified blight-free seed in California. All the commercial bean acreage in Louisiana is now planted with blight-free, California-grown seed. So successful has this project proved that bacterial blight, once the most destructive disease of beans, is no longer of economic importance and, in fact, is practically nonexistent in Louisiana and other Deep South states.

**Caution.** It is very important to remember that this California-grown seed is blight-free, not blight-proof. None of the commercial varieties of snap beans is blight-proof... not even blight-resistant. Plants from California-grown seed will blight if they come in close contact with plants grown from blight-infected seed. Therefore, never mix California-grown seed with seed from other sources. If enough seed is available, make all plantings with California-grown seed. If enough California-grown seed is not available and you have to use seed from other sources, plant the California-grown seed separately, removed by at least a quarter of a mile.

**Bacterial Wilt** *(Corynebacterium flaccumfaciens)*  
Like the blight organisms, the wilt bacteria are also seed-born. They invade the vascular elements and plug or otherwise injure the vessels which conduct
water from the roots to the top of the plants. The infected plant thus wilts and dies. If the plants become infected when two or three inches tall, they usually die; if infected later, they may take considerable growth before being killed. Infected plants wilt and droop, and their leaves hang limp, during the warm part of the day, but recover partially during the night or during humid cool spells. Most infected plants eventually die, although an occasional plant may survive to maturity. Quite often both blight and wilt occur together.

Control. Same as for blight; disease-free seed. California-grown seed is free of wilt bacteria.

Rhizoctonia Diseases

Rhizoctonia (Pellicularia), a fungus consisting of many forms or races (some of these are recognized as distinct species by many investigators), is very widely distributed, occurring in practically all soils, virgin and cultivated, and causing diseases of many crops. On beans, it causes the following distinct phases of disease:

1. Damping-off. The germinating seed before emergence, or the young seedlings after emergence, are attacked and killed. This phase is most likely to occur if unfavorable (cold, wet) weather conditions prevent quick germination of the seed and rapid growth of the young seedlings.

2. Stem canker. Elongated, sunken, reddish-brown cankers develop on the stem near the soil line (Fig. 3). The plant may be killed if the canker girdles the stem completely. Normally, the plant is not killed, but its growth is retarded and the yields are reduced. Losses of 5 to 20 per cent have been reported by different investigators.

3. Pod canker. When pods touch the soil or are close enough to the surface of the soil to be splashed with soil particles during heavy rains, a disease phase known as pod canker or soil canker often develops on the pods. The affected tissue decays, forming prominent sunken cankers of varying sizes.

4. Web Blight. The first symptoms of the disease include a scalding of some of the leaves, and the appearance of spots or cankers on the pods. Affected leaves
cling to other leaves or to stems, and when pulled apart it is seen that they are held together by means of a cobweb-like material. Later the whole plant may become blighted, and leaves and stems become peppered with minute, dark-brown bodies (the sclerotia of the web-blight fungus) which look somewhat like grains of sand.

Web blight can be an extremely destructive disease. In Florida it is considered one of the most serious diseases of this crop. Fortunately it does not occur in Louisiana every year. The first recorded outbreak of the blight in Louisiana was in 1940. The following year it destroyed about 75 per cent of the fall bean crop. Other severe outbreaks occurred in 1951 and 1955. Weather conditions have a decided influence on the development of this disease. The organism causing web blight is a form of Rhizoctonia that prefers the above-ground parts of various plants, in contrast to most forms of this fungus which attack mostly roots and other underground organs. It is considered by many mycologists as a distinct species, designated as *Rhizoctonia microsclerotia*. It thrives in hot, humid weather. It has never been observed on the spring crop of beans because the weather then is too cool for the fungus. It attacks the fall crop only in years with heavy and excessive rainfall in September and/or October.

**Control.** There is no easy, practical control for the *Rhizoctonia* diseases. The fungus is a common soil inhabitant, occurring even in virgin soils, and it attacks a very large number of non-related crops. Rotation, therefore, probably would not help. Coating the seed before planting with some fungicidal dust, such as Spergon or Arasan, aids germination and reduces to some extent the damping-off phase of the disease. It has been reported from Florida that a new organic fungicide, PCNB (pentachloronitrobenzene) applied in the furrow at the rate of 10 lb. per acre, reduced greatly the stem canker phase. Reports from other parts of the country indicate that PCNB is the most effective fungicide yet found against *Rhizoctonia*. This suggests that this material, as a soil application, may control all phases of *Rhizoctonia* diseases of beans. Whether or not this would be an economically practical control measure remains to be determined.

**Rust**

(*Uromyces phaseoli typica*)

Rust is one of the most destructive fungous diseases of beans in many regions of the country. In our State it occurs only rarely on bush beans and it is not a factor to be reckoned with in the commercial production of snap beans. However, rust attacks pole beans almost invariably in home gardens in the summer and fall. Rust is easy to recognize. It is characterized by the appearance of numerous small, orange-colored pustules which occur for the most part on the under surface of leaves (Fig. 4), but also on petioles, stems, and pods. Soon after the appearance of the spots, the leaves turn yellowish, dry up, and fall off.
Fig. 4. Bean rust.

**Control.** Sulphur is specific against rusts in general. Bean rust can be controlled by sulphur, either as a dust, or as wettable sulphur spray. Many rust-resistant varieties of beans exist. However, the development of resistant varieties has not solved the rust problem because the rust is composed of several races that differ in pathogenicity, so that a variety of bean that is resistant in one locality will not be resistant in another locality where a different race of the rust occurs.

**Southern Blight or Wilt**

*(Sclerotium rolfsii)*

This, in general, is a minor disease of beans and lima beans, but, because of its striking symptoms, it attracts attention and causes concern. It is characterized by yellowing, wilting, and shedding of the leaves, and sudden wilting and death of the vine. (See under pepper, page 38, for a more detailed description of this disease and its causal fungus).

**Stem Anthracnose and Pod Blotch of Lima Bean**

*(Colletotrichum truncatum)*

**Symptoms.** This disease affects stems, leaves, pods, and seed. On stems it causes elongated cankers. In severe cases, the cankers may girdle the stem and cause death of the plant. In less severe cases, the plant becomes stunted and the leaves show varying degrees of yellowing. Brown lesions develop on the leaves, both petioles and blades. On the leaf blade the lesions occur most commonly along the veins. On the pod, the disease begins as small purplish to reddish blotches. These enlarge and eventually cover the greater part of the pod surface (Fig. 5). In later stages, the color of the blotches changes to tan or brown. Often the fungus may penetrate the pod and infect the seed. Stem anthracnose is primarily a disease of lima beans, although the anthracnose fungus is capable of infecting most varieties of common beans.

**Control.** It is doubtful that control measures are justified against this disease in Louisiana where lima beans are not grown commercially to any extent. In home gardens the disease normally is of minor importance. In other southern states where limas are grown commercially, the disease, in some years, becomes destruc-
tive enough to require control. Spray tests in North Carolina showed that several organic fungicides (Ferbam, Ziram, Zineb, Phygon) were effective in controlling this disease.
Pod Blight

(*Diaporthe phaseolorum*)

This disease, limited to lima beans, is striking in appearance, but is of minor importance. It is characterized by spots on leaves and pods (Fig. 6). On the leaves the spots are large, circular and brown in color. On the pods the spots, which usually do not appear until the pod is nearing maturity, are at first more or less circular with definite margins but, as the pod matures, the infection covers the entire surface of the pod. Numerous raised black specks, the fruiting structures of the fungus, cover the affected area.

No control is necessary or justified since the disease does not cause much damage.

Mosaic

(*Virus*)

There are several virus diseases of bean and lima bean. The ones most common in Louisiana are the common bean mosaic, the Southern bean mosaic, and the lima bean mosaic. The last-named one is caused by a strain of the cucumber mosaic virus. The first two are transmitted through the
seed. All are transmitted by insects, particularly aphids. It is not easy to tell what particular mosaic is involved by examining the plants in the field as all cause somewhat similar symptoms. Leaves become mottled (irregular yellow areas on the green leaf), puckered and deformed (Fig. 7). The whole plant is somewhat stunted and of a sickly yellow appearance. Some plants are killed. If the infection starts when the plant is young, few pods are formed, and those that form are of inferior grade. On some varieties (Black Valentine and Tender-green in particular) the Southern mosaic causes water-soaked irregular spots on the pods. This type of injury has been termed "water wave" by inspectors, and beans so affected fail to make U.S. No. 1 grade.

**Control.** Since the mosaic viruses are systemic, that is, they are carried in the sap of the plant, there is no cure for the disease once the plant has become infected. Some bean varieties are resistant at least to some of these mosaics. In general, mosaic is a relatively minor bean disease in the State.

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**Root Knot**

(*Meloidogyne* spp.)

Both bean and lima bean are very susceptible to root knot nematodes. Nematodes invade the root tissues and cause the formation of galls or knots (Fig. 8). These galls interfere with the ab-
sorption of water and minerals by the roots and the plant suffers.

**Control.** In spite of the fact that beans are very susceptible to root knot, the early-planted spring crop usually escapes serious injury because the soil temperature in the spring is still relatively low and nematodes are not very active under low temperature conditions. In late plantings, and particularly on lima beans and the fall crop of snap beans, considerable injury often occurs. Nematodes are much worse in light sandy soils than in heavy clay soils. It is advisable to avoid, as far as possible, the planting of fall beans in fields known to be heavily infested with nematodes. There are many nematocides available (see soil fumigants, pages 121-127) but in most cases these would be too costly to use.

**CARROT**

Like the garden beet, carrots are grown only to a limited extent commercially in the State, although they are grown in many home gardens as a winter vegetable. Carrot is subject to many diseases which affect the foliage or the roots or both, but because it is grown during the cool months of the year when most of its parasites are not very active, it usually escapes any serious injury.

Fig. 9. Nematode galls on carrot.

**BEET**

Beets are grown as a commercial crop only to a very limited extent in Louisiana, but they are grown in many home gardens as a winter vegetable. In regions where beets are grown extensively
in the summer, they are subject to a very large number of diseases. In Louisiana where they are grown only during the cool months, they are relatively free of any serious disease.

**Damping-off**

Many soil-borne and seed-borne fungi attack the germinating seed and the young seedlings. The young tap roots turn black and rot and the seedlings die. Much of this can be prevented by treating the seed with some fungicide before planting. Several fungicides, such as Cuprocide, Arasan (Thiram), and Phygon (Dich-lone) are suitable for this purpose.

**Leaf Spot**

*(Cercospora beticola)*

This disease is caused by a fungus parasite which is seed-borne. The spots are small, circular, with brownish to grayish centers and purplish margins. When the spots are very numerous, the leaf turns yellowish and either drops or scorches. The leaf spot fungus is a warm weather organism, and for this reason the disease is of no importance during the winter months. It usually occurs only in the fall on early planted beets or in late spring on late planted ones. It does not cause enough damage to justify control measures.

**Root Knot**

*(Meloidogyne sp.)*

Beet is very susceptible to root knot nematodes which cause numerous galls or knots on the roots. However, because nematodes are not very active during the winter months, very little damage to beets results from this pest, except during fall and late spring.

**CRUCIFERS**

*(Cabbage, Cauliflower, Broccoli, Brussels Sprouts, Turnip, Rutabaga, Chinese Cabbage, Mustard)*

These plants of the crucifer family are all affected more or less by the same diseases, so they are all treated here as a group. Where differences occur, they are indicated.

**Damping-off**

*(Caused by several soil fungi)*

**Description.** The term “damping-off” has been used to designate a disease of seedlings of many different plants, in the plant bed or in the field, which causes the seedlings to rot at the soil line and collapse suddenly.

The soil contains various fungi which are capable of causing damping-off of seedlings of many different plants. Damping-off damage is of two kinds. Germination may be considerably reduced by the rotting of the seed or of the young seedlings while still under ground (pre-emergence damping-off); or the seedlings may be killed after germination (post-emergence damping-off).

**Control.** Damping-off can be prevented to a large extent by treating the seed with some fungicide before planting. Arasan (Thiram) 75, at the rate of about one tablespoonful per pound of seed, is recommended for seed of
cabbage, cauliflower, broccoli, rutabaga, turnip, kohlrabi, and other crucifers. Place the seed in a closed container, add the fungicide, shake until the seed is well coated, then screen off any excess dust.

**Black Rot**  
(*Xanthomonas campestris*)

**Description.** This is one of the most destructive diseases of crucifers. The organism causing the disease is seed-borne and may affect the plant at any stage of its growth, from seedling to maturity, in the seedbed or in the field. Symptoms vary with the age of the plant. However, one symptom is nearly always present, and that is the blackening of the leaf veins and vascular bundles of the affected leaves and stems (Fig. 10). Affected leaves usually turn yellow and drop off. Secondary organisms (soft rot bacteria) often invade affected tissues, causing a soft rot with a very offensive odor.

**Control.** The bacteria causing black rot are carried both on and inside the seed. Those that are borne on the outside of the seed can be easily killed by treating the seed with a bactericidal solution such as mercury bichloride (see page 117). This treatment is not enough to insure control, because the bacteria that are borne inside the seed will initiate the infection in the seedbed, and, if weather conditions are favorable, the disease can spread very rapidly in the field. Since the black rot bacteria do not survive the summer in the soil in Louisiana, the only source of infection is the seed. Therefore, if the seed is treated by the hot water method (see page 120) complete prevention of black rot is obtained.

Seed produced in regions of little or no summer rainfall (such as in California and some other Pacific Coast areas) is free of black rot infection. Such seed need not be treated by the hot water method.

**Blackleg**  
(*Phoma lingam*)

**Description.** This disease is
mentioned not so much for its present importance—for in recent years blackleg has rarely been seen in the state—but because it is potentially one of the most destructive diseases of cabbage and allied plants. The disease may affect any part of the plant in the seedbed, in the field, or in storage, but primarily it rots the roots and stems, causing the collapse and death of the plants (Fig. 11). In the seedbed, affected seedlings show whitish sunken dead areas on the stems. Numerous minute specks dot the surface of the killed tissue. These are the fruiting bodies of the organism causing the disease. These bodies produce millions of spores which in turn infect other plants in the seedbed or in the field if conditions are favorable. Infected seedlings usually die soon after transplanting. Older plants in the field may collapse and die at any time.

Control. Blackleg is another of the many diseases that are seed-borne. To control blackleg, then, it is necessary either to plant disease-free seed or to treat the seed. Seed produced in the Puget Sound district, where blackleg does not normally occur, is free of infection and requires no treatment for the control of blackleg. If the seed has been grown in a region in which blackleg is known to occur, it is necessary to treat it. The blackleg fungus occurs both on the surface and inside the seed. The corrosive sublimate treatment (see page 117) will kill the fungus on the outside but not on the inside of the seed. Treating the seed with hot water (see page 120) will kill the fungus inside the seed.

Yellows

(*Fusarium oxysporum f. conglutinans*)

Yellows, or wilt, is one of the most important diseases of cabbage in regions where this crop is grown during the summer. Until recently, yellows was unknown in Louisiana and it was thought that perhaps the climatic conditions here did not favor the growth of the fungus. However, the disease was found recently (1955) in destructive form in certain fields in St. Martin and Plaquemines Parishes. It was probably introduced on cabbage seedlings brought in from other states.

Description. The disease affects cabbage plants at any age. The leaves turn sickly yellow. Often one side of the leaf or of the plant turns yellow. The lower
leaves become yellow first. The yellowed areas of the leaves soon dry and turn brown. Affected leaves fall prematurely. The plants become stunted. The vascular bundles become brown. The symptoms of yellows resemble somewhat those of black rot, and the two diseases may easily be confused. The leaf veins of plants affected with black rot are black rather than brown. This is the most reliable differentiating feature between the two diseases.

Control. Yellows is controlled by the use of resistant varieties. There are many resistant varieties available, so the cabbage grower has a wide choice of varieties that are resistant and still suitable to his particular region.

Downy Mildew

(Peronospora parasitica)

Downy mildew affects many members of the crucifer family. In Louisiana it is almost exclusively a disease of seedlings in the seedbed, occurring only rarely in the field.

Description. Lesions appear on the leaves, petioles, and stems as small irregular areas, grayish or purplish. Close inspection of the affected areas shows a fluffy white to purplish downy growth, which is made up of sporangio- phores and sporangia of the fungus. Later the affected areas enlarge, turn yellow, and finally the leaves dry up and drop off. Under favorable conditions (cool weather and high humidity) the disease progresses very rapidly and may ruin most seedlings in a seedbed in a few days.

Control. Spergon (Chloranil), either as a spray or as a dust, gives satisfactory control if applied early before much damage has been done. Whether as a spray or as a dust, it should be used twice a week during periods of cool, humid weather.

Spray:

1. Wettable Spergon—2 lbs.
2. Spreader (any detergent powder such as Tide or Dreft)—4 ozs.

Dust:

1. Wettable Spergon—6 parts
2. Clay or talc—94 parts

Watery Soft Rot

(Sclerotinia sclerotiorum)

This disease is not limited to crucifers. The soft rot fungus is an omnivorous pathogen attacking numerous vegetable crops, and also strawberries and some winter ornamental plants such as calendulas. It is a cool weather fungus and it is favored by highly humid conditions. The fungus passes the warm period of the year in a dormant state in the form of black hard bodies, the “sclerotia.” In winter and early spring these sclerotia resume growth and give rise to spore cups (apothecia) which in turn produce spores. These spores are blown about by the wind and when they fall on a susceptible plant, they cause infection if the right temperature and humidity prevail.

Description. The cabbage or cauliflower head collapses rather rapidly with a very soft type of rot. At first, the fungus may be seen as a white, cottony growth and this white growth soon gives rise to the hard black sclerotia. These fall to the ground and mix with the soil, there to remain in a dormant state until next season.
Control. Control of this disease is difficult; in fact, there is no satisfactory control. Rotation does not help much since the fungus attacks many other vegetables. Removal of the affected plants from the field before the sclerotia fall to the ground helps. Normally, however, the disease does not become very destructive. It affects individual plants and not the whole field.

Turnip Anthracnose
(Colletotrichum higginsianum)

This is primarily a disease of turnip, although it affects other crucifers including mustard, rutabaga, radish, and Chinese cabbage.

Description. Numerous, mostly circular, spots appear on the leaves, first water-soaked and later drying-up and becoming brown. The dead tissue in the center of the spot often falls out, producing a shot-hole effect. Elongated gray or brown spots also appear on the midrib and petiole. The fungus is seed-borne and the initial infection starts from the few infected seed.

Control. The anthracnose fungus is a warm weather organism. Therefore, the disease normally does not affect turnips or mustard planted in the cool season. Growers often try to rush the season by planting early—in late August or early September—in order to cash in on the early market for turnip and mustard greens.

Wettable Spergon, 4 pounds in 100 gallons of water, has been reported from North Carolina as giving satisfactory control.

Whiptail, Blind Plant
(Molybdenum Deficiency)

Physiogenic diseases due to deficiencies of one or more of the so-called "minor" elements, copper, zinc, boron, manganese, and molybdenum, are common on crucifers on certain types of soils in many parts of the country. Deficiency diseases are rather rare in Louisiana. Molybdenum deficiency, however, occurs in some of the acid soils, particularly in the Florida Parishes, and also in both acid and non-acid soils in Plaquemines and St. Bernard parishes.

Description. Some of the older leaves (especially those of cauliflower) grow narrow and malformed (whiptail); there is considerable crinkling and cupping of the margins of the leaves; the young leaves near the growing point may show bronzing, brittleness, and tip burning; the growing point is often killed, the plant becoming "blind"; cauliflower may not head at all, or may form only small, imperfect heads.

Control. In acid soils, liming gives very satisfactory control. Molybdenum may be present but is unavailable under acid conditions. Liming corrects the acidity and the molybdenum becomes available to the plant. Before planting cauliflower or other crucifers on soil suspected of being acid, have your soil tested. Consult your county agricultural agent on how to get a representative sample of your soil and where to send it to be tested. You will be advised on the degree of acidity and the amount of lime needed to correct it.
Where the trouble occurs on non-acid soils, it means that the element is lacking. In such cases, control may be obtained by using a molybdenum salt as an amendment. Tests at the Plaquemines Parish Agricultural Experiment Substation showed that spraying the plants with a solution of sodium molybdate—\( \frac{1}{2} \) pound in 100 gallons of water—gave very satisfactory control. A molybdenum salt can probably be mixed with the fertilizer and applied to the soil. In Long Island, New York, where this trouble occurs, it has been corrected by applying either sodium or ammonium molybdate to the soil at rates varying from 1 to 16 pounds per acre.

Different varieties of cauliflower seem to vary in their susceptibility to this deficiency trouble. Snowball A, Super Snowball, and Master are very susceptible; Stella Nova, Snowball X, Snowball Y, and Helios are considerably resistant.

**CANTALOUPE, CUCUMBER, SQUASH, WATERMELON**

Plants of the cucurbit family are subject to a very large number of diseases. Some of these are of universal occurrence and importance; others are of great economic importance in some regions and relatively unimportant in others. While practically all the diseases that affect cucurbits occur in Louisiana, only the ones that are of economic importance are included in this bulletin.

**Downy Mildew**

*Pseudoperonospora cubensis*

Although downy mildew affects practically all cucurbits, in Louisiana it is primarily a disease of cucumbers and cantaloupes. Cantaloupes are grown commercially to a limited extent only, mostly in Plaquemines and Lafourche parishes. A small acreage of spring crop of cucumbers is planted in St. Bernard, Plaquemines and Tangipahoa parishes. A larger acreage—about 2000 acres—is planted to fall cucumbers, mostly in Tangipahoa Parish. The spring crop of cucumbers in Tangipahoa Parish either escapes infection completely, or becomes infected late in the season when the crop is nearly over and the resulting damage is small. Fall cucumbers, on the other hand, become infected almost as soon as the plants come up. The reason for the difference between spring and fall crops is that the mildew fungus does not survive the winter in this area. It passes the winter in the frost-free southern part of Florida, and, as the weather warms up in the spring, it spreads northward gradually, reaching the Hammond area of Louisiana about the last part of June. This explanation does not seem to hold true for Plaquemines Parish, because the mildew appears in this area on cucumbers and cantaloupes usually about the first of April, about two months before it appears in the Hammond area.

**Description.** The leaves become covered with numerous yellowish spots, usually angular in shape (Fig. 12). Later the whole leaf dries and shrivels. The older leaves are killed first so there is a progressive defoliation from the base of the vine toward the tip.
Mildewed vines produce very little fruit of marketable grade.

Fig. 12. Downy mildew of cucumber. Early stage, showing numerous, angular, yellow spots on the leaf.

Control. Copper fungicides, such as Bordeaux mixture, are very toxic to the downy mildew fungus but, unfortunately, they are also toxic to cucurbits, causing burning of the foliage, stunting of growth, and reduction in yields. Furthermore, copper fungicides are not very effective against another disease, anthracnose, which usually occurs at the same time as mildew and, under humid conditions, is often more destructive than the mildew. Some of the organic fungicides, Zineb (Z-78 or Parzate), Maneb (Manzate), although somewhat less effective than the copper fungicides against downy mildew, are nevertheless more satisfactory than the copper fungicides because they cause little or no injury to the vines.

The recommended material for control of downy mildew, anthracnose, and insect pests (aphids, beetles, worms) of cucumbers and cantaloupes is a dust of the following composition:

- **Fungicide**—8 lbs.
- **Cryolite**—20 lbs.
- **Black Leaf 10 (Nicotine)**—10 lbs. or
- **Black Leaf Dry Concentrate (Nicotine)**—7 lbs.
- **Diluent (talc, pyrophyllite, or clay)**—62 lbs. if Black Leaf 10 is used or 65 lbs. if Black Leaf Dry Concentrate is used.

* Either Zineb (Z-78 or Parzate), Ferbam (Fermate), or Maneb (Manzate).

The dust should be applied twice a week. New growth should be kept covered with the dust. As anthracnose may attack and damage young plants, start dusting when the plants are small. Thorough applications are necessary. Apply the dust when there is little or no wind, either early in the morning or late in the afternoon. The percentages of insecticides (cryolite and nicotine) in the dust formulation are sufficient for insect control if the dusting is done twice a week. However, if aphid infestation becomes heavy, the content of nicotine should be increased.

There is hope that satisfactory control of downy mildew will eventually be attained by means of resistant varieties. The Palmetto variety of cucumber, while not immune, shows considerable resistance. This variety is grown to some extent commercially in other southern states, but it has not done well in Louisiana.

**Anthracnose**

*(Colletotrichum lagenarium)*

Anthracnose affects many members of the cucurbit family, but it is particularly destructive to cantaloupe, cucumber, gourd, and watermelon.
Description. The disease is characterized by numerous dead spots on the foliage (Fig. 13). On watermelon, the color of the spots is dark brown to black; on cantaloupe and cucumber the color is distinctly brown. The spots are mostly circular in outline and 1/4 to 3/4 inch in diameter. In older spots the center tissue often falls out. As the older, lower leaves scorch and shrivel, the plant becomes gradually defoliated, and the fruit, exposed to the sun, becomes sunscalded. Spots develop also on stems and fruit.

The symptoms of anthracnose resemble considerably those of downy mildew and the two diseases are often confused. In general, the anthracnose spots are circular to oval in shape, in contrast to the angular spots of downy mildew, and the centers of the anthracnose spots either crack or fall out, whereas those of downy mildew remain intact. From the practical point of view, these differences are not impor-
tant because the same control measures apply to both diseases and, furthermore, both diseases often occur together.

Control. See under Downy Mildew, page 22.

Bacterial Wilt
(Erwinia tracheiphila)

Bacterial wilt is a disease of cantaloupe and cucumber. Squash and pumpkin are only slightly affected and watermelon not at all.

Description. The first noticeable symptom is the wilting of a few leaves or of a single branch of the vine. This is soon followed by the sudden wilting of the entire plant. When the stem is cut and squeezed, a sticky whitish ooze exudes from the cut surfaces. This is a reliable means of telling bacterial wilt from Fusarium wilt, which is discussed next.

Control. Bacterial wilt is caused by a species of bacteria (Erwinia tracheiphila). These bacteria, as far as is known, are not seed-borne and do not survive in the soil or in plant refuse. They pass the winter within the bodies of the cucumber beetles and the plants become infected when the beetles feed on them. Therefore, the only effective control for bacterial wilt is to control the beetles. The beetles are easily controlled by dusting the plants with calcium arsenate or with cryolite. In the case of cucumbers which are sprayed or dusted for the control of downy mildew, the arsenical or cryolite is mixed with the spray or dust.

Bacterial Leaf Spot
(Pseudomonas lachrymans)

This bacterial disease is limited
to cucumbers. The first symptoms appear as small water-soaked spots on leaves, stems, and fruit. On leaves, older spots are about ⅛ to ¼ inch in size, somewhat angular in outline, tan on top and gummy and shiny on the under surface. The center of the spots may fall out. On stems, fruits, and leaf petioles the spots are often covered with white, gummy or crusty droplets (tear drops), made up of masses of bacteria that ooze out of the tissue. This is the most reliable diagnostic feature of this disease.

**Control.** No really satisfactory control is available for this disease. The bacteria are seed-borne, both internally and externally. They do not survive in the soil under Louisiana conditions, so rotation does not help. In the field, the infection starts from the few infected seed in a lot, and then it spreads by wind, splashing rains, and insects. Treating the seed with mercury bichloride (see page 117) helps in that the treatment kills the bacteria borne externally on the seed, but does not eradicate the internal infection. Seed produced in regions of rainless summers (California) is free of infection.

**Fusarium Wilt**  
*Fusarium oxysporum f. niveum*)

Fusarium wilt, a fungous disease, is limited to watermelon. Squash and pumpkin are not affected. Two different races of the wilt fungus have been reported elsewhere, one causing wilt of muskmelon and the other of cucumber, but neither of these has been found in Louisiana.

**Description.** The wilt fungus may affect the plant in all stages of its development. It can cause rot of the seedlings underground before they emerge, wilt and damping-off of the seedlings after emergence, and wilt and death of older plants. Wilt shows first at the tips of the runners during the hot part of the day. Wilted vines at first recover during the night, only to wilt again the next day. **W i l t i n g** becomes progressively more severe and the vine finally dies.

**Control. Control of watermelon wilt** is a difficult problem. The wilt fungus can live in the soil, and once a field becomes infected it remains so for a long time. Furthermore, the wilt fungus is seed-borne, and in this way it may be spread to new ground if infected seed is planted. Seed-borne infection is not important the first year watermelons are planted on wilt-free soil, because only relatively few seeds will harbor the fungus, but it is important from the point of view of dissemination of the disease to new fields.

A five-year rotation, that is, not planting watermelons in the same field any oftener than once in five years, offers a practical relief against wilt. The wilt fungus is not eliminated from the soil in five years (it is known that it persists in soils 16 years or longer), but it is reduced to the point where watermelons can be grown for one season without much loss from wilt.

The most satisfactory means of controlling wilt is the use of wilt-resistant varieties. Many such varieties exist, and new ones are being developed by breeding. The
most important resistant varieties are Klondike (California), Miles (Tennessee), Dixie Queen (Iowa), Charleston Gray (South Carolina), Leesburg, Blacklee, Improved Leesburg, and Brownlee (Florida), and Calhoun Sweet and Summit (Louisiana).

Many difficulties have been encountered in developing resistant varieties. It is easy to obtain wilt resistance by breeding, but very difficult to combine resistance with desirable qualities, such as size, productiveness, taste, flavor, color of flesh, and toughness of rind. Also, a variety may be resistant in one region and not in another. For example, Klondike is very suitable for California conditions and is widely grown there, but is not suited to the South. The same is true for the resistant varieties developed in Iowa. They maintain their resistance in the Mid-West, but not in the South. Because of these difficulties, most of the resistant varieties have not found wide acceptance by the growers in the Southern States. One notable exception is the Charleston Gray. This variety, which possesses many admirable qualities in addition to its wilt resistance, has been accepted by both the growers and the market and is rapidly displacing wilt-susceptible commercial varieties.

The Calhoun Sweet, developed by the North Louisiana Agricultural Experiment Station at Calhoun, is highly resistant to wilt and possesses many excellent qualities—good size, shape, color, taste and flavor, and high yields. Unfortunately, its rind is tender and this limits its use to the local market because it will not stand long distance shipping. Seed of this variety is available.

A second variety, developed by the same station and named Summit, appears extremely promising. It appears to be completely wilt-resistant, has excellent quality, desirable size and shape, tough rind, and produces high yields.

Powdery Mildew
*(Erysiphe cichoracearum)*

In Louisiana powdery mildew is of some importance only on squash. It is hardly ever seen on cucumber, cantaloupe, or watermelon.

**Control.** Powdery mildew on squash can be controlled by dusting with sulphur. Sulphur should not be used on cucumber, cantaloupe or watermelon because these plants are sulphur sensitive and severe burning may result. Squash is tolerant to sulphur and can be dusted with sulphur without suffering appreciable injury.

Southern Wilt (Southern Blight)
(See under Pepper, page 38).

**Mosaic**
*(Virus)*

Mosaic, which is caused by a virus (see page 5), is one of the most serious diseases of cucumbers in the North, but in Louisiana it is rarely seen on cucumbers. This is probably due to the fact that the insects which spread the virus from diseased to healthy plants are kept well under control in the process of dusting for downy mildew. Mosaic often occurs on squash in Louisiana, probably because this crop is not sprayed so assiduously as cucum-
bers. Watermelon is resistant to most strains of the mosaic virus and the disease is seldom seen on watermelon in the field.

**Symptoms.** Symptoms vary with different strains of the virus, but in general the leaves and fruit become mottled and distorted and the entire plant is stunted.

**Control.** Since mosaic is spread by insects, especially by plant lice, control is obtained by controlling the insects by spraying or dusting.

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### Root Knot

**(Meloidogyne sp.)**

Cucurbits are among the plants most susceptible to the root knot nematode (see page 4). Plants affected with root knot are stunted in growth, pale green and unthrifty in appearance. When dug and examined, their roots are found to be covered with swellings or knots.

**Control.** See under TOMATO, page 66.

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### COWPEA

**(Field Pea, Crowder Pea, Blackeye Pea)**

Cowpea (*Vigna sinensis*) is primarily a field crop, grown for hay and as a green manure cover crop. In the South, selected horticultural varieties are grown extensively as a summer vegetable. In Louisiana, it is grown for the most part in home gardens but also commercially to a limited extent.

Cowpea is subject to a very large number of diseases caused by bacteria, fungi, nematodes, and viruses. Only three that are common and of considerable importance in Louisiana are treated here. These are, wilt, leaf spot, and stem canker.

**Stem Canker**

**(Rhizoctonia)**

(See under Bean, page 9).

**Wilt**

**(Fusarium oxysporum f. tracheipilum)**

**Description.** The fungus invades the plant from the soil through the roots. The plant wilts and dies. The stem tissue under the bark (vascular tissue) becomes brown in color. The brown discoloration of the vascular tissue is a good diagnostic symptom.

**Control.** Like other fusarial wilts (tomato, cotton, watermelon), cowpea wilt is controlled by the use of wilt-resistant varieties. Many such varieties exist. Two resistant varieties have been developed by the Louisiana Agricultural Experiment Station. These have been released and seed is available through regular seed channels. The first of these, Calhoun Crowder, is highly resistant to wilt and to the leaf spot, but is of relatively poor quality, compared to the better varieties. The second variety, Louisiana Purchase, is a good quality pea, and is highly resistant to wilt and somewhat resistant to leaf spot.

Dixie Lee is another high quality wilt-resistant variety that does well in Louisiana.

**Leaf Spot**

**(Cercospora spp.)**

A large number of parasitic
fungi (and bacteria) are capable of causing dead spots on the leaves, stems, and pods of cow-pea, but the most important ones are species of *Cercospora*. Susceptible varieties may become severely defoliated.

**Control.** Although many fungicides are effective in controlling leaf spot, it is doubtful that the use of fungicidal sprays will be economically practical. The use of resistant varieties is the most practical means of control. Many varieties show resistance to leaf spot. Varieties that possess resistance both against wilt and leaf spot are the most desirable.

### EGGPLANT

**Damping-Off**

*(Caused by several soil fungi)*

Eggplant seedlings are very susceptible to damping-off, and to control this trouble it is necessary to treat both the seed and the soil. Treat the seed with Cuproicide (see page 119). As soon as the seedlings begin to emerge from the ground, water the seed bed with a suspension made of 1½ ounces of Cuproicide in one gallon of water. Repeat this once a week.

**Blight**

*(Phomopsis vexans)*

Blight is by far the most serious disease of eggplants and in the past, before resistant varieties were developed, it was the limiting factor to the successful growing of eggplants in the state. It affects the plant and its fruit in all stages of development from seedlings to mature fruit.

**Symptoms.** Brown dead spots form on the leaves. When the spots are numerous the entire leaf is killed. Elongated cankers develop on the main stem and its branches, usually occurring close to the ground. When the cankers girdle the main stem the plant wilts and dies. On the fruit, the disease shows sunken brown spots of various sizes. Sometimes these spots grow very large. Infected fruit usually sheds. The fruit tissue rots underneath the spots. Very numerous dark-colored pimples dot the surface of the cankers on the stem and of the spots on the leaves and fruit. These are the fruiting bodies of the blight fungus. They give rise to millions of spores which are scattered by winds and rains and spread the disease in other plants.

**Control.** Previous to the development of resistant varieties, no completely satisfactory control for Phomopsis blight was available. The disease is seed-borne, the causal organism occurring both on and inside the seed. The seed treatment recommended above for damping-off control will kill the fungus on, but not inside, the seed. Fungicidal sprays are fairly effective in preventing infection of leaves and stems but not of fruit.

The varieties Florida Market and Florida Beauty are resistant.

**Yellows**

*(Virus)*

Yellows is a new disease of the eggplant and is probably caused
by a virus (see page 5). The upper leaves turn bright yellow, or sometimes, bleach nearly white. Later the entire plant may become yellow and may finally die.

Control. In Texas, where the yellows disease is sometimes very prevalent in some sections, good control has been obtained by the use of sulphur dust. The plants in the seedbed are kept dusted with sulphur, then one or two additional dustings are given the plants after they are set out in the field. This apparently is a preventive measure. Sulphur evidently kills or repels the insect which transmits the yellows virus from diseased to healthy plants. Although yellows has been found on eggplants in Louisiana, so far it has not become prevalent enough to be of economic importance.

OKRA

Okra is grown in practically every garden in Louisiana and is usually considered a "fool-proof" crop. However, this plant also is subject to several diseases, some of which may be destructive at times. Of these, wilt and root-knot are the most important.

Wilt

Okra wilt is caused by the same fungus that causes wilt of cotton (Fusarium oxysporum f. vasinfectum). It is a typical vascular wilt. First symptoms are yellowing of the lower leaves, followed by gradual wilting and finally death of the plant. The tissue of the stem under the bark shows a dark-brown discoloration.

Root Knot

(Meloidogyne sp.)

Okra is very susceptible to the root knot nematode. Gall or knots of varying sizes develop on the roots. The gall tissue rots and the plant dies for lack of a root system.

There is a relation between wilt and root knot, in that wilt is more prevalent and more severe in soils that are infested with the root knot nematodes.

ONION, SHALLOT, GARLIC

Some onion diseases (smut, for example) which are destructive in other parts of the country either do not occur or are of minor economic importance in our state. On the other hand, some diseases that are of no importance in the North are very destructive in Louisiana and in the South in general. The diseases which attack onions and garlic in Louisiana are extremely difficult to control. In fact, diseases constitute the chief factor limiting the development of an extensive onion-growing industry in the State.

Downy Mildew (Blight)

(Peronospora destructor)

Symptoms. Leaves first become pale green, then turn yellow, and finally collapse and shrivel (Fig. 14). Seed stalks are also affected. The plant is not completely killed, but the destruction of the top growth causes the bulbs to be small. Mildew is especially
destructive to onions used for production of seed, as mildewed

stalks usually fall over before the seed is mature.

Cause. The disease is caused by a fungus (*Peronospora destructor*). The fungus carries over from season to season in many ways; in the seed, in the bulbs, and in the soil. Development and spread of the fungus are favored by cool, humid weather.

Control. Control of mildew is extremely difficult. Since the fungus can survive from one season to the next in so many different ways control or eradication by sanitary measures is practically impossible. Spraying has been tried in the past, both in Louisiana and in other onion-growing states, but it has not proved very satisfactory. To obtain good control it is necessary to keep the new growth covered with spray material as soon as it develops. This means spraying at least once a week for several months. Obviously such a procedure is economically impractical.

The ultimate control of downy mildew will undoubtedly be accomplished by developing resistant varieties. A few such varieties exist but these are not suited to Louisiana. An onion-breeding project now in progress at the Louisiana Agricultural Experiment Station has as one of its chief aims the development of mildew-resistant varieties adaptable to Louisiana conditions.

**Purple Blotch and Black Stalk Rot**

These two diseases, caused by two distinct species of the same fungus, *Macrosporium (Alternaria) porri* and *Macrosporium parasiticum*, are somewhat similar in their symptoms, and for this reason are treated together.

Purple blotch affects leaves, seed stalks, and bulbs. The disease starts as small, whitish, somewhat sunken spots on leaves and stalks. These spots soon enlarge and girdle the affected leaf or stalk. A little later, a black growth consisting of masses of fungus spores covers the affected area. If conditions are favorable to the development of the disease, the girdled leaves and stalks topple over. The fungus may also infect the bulb, at or after harvest, penetrating the scales at the neck and causing bulb rot. The blotch fungus is capable of infecting non-injured tissues.

The black stalk rot fungus cannot infect un-injured tissues. However, it enters tissues that
have been injured. It normally follows downy mildew, growing on the parts of leaves and stalks that have been weakened and injured by the downy mildew fungus, thus completing the destruction. The affected areas become

covered with black masses of spores (Fig. 15). Affected seed stalks topple over.

**Control.** No satisfactory control is known for either purple blotch or black stalk rot.

**White Rot**

This disease, which was found in Louisiana for the first time in 1942, is included here not because it is of economic importance at present, but because it is potentially a very serious disease of onions, shallots, and garlic, and should be brought to the attention of growers so as to have them on the lookout for it in case it appears in their fields. In this way it can be caught before it spreads. White rot (caused by the fungus *Sclerotium cepivorum*) is a serious disease of onion and gar-

![Fig. 15. Black stalk rot of onion.](image1)

![Fig. 16. White rot on shallots.](image2)

...lic in Europe. In the United States the disease has been found previously in localized areas in Kentucky, Virginia, Oregon, California and New Jersey.
Symptoms. The roots and the bases of the scales rot. A white fluffy growth (the mycelium of the fungus) and small, spherical, black bodies (sclerotia) occur on the surface of the bulbs (Fig. 16). Affected plants may wilt and die rather suddenly, or may persist in a sickly, unthrifty condition.

Control. Prevention is the only effective control measure for this disease. Once the soil becomes infested, it remains so for many years, because the fungus can survive in the soil even when onions or garlic are not planted. Care, therefore, should be taken to use only healthy sets or transplants. The white rot fungus thrives in cool weather and since onions in Louisiana are grown during the cool months of the year this disease is a potential menace and care should be taken to prevent its spread.

Pink Root

Pink root is another serious disease of shallots, onions, and garlic. The disease is caused by a fungus (Pyrenochaeta terrestris) which lives in the soil.

Symptoms. The most charac-

Fig. 17. Pink root on shallots. One healthy and three diseased bunches.
teristic symptom is the pink color of the roots. In addition to the pink color, the affected roots become soft, limp, and finally rot. The plants have an unhealthy, unthrifty appearance, pale green color, more or less stunted growth, and a die-back of the leaf tips (Fig. 17). As these above-ground symptoms may be brought about by other conditions, the only sure way of knowing whether or not plants have the pink root disease is to examine the roots.

**Control.** Control of pink root is a very difficult problem. Once a field becomes infested, the pink root fungus can survive in the soil for many years, even if no onions or garlic are planted, and rotation, therefore, is of doubtful value as a control measure. Furthermore the fungus is carried over on infected bulbs and sets, and its presence on the dried bulbs and sets is not easy to detect. By the use of diseased sets, the disease is unwittingly spread to new fields. It is possible that varieties resistant to pink root will be developed eventually. Until this has been accomplished the only control measure that may be suggested is prevention. Do not plant onions, shallots, or garlic in fields that are known to be infested. Whenever possible, make sure that the sets you plant have come from disease-free fields. Plant onion seed on new soil or in soil which is not infested with the pink root fungus. This precaution is very important. If the seed is sown in infested soil, the seedlings will become infested and the disease will be spread to areas in which these seedlings are transplanted.

The so-called “summer shallot” varieties, derived from the Japanese Nebuka, possess a high degree of resistance to both pink root and yellow dwarf. They remain green during the summer, and are desirable for the home garden.

**Storage Rots**

Decay of onions and garlic in storage or in transit is caused by a large number of fungi and bacteria, such as species of *Botrytis* (neck rot), *Fusarium* (dry rot), *Aspergillus* (black mold), *Macrosporium*, *Colletotrichum* (smudge), bacteria (soft rot), and many others. White onions are more susceptible to storage rots than those with colored skins. Our Creole onion is a good keeper, and shows considerable resistance to many of the storage rots.

**Control of Storage Rots.** All organisms causing storage rots require moisture for their development. Control of storage rots, therefore, is based on proper curing and storage. Many of the storage rots start in the field, about harvest time, and continue their development in storage. If dry weather prevails during the period of harvesting so as to allow drying and curing, losses from subsequent storage rots will be small. On the other hand, if rains prevail during the period of harvesting and curing, losses from storage rots are to be expected. Curing by the use of artificial heat is very helpful but facilities for artificial curing are not always available.

**Yellow Dwarf**

*(Virus)*

**Description.** Yellow streaks ap-
pear on the leaves. In addition to these distinct yellow streaks, affected plants show a general chlorosis. Leaves become twisted and bent. Plants infected in the seedling stage become greatly stunted; those infected later, after they have made considerable growth, are not injured very much. If infected sets, or bulbs, are planted, the injury is much more severe, resulting in dwarfed, malformed plants and reduction in yield of bulbs or seed. Yellow dwarf is primarily a disease of onion and shallot, particularly of the latter in Louisiana. On garlic, the yellow dwarf virus (a particular strain) causes mosaic symptoms. All garlic (the common Italian garlic) plants carry this virus, but it does not appear to cause any appreciable damage.

Control. The yellow dwarf virus is spread in the field by aphids. It is not transmitted through the seed. Therefore, when onions are grown from seed rather than from sets, yellow dwarf is no problem. It is much more of a problem with shallots since shallots are grown from sets. There are shallots that are resistant, but these are not commercially acceptable. A breeding project is in progress designed to develop shallot varieties with acceptable market qualities and at the same time possessing resistance to this and other diseases.

Yellows
(Virus)

This disease is mentioned here not because it is important but because it is so striking in appearance that it is easily noticed in the field and may arouse curiosity or concern. The disease has been seen on shallots and the Creole onion. The leaves of affected plants are so strikingly bright yellow that such plants can be easily noticed from a distance. The plants are stunted in growth and the bulbs are small, soft, and flaccid. If harvested, affected bulbs or sets usually shrivel and dry up in storage. This is fortunate, for the disease is thus self-eliminating.

Yellows is caused by the aster yellows virus which is transmitted by a leafhopper. It affects many different plants, both vegetables (carrot, for example) and ornamentals.

PEA (GARDEN and SWEET)

Damping-Off and Root Rots

Peas, both the edible (English) and those used for their flowers (flowering sweet peas), are attacked by a large number of soil-inhabiting fungi which cause the roots to rot. In this popular bulletin it is considered unnecessary to name and describe the various root-decaying fungi. It is enough to state that at least seven different soil-inhabiting fungi are known to cause root rots in peas.

Root troubles may manifest themselves in different ways: (1) The seed may rot without germinating, or the little seedlings may rot before coming out of the ground (pre-emergence damping-off); (2) the emerged seedlings may be killed gradually; (3) the older plants may show an un-
thrifty, unhealthy kind of growth, pale green color, stunting, wilting, and gradual dying. If such plants are examined it will be found that their underground parts will show various degrees of decay.

**Control.** Root rots are difficult to control. Most root-rotting fungi live in the soil; others are seed-borne. Soil and moisture conditions also influence the severity of root rots. No single control measure for root rot can be offered. However, the following measures are suggested as of value for keeping injury from root rots to a minimum:

1. **Seed Treatment.** Treat the seed with Cuprocide (see page 119). This treatment controls pre-emergence damping-off and insures a good stand.

2. **Source of Seed.** Use Western-grown seed when available. Western-grown seed is not only free of some of the root and foot-rotting organisms, but also of those of bacterial blight and *Ascochyta* blight.

3. **Rotation.** Rotation is very helpful. If enough land is available it is advisable not to plant peas on the same ground any oftener than once in four years.

4. **Resistant Varieties.** The "Creole" pea, which in recent years has been grown extensively in home gardens throughout the State, is relatively resistant to root rots. It is also fairly tolerant to mildew. Unfortunately, the Creole is a rather poor quality pea.

5. **Soil Moisture.** Plant peas only on well-drained ground.

Root rots are decidedly more destructive in poorly drained soils.

**Ascochyta Blight**

Three species of the fungus known as *Ascochyta* are involved in this blight. These cause purplish to tan-brown, irregular to round, often sunken spots on the leaves and pods (Fig. 18, A) and elongated lesions on the stems. When stem lesions occur near the ground a foot rot is produced which kills the plants.

**Control.** Since the fungi causing this disease are seed-borne, good control has been obtained by planting blight-free seed on land on which peas were not growing the previous year. That is, control of blight is based on a combination of disease-free seed and rotation. Western-grown seed is usually free of blight. If local seed is used, it should be saved only from healthy plants.

**Bacterial Blight**

A second blight which very
commonly becomes destructive on peas in Louisiana is that caused by bacteria (*Pseudomonas pisi*).

**Symptoms.** Numerous water-soaked spots on leaves, stems, and pods (Fig. 18, B). Later the spots turn brown in color. Heavily diseased plants may wilt.

**Control.** Use blight-free seed. Seed grown in the semi-arid western states is usually blight-free.

**Powdery Mildew**  
(*Erysiphe polygoni*)

Powdery mildew is easily recognized by the whitish, powdery growth on the upper surface of leaves and stems. After some time affected leaves shrivel and fall off.

**Control.** Powdery mildew usually occurs late in the season after the crop is nearly over, and it is doubtful that control measures are justifiable. However, powdery mildew can be easily controlled by dusting with sulphur. It is advisable to dust as soon as mildew appears before any damage is done. A second application of sulphur may be necessary if mildew persists.

**Anthracnose**

Anthracnose, caused by a fungus (*Colletotrichum pisi*), is of no importance on English peas in Louisiana but it is often very destructive on flowering sweet peas. It causes irregular brown dead spots on leaves and flowers and elongated dead areas on stems and flower stalks.

The disease is favored by cool, moist weather. It often becomes very destructive on sweet peas during April if cool, rainy weather prevails.

No satisfactory control is known for this disease.

**Leaf Spot**  
(*Mycosphaerella arachidicola* and *M. berkeleyii*)

**Description.** The most important disease of peanuts is the leaf spot which is caused by two species of the fungus *Mycosphaerella*. The spots on the leaves are brownish to black with light-colored margins and circular to irregular in outline (Fig. 19). On the stems and leaf stalks, the spots are elongated. The disease causes the leaves to shed before the crop is ready to harvest and this premature defoliation results in low yields of both nuts and hay.

Control of leaf spots by the use of fungicidal dusts has become a common practice in the principal peanut producing states. Tests conducted in Louisiana showed that sulphur dusted plots yielded...
about 40 per cent more nuts and 32 per cent more hay.

**Southern Blight**  
* (Sclerotium rolfsii)  
This fungus which attacks many different kinds of plants

**Control.** Rotate. Do not plant peanuts on the same land on which the disease occurred the previous year.

**Damping-Off**  
*(Caused by several soil fungi)*  
**Description.** See SEED TREATMENT, page 116.

**Control.** By treating the seed with copper oxide (Cuprocide) better germination and better stand of seedlings are obtained. Add 2 level teaspoonfuls of Cuprocide to each pound of seed in a closed container, shake until the seed is well covered, then screen to remove any surplus dust that has not adhered to the seed.

This treatment is usually sufficient to insure good germination and to prevent damping-off of the seedlings after germination. If the seed has not been treated, or if plants continue to damp off in spite of seed treatment, water the plants with a suspension made with 1 1/4 ounces of Cuprocide per gallon of water. One watering usually is enough, though a second will not be harmful.

**Bacterial Spot**  
* (Xanthomonas vesicatoria)  
**Description.** This disease occurs both in the seedbed and in the field. It forms spots on leaves and fruit. On the leaves, the spots are at first raised and wart-like but soon the tissues dry out, leaving small, dark-brown, more or less angular spots (Fig. 20). Spotted leaves soon turn yellow and shed, resulting in defoliation and stunting of the plant. Severely defoliated plants set very little fruit, and that is usually of unmarketable quality. On the fruit, the spots are raised and wart-like.

**Control.** The disease is seedborne. The bacteria causing the disease are carried on the seed and they are known to remain viable for at least a year. It is suspected that the bacteria may live over in the old plants in the field, but this has not been proved experimentally. Under cultural practices prevailing in the sweet pepper growing districts of Louisiana, where the plants are plowed under as soon as the crop is harvested in early summer, it is very doubtful that the bacteria survive in the soil from one year to the next. So far as sweet peppers are

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Fig. 20. Bacterial leaf spot of pepper.
concerned the control of bacterial spot is best accomplished by disinfecting the seed. Cuprocide, which is recommended for the control of damping off, unfortunately does not control bacterial spot. A more drastic method is necessary.

The Corrosive Sublimate Treatment. Soak the seed in a 1-1000 solution of corrosive sublimate (see SEED TREATMENT, page 117, for directions for making the solution) for five to six minutes, wash thoroughly in running water (or in several changes of water), and either plant directly while still wet or spread out to dry. It is better to dry the seed after this treatment, for then it can be dusted with Cuprocide for the control of damping-off. While the corrosive sublimate treatment is very effective, it is also risky and should be used with care. Pepper seed is sensitive to corrosive sublimate and may be injured somewhat under certain conditions.

Cercospora Leaf Spot (Leaf Drop) (Cercospora capsici)

Description. This disease is differentiated from the bacterial leaf spot by the large, circular to oblong spots with grayish centers and dark brown margins (Fig. 21). Spotted leaves turn yellow and drop off, hence the common name “leaf drop.” The damage is caused by the defoliation of the plant. Spots develop also on the stems of the plant and on the fruit.

The disease appears in the field usually about the middle of May, and if conditions are favorable (hot, wet weather), the plants may become badly defoliated in two or three weeks. The disease apparently is not seed-borne. We have been unable to obtain the fungus from the seed and we have never found the disease in the seedbed, although a careful search for it has been made. On the other hand, we have found the fungus fruiting profusely in the spring on infected pepper stems and leaves which had over-wintered outdoors. So it appears that, under Louisiana conditions, the leaf drop fungus is carried over from one season to the next on infected pepper refuse.

Control. The disease can be controlled by spraying with 4-4-50 Bordeaux mixture or with some other copper spray. We have obtained good control by spraying with 4-4-50 Bordeaux and also with some of the “fixed” copper fungicides, such as “Spraycop” and Tribasic Copper Sulphate, 3 pounds in 100 gallons of water.

Even though spraying is effective in controlling this disease, it is still a question whether or not it pays to spray. The disease be-
comes progressively worse as summer advances. If the harvesting season is long, it will undoubtedly pay to spray, and the length of the harvesting season is conditioned by the market price for peppers. Some years the price of peppers drops by the end of June to the point at which it does not pay to pick. Under these conditions it is questionable whether or not spraying for the control of this disease would be economically practical.

**Southern Wilt (Southern Blight)**

This disease is caused by a soil-inhabiting fungus known by the technical name of *Sclerotium rolfsii*. The fungus is a warm climate organism and is common in the Southern States. It attacks a very large number of different plants during the hot summer months. The fungus attacks the plant at the ground line, girdling and causing it to wilt and die rather suddenly. The disease is easily recognized by the white web-like growth of the fungus and the numerous creamy-white to brown seed-like bodies (sclerotia) which are found on the girdled part of the stem and on the ground. The sclerotia are about the size, shape, and color of mustard seed. These bodies remain viable in the soil and carry the fungus over from one season to the next.

No control is known for this disease. Fortunately, it is a minor disease. Occasionally it may cause the death of a considerable number of pepper plants in some fields, but in general it is a disease of small importance.

**Mosaic**

**(Virus)**

**Description.** The symptoms of mosaic vary considerably (there are different strains of mosaic) but in general they consist of mottling (green and yellow color) and distortion (puckering, twisting, malformation) of the leaves and general stunting of the entire plant. If the plant becomes infected when young it is entirely worthless; it remains stunted and either sheds its blossoms or, if any fruit is set, it is small and misshapen. If infection occurs after the plant has reached maturity the damage is decidedly less.

**Control.** Mosaic is highly infectious. It is spread principally by plant lice (aphids), but also by other insects and by handling, such as weeding the seedbed, transplanting, and picking. Some of the mosaic viruses are carried in chewing and smoking tobacco, even in cigarettes. Use of tobacco should be avoided while handling pepper seedlings. Furthermore, many common weeds take the virus and may thus serve as a reservoir. Aphids feeding on weeds can pick the virus and transfer it to peppers in the seedbed or the field. It is advisable, therefore, to remove all weeds from the vicinity of seedbeds. The seedbed should be sprayed or dusted about once a week with some good aphicide, such as nicotine, vapo- tone, or malathion. The thing to remember is that mosaic is much more destructive if the plant is infected when young; if the plant becomes infected after it has set the first fruit, the injury is decidedly less. Therefore, every ef-
fort should be made to prevent infection of the seedlings.

**Wilt of Tabasco Pepper**  
(*Virus ?*)

A destructive disease, characterized by sudden wilting and dying of the plant, is common in tabasco pepper plantings in Louisiana. The plant, usually when fully grown and bearing flowers and fruit, wilts suddenly as if from drouth and dies (Fig. 22). Affected plants are usually scattered through the planting rather than occurring in spots.

The cause of this disease has escaped detection for many years. It was first noted in New Mexico over 50 years ago, where it was attributed to a soil fungus, *Fusarium annuum*, but the evidence was not particularly convincing. It was studied to some extent in Louisiana and it was decided that it was not caused by a soil-borne fungus, but, beyond this, no conclusive evidence as to its cause was obtained.

The latest information regarding the cause of this disease comes from Alabama where it was shown that it is caused by a severe strain of the tobacco etch virus.

No practical control is known.

![Fig. 22. Wilt of tabasco pepper. Healthy and wilted plants.](image)

**IRISH POTATO**

The Irish potato is affected by a very large number of diseases. Fortunately, control measures have been worked out for most of these diseases. Furthermore, climatic conditions play an impor-

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2 For a more detailed account of potato diseases see U.S. Dept. of Agriculture Farmers' Bulletin 2098.
tant role in the distribution and severity of some diseases, and so it happens that one of the most serious diseases of the potato—late blight—seldom occurs in Louisiana. Most potato diseases are “seed-borne,” that is, they are carried over on or in the tubers. For this reason, the planting of certified seed is the best preventive measure against diseases of the potato. Certified seed, however, is not a “cure-all.” Some disease-producing organisms are soil-borne, and others are carried over on other plants which are related to the potato, such as tomato, eggplant, pepper and many weeds. In this bulletin, the potato diseases which commonly occur in the State, or are likely to occur, are briefly described and recommendations for their control or prevention are given.

**Common Scab**  
*Streptomyces scabies*

**Description.** Scab affects only the tubers (Fig. 23). It forms round to irregular, hard, corky areas on the tubers. Scabby spots may be small and solitary or large and fusing together to cover most of the surface of the tuber. The scab organism is both seed- and soil-borne. It likes neutral to alkaline soils. Scab is not a problem in acid soils.

**Control.** Treat the seed with either of the following disinfectants: (1) **Hot formaldehyde** (page 120). This method has been in use in Louisiana for several years and has proved its usefulness. (2) **Acidified mercuric chloride** (page 118).

**Black Scurf**  
*Rhizoctonia solani*

Scurf affects both tubers and stems. On the tubers it forms hard, black bodies (sclerotia) which adhere tightly to the skin (Fig. 24). When the tubers with scurf **sclerotia** on them are planted, the scurf fungus (Rhi-zoctonia) grows and attacks the new shoots, forming cankers on the stems and stolons and finally on the new tubers.
Control. Same as for “scab” (pages 118, 120).

Since both scab and scurf organisms are common soil inhabitants (they occur even in virgin soils), seed disinfection does not give 100 per cent control, although it helps to reduce the amount of infection to some extent. In view of the rather limited degree of control obtained, many pathologists question the soundness and practicality of treating seed potatoes.

A new chemical, “Terraclor” (Parachloronitrobenzene) has been tried as a soil amendment in various parts of the country and it appears very promising. It shows remarkable effectiveness against both the scab and the black scurf organisms. In California when it was applied to soils very heavily infested with scab, at rates of 150-300 pounds per acre, it gave nearly 100 per cent control of scab.

**Brown Rot (Bacterial Wilt)**
*Pseudomonas solanacearum*

**Symptoms.** The first manifestation of the disease is a slight wilting of the plant during the hottest period of the day. The plant recovers at night but wilts again the next day and the wilting becomes progressively worse until the plant dies. At first there is a brown discoloration in the inside of stems and roots (in the vascular bundles), but later the brown color appears externally. The same is true of the tuber. In the early stages the brown discoloration is internal—around the vascular bundles—but later the brown color appears on the outside of the tuber, especially about the eyes. Finally the tubers rot.

**Control.** Brown rot does not occur in the northern states where potato seed is grown, so the disease cannot be avoided by the use of certified seed; the disease is limited to the Southern States. The bacteria causing brown rot can survive in the soil (particularly in sandy soils) for long periods, and they also attack many other cultivated plants and weeds. This makes it very difficult to try to eliminate the disease from potato-growing land. In Florida where brown rot has been very severe in certain areas, good control has been obtained by applying sulphur to the land in the summer (800 pounds per acre), followed by liming in the fall (3,000 pounds per acre). In Louisiana, brown rot has not been of sufficient economic importance to justify such a drastic and costly method of control.

**Ring Rot**
*Corynebacterium sepedonicum*

Ring rot also is caused by bacteria (a different species from that causing brown rot). The field symptoms of ring rot and brown rot are similar to the extent that both diseases cause wilting of the plants. They vary, however, in many other respects. Ring rot does not cause a brown discoloration of the stem; brown rot does. Ring rot causes cracking of the tubers and a reddish-brown discoloration of the skin of the tubers; brown rot produces a dark-brown to black discoloration of the tissue of the tuber, with no trace of red color and no cracking.
Control. Unlike brown rot, the ring rot disease is not limited to the South, but occurs in practically all the potato-growing regions of the country. Fortunately, the ring rot bacteria apparently do not survive in the soil from one season to the next. The disease is carried over in slightly infected tubers which do not show external symptoms and may therefore be overlooked by the seed inspector. The bacteria are very infectious and the disease can easily be spread from the few infected tubers by the knife during the process of cutting seed potatoes for planting. In spite of this difficulty, the use of certified seed helps to keep losses from ring ro to a minimum. Seed-producing states are very strict regarding this disease. They will not certify any field that shows even a trace of ring rot, and the only way that the disease can get by is in slightly infected tubers which show no external symptoms and thereby escape detection. Furthermore, Louisiana allows no tolerance for ring rot in certified seed that enters the State. If any trace of ring rot is found in a lot of seed shipped into the State, certification tags are removed, and the lot cannot be sold as certified seed. In this way the grower is protected, to a great extent, against this serious potato disease.

Blackleg and Soft Rot

(Elwinia atroseptica)

Blackleg is a very common bacterial disease of potato, and under certain conditions it may cause severe rottin g of tubers both in the field and in storage. The bacteria are carried on the seed pieces if tubers from infected hills have been harvested. The bacteria may also be present in the soil and infect cut seed pieces if these are planted before the cut surfaces have had time to form a protective cork layer. They are also spread by seed-corn maggots.

Description. The first symptoms of blackleg in the field are yellowing and rolling of the upper leaves of one or more shoots in a hill. The plant soon wilts and dies. Inky-black lesions develop on the stem, which may extend several inches above the ground and downward through the stolons into the tubers. Soft rot then develops in the tubers, starting from the stolon end. Affected tubers usually rot very rapidly in the soil. However, some tubers may survive, but these will carry the bacteria and may rot in storage, or, if planted, will carry the infection to the field.

Control. There is no really satisfactory control for blackleg and soft rot. Selection of the seed helps, but it is not easy to detect infected or infested tubers. Cutting the seed several days in advance of planting, thus allowing the cut surfaces to form cork layers is a good preventive measure but not very practical under our climatic conditions. Because of the uncertainty of weather during planting time, the grower cannot cut his seed, let us say, on Wednesday and plan to plant it the following Monday, because heavy rains may make his field unfit for planting for many days. He has to plant whenever weather permits.

Coating the freshly cut seed
pieces with fungicide is a big help. Not enough experimental work on this problem has been done in this state, but work done elsewhere indicates that fungicides are of value in preventing seed piece decay in the soil, particularly when conditions are unfavorable for quick germination. Of the many fungicides tested, Ferbam (Fermate) gave the best control.

**Early Blight**
*Alternaria solani*

**Description.** This disease is caused by the same (or closely related) fungus which causes leaf blight of tomatoes (see page 63). It forms brown, dead spots on the leaves. When the spots are numerous they run together and kill large portions of the leaves, thereby causing a reduction in the yield of potatoes. Early blight makes its appearance usually toward the latter part of April. The disease is influenced by weather conditions; wet, warm weather favors its development.

**Control.** Early blight can be controlled by fungicidal sprays or dusts (see under Late Blight, page 44). It is questionable, however, whether or not it is economically profitable to spray for this disease. The severity of the disease and the price of potatoes in any particular year are the chief factors to be considered. In general, it is not profitable to spray for this disease alone. The small increases in yield in most cases will not compensate for the cost of spraying.

The blight fungus passes the winter on infected plant refuse left in the field. For this reason, it is not a wise practice to plant a spring crop of potatoes in a field in which potatoes or tomatoes were grown the previous fall.

**Late Blight**
*(Phytophthora infestans)*

Late blight is by far the most destructive disease of potatoes. It occurs in practically all parts of the world. In this country it is most prevalent in the Northeastern States. It is called "late blight" because in the North it occurs in late summer. In Louisiana the blight first appears, usually about the last week in March or the first week in April. Fortunately, late blight does not occur in Louisiana every year. Its first occurrence in epidemic form was in 1944. Since then it has occurred in 1947, 1948, 1949, 1950, 1952, 1953, and 1957. It occurred in epidemic form severe enough to destroy a large percentage of the potato crop in 1944, 1947, 1948, and 1949. Although the blight does not occur every year in Louisiana, it still constitutes a potential menace to the crop, and the potato grower cannot afford to be caught unprepared; he must keep his spray equipment in readiness.

**Description.** Blight first appears as pale-green, irregular spots on the leaves. These spots enlarge very rapidly, if moist, cool weather prevails, and soon may kill the entire leaflet (Fig. 25). The tissue of the spots is soft and dark-brown to black in color. A whitish downy growth occurs on the under surface of the blighted tissue. This growth is made up of the fruiting bodies and spores of the blight fungus. The leaf petioles and stems may
also be affected, and, under humid, cool conditions, the entire plant may be blackened and killed within a few days.

The tubers in the soil become infected from spores which are washed down by rains. Infected tubers may rot in the soil and also later in storage.

Control. Late blight is effectively controlled by the use of fungicides. Before the advent of organic fungicides, Bordeaux mixture and other copper compounds were universally employed and these are still used to some extent. Copper fungicides, although very effective, caused some injury to potato vines. At present the most widely used fungicides for potatoes are organic compounds, carbamates (Dithanes). These come in liquid or solid forms and are sold under different trade names. The carbamates cause no injury to the vines, and, as a rule higher yields are obtained than when copper fungicides are used.

1. Liquid Carbamates. These are made by different manufacturers under different trade names.
names. The two most common ones are "Dithane D-14" and "Liquid Parzate." Both are of the same chemical composition and are known by the technical name of "Nabam."

To make a spray, use 2 quarts of Nabam and 1 pound of zinc sulfate in 100 gallons of water. Pour the Nabam in the water first, then add the zinc sulfate and stir well.

2. Solid Carbamates. These come in wettable powder form. These, also, are known by different trade names, such as "Z-78" and "Parzate," and by the technical name of "Zineb." These do not require the addition of zinc sulfate. The wettable powder is added to the spray tank (usually at the rate of 3 pounds in 100 gallons of water) and the mixture is ready to use. Solid carbamates are easy to use; all one has to do is add the wettable powder to the tank and go ahead and spray. On the other hand, the liquid forms have the advantage of being somewhat cheaper.

3. Dust. The same materials may be used as a dust. Ten pounds of Zineb (Z-78 or Parzate) are mixed with 90 pounds of a diluent, such as talc or clay. Dusts, in general, are not as effective as sprays. However, if the ground is too wet to allow the use of heavy, tractor-drawn spray machinery, a mule-drawn light-weight duster may be used to save the crop.

Virus Diseases

The potato is subject to a very large number of virus diseases (something like 25 different ones are recognized). All these are not of equal importance. The most important ones in Louisiana are the mosaics and leaf roll.

Mosaic. There are several of these, differentiated by the type of symptoms they produce on the plant. Two of the most common ones are treated here, namely, "mild mosaic" and "rugose mosaic."

Mild mosaic is characterized by mottling—scattered yellowish areas on the green leaf—and by slight crinkling of the leaves. Affected plants usually droop somewhat and die prematurely. This is a relatively mild disease.

Rugose mosaic is a much more serious disease than mild mosaic. When we speak of mosaic in Louisiana we refer to rugose mosaic. There is mottling of the foliage, as in the case of mild mosaic, but the yellow areas are smaller, more numerous, and close to the veins. The crinkling of the leaves is very pronounced (Fig. 26). Diseased plants are decidedly stunted and die earlier than the healthy ones. Losses from rugose mosaic run very high.

Leaf Roll. The most prominent symptom of leaf roll is the pronounced upward rolling of the leaflets. Other symptoms are stunting of the growth of the plant, stiff, leathery texture of the leaves, yellowish color, reddish or purplish discoloration of some of the leaves, and reduction in yield.

Control of Virus Diseases. Viruses are systemic, that is, they are carried inside the plant. Fungicidal sprays, therefore, are not effective against virus diseases. Furthermore, in the potato, as in other vegetatively propagated
crops, the viruses are perpetuated in the "seed." All tubers produced by a mosaic-affected vine will contain the mosaic virus and transmit it to their progenies. In nature, viruses are spread from infected to healthy plants by means of insects, particularly aphids. Control of virus diseases of the potato is based on the use of certified seed which is free, or nearly free, of virus. Certified potato seed is produced for the most part in the Northern states where climatic conditions keep the insect populations to a minimum. Seed-producing states have strict regulations in respect to seed certification in order to keep virus and other seed-borne diseases to a minimum. The tolerances permitted by Louisiana for virus diseases in certified seed are 2 per cent for rugose mosaic and leaf roll, respectively, and not over 5 per cent for all viruses combined.

**Root Knot**

*Meloidogyne sp.*

The potato is one of many crop plants that are affected by the root knot (gall) nematodes. Swellings or galls form on the roots and tubers. Infected tubers have a knotty, bumpy surface.

The root knot disease is relatively of minor importance. Losses from it are slight, especially on the spring crop which is grown during the cool season. However, care should be taken not to use infected tubers for seed, for that is a very effective way of spreading the nematodes to new fields.

**SPINACH**

In the past, spinach has been grown in Louisiana only in isolated patches in home gardens, and under these conditions dis-
Damping-Off
(Caused by several soil fungi)

Spinach seed responds very favorably to treatment. Better germination, better stand, and less post-emergence damping-off of seedlings are obtained if the seed is treated. The seed may be treated either with Cuprocide (see page 119), or with Arasan (see page 119).

Downy Mildew
(Peronospora effusa)

Symptoms. Yellowish spots appear on the upper surface of the leaves and a bluish moldy growth on the under surface of the spots. Later the entire leaf may be killed.

Control. This disease is difficult to control. It can be controlled by sprays and dusts, but these leave objectionable residues on the leaves which detract from the market value of the crop. If sprays or dusts are used, applications should stop at least 10 days before harvesting.

The downy mildew is seed-borne. In some regions of the country where a single crop of spinach is grown (no early and late planting) excellent control has been obtained by treating the seed with hot water. Although this method has not been tried in Louisiana, it is felt that it should work and it is recommended. Since only one crop of spinach is planted in Louisiana, the only source of infection would be the seed; there would be no spread from an early to a later planting.

Place the seed in a loose bag and immerse it in hot water, 50° C. (=122° F.) for 25 minutes. Remove and plunge in cold water. It is very important to maintain the temperature of the water as nearly constant at 122° F. as possible.

After the hot water treatment, the seed is spread out to dry, and then it can be treated with Cuprocide or Arasan.

Plant breeders are working toward the development of spinach
varieties resistant to downy mildew, and considerable success has already been attained. The California Agricultural Experiment Station has an immune variety, the “Califlay.” Whether or not this variety would be suitable for Louisiana conditions is not known.

White Rust
(Albugo occidentalis)

White rust is characterized by white, blister-like spots, mostly on the underside of the leaves and yellow areas surrounding these spots (Fig. 27).

White rust is a very destructive disease in the Winter Haven area of Texas. It appeared for the first time in Louisiana in 1952, destroying completely a planting of several acres in Rapides Parish.

Control. Zineb (Z-78 or Parzate) sprays have been found effective in Texas.

SWEET POTATO

Every year growers and shippers suffer losses from sweet potato diseases. These losses result from reduced yields of marketable potatoes; from spoilage in transit, on the market and in storage; and indirectly from a poor quality product.

Five Most Costly Diseases

Twenty different diseases have been observed on sweet potatoes in Louisiana. Fortunately most of these do not cause much damage to the crop. However, at least five diseases do cause great damage—black rot, stem rot or wilt, soil rot, scurf, and soft rot. These five diseases are caused by five different fungi. The relative importance of these diseases varies from year to year and from locality to locality. In general, however, black rot probably takes the heaviest toll year in and year out.

At least one other disease can be serious in Louisiana—internal cork, which is caused by a virus. Although internal cork has not caused severe losses in Louisiana, it is present in some sections. In-

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2 The section on sweet potato diseases was prepared by Dr. Weston J. Martin.
being lifted from the mother potato or shortly after planting. However, slightly infected slips continue to grow and may produce a fair crop. Some potatoes, not necessarily all, from such plants will have black rot lesions (diseased areas) varying from spots too small for the naked eye to see to spots that cover the entire potato. A typical black rot lesion on a potato at harvest is illustrated in Fig. 28, B.

Washing and packing such a potato for shipment before curing will spread millions of spores. The contaminated washing machine will infect other potatoes as they are washed. The disease can then develop on the newly-infected potatoes within the 5 to 12 days in transit or on the market (Fig. 28, C).

If a black-rot-affected sweet potato is stored after harvest, the lesion will enlarge (Fig. 28, D) and eventually destroy the entire potato. Other potatoes that touch the rotted potato can become infected and rot. Entire crates of potatoes can thus be destroyed during storage.
Little effort is made by some growers to control black rot in plantings. It is, therefore, necessary to apply control measures to washed, uncured sweet potatoes, as well as stored potatoes. Control measures follow.

Control of Black Rot in Field Plantings. 1. Select black-rot-free mother potatoes.
2. At bedding time treat mother potatoes as outlined under “General Procedures,” page 57.
3. Bed the treated mother potatoes in soil that has not had sweet potatoes in it for at least three years.
4. Use vine cuttings as much as possible in making field plantings.
5. Do not plant in fields that produced black-rot-affected sweet potatoes at any time during the previous two seasons.

Control of Black Rot in Washed, Uncured Sweet Potatoes. For sweet potatoes that are to be washed shortly after harvest and shipped to market:
1. As far as possible wash and package sweet potatoes from crops that have not shown black rot.
2. When a black-rot-affected sweet potato is washed and packed for shipment before curing, it will contaminate the washing machine with millions of spores produced by the fungus. Results of recent research at Louisiana State University have given a very effective method of disinfecting such a contaminated sweet potato washing machine.
   a. Directions. Spray the empty machine thoroughly with a two per cent water solution of Vancide 51.* Immediately after spraying, flush out the sprayed parts with water for 3 to 5 minutes before resuming the potato washing operations.

Control of Black Rot in Storage. (See Control of Storage Rots, page 57.)

Stem Rot or Wilt

The disease is caused by the fungus Fusarium oxysporum f. batatas. It affects the vascular tissues, causing them to turn dark-brown or black. Infected plants usually develop yellow leaves or may wilt and die. The fungus-causing wilt lives in some soils several years and may infect sweet potatoes planted in such soils. It may infect plants in the seedbed also through affected mother potatoes. Thus the disease can be carried to the field.

Severely infected plants usually die. Others, only slightly infected, may grow and produce potatoes. Such potatoes may carry the fungus, more or less dormant, through storage. Infected potatoes used as mother potatoes can infect some of the slips with wilt fungus.

Control of Stem Rot or Wilt.
Unit I Porto Rico is very susceptible to stem rot. In heavily infested soils, under some conditions, as much as 50 to 75 per cent of plants of this variety may be killed shortly after planting. Goldrush variety is very resistant to stem rot. So far, Goldrush has

* Vancide 51 is a water solution of the sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole with a total of 30 per cent active ingredients. It is a very effective eradicant of sweet potato rot fungi.
not developed much stem rot, even in heavily infested soils. It should be tried wherever sweet potatoes are to be grown in soils known to be infested with stem rot fungus.

If Unit I Porto Rico is to be planted, follow practices below:

1. Select mother potatoes from fields that have not shown stem rot.
2. Treat mother potatoes as outlined under General Procedures, page 57.
3. Bed mother potatoes in soil that is free from stem rot.
4. Plant in fields that have not produced stem-rot-affected crops of sweet potatoes.

Growers whose soils are free from stem rot should be very careful not to introduce the disease into their fields. They should take every precaution when new seed potatoes are brought on the farm to be sure that the potatoes are free from stem rot. Most farms in the principal sweet potato commercial areas are still free from the disease. Recently, however, stem rot was found in several new locations in the areas.

**Soil Rot**

Soil rot, caused by the fungus *Streptomyces ipomoea*, affects the roots of sweet potato plants. Smaller roots rot (Fig. 29, A). Typical scabby lesions form on larger roots and on the potatoes (Fig. 29, B). In dry seasons, soil rot occurs most severely, causing stunted plants, which fail to grow and vine out for weeks after planting (Fig. 29, C). The fungus lives in the soil many years. Usually new infestations appear in small, localized spots in the field. Plants in these spots fail to grow and weeds take over. Many stunted plants may die; some may vine out and produce a few poorly-shaped potatoes.

The disease spreads gradually from these localized spots and within a period of years may spread throughout the field. Infestations vary in severity in different fields. In some fields stunting of the plants may not be noticed and yields may be good. But many of the potatoes may be poorly shaped and scabby.

Soil rot is a disease which is very sensitive to weather conditions, particularly to moisture. During wet seasons a fairly good yield may be obtained in a field that produced only stunted plants during a previous dry season. Usually, however, the potatoes produced during a wet season are badly scarred by scabby lesions.

**Control of Soil Rot.**

1. Select mother potatoes free from soil rot. Take special care to avoid introducing the disease on farms that are free from it.
2. Plant in soils free from soil rot after treating mother potatoes as outlined under “General Procedures,” page 57.
3. Make field plantings in soils free from the disease or in soils that have been treated with sulfur, as recommended in Louisiana Agricultural Experiment Station Bulletin No. 408.
4. On the lighter soils with pH values of 5.8 (which includes most of the soils in the commercial sweet potato growing areas), broadcast the sulfur at the rate of 500 to 700 pounds per acre.
Fig. 29. Soil rot of sweet potatoes. (A) Young plants showing the typical root rot caused by the disease. (B) Sweet potatoes with typical soil rot lesions. (C) A spot of soil rot in a field of sweet potatoes showing the affected, stunted plants in the foreground and the normal vining of less-severely affected plants in the background.

5. Be sure to have a pH determination made of infested soil before applying agricultural soil sulfur. In some poor soils very low in organic matter, as little as 300 pounds of sulfur per acre may
be adequate to reduce the pH to about 5.0. Too much sulfur or uneven spreading of the sulfur in the soil may be harmful, for it may reduce the pH too much for good growth of the potato plants.

Apply sulfur from October to December. Thoroughly disc it into the soil. This allows sufficient time for the action of the sulfur to bring the pH down to about 5.0 (where the causal organism is inactivated) before potatoes are planted the following summer.

Plant only sweet potatoes in the sulfured field the first year after application. After 5 to 6 years it will be necessary to add 200 to 300 pounds of sulfur per acre to the sulfured field, depending on the pH reading of the soil.

6. Heartogold has shown great tolerance to soil rot and has produced moderate yields of fairly good-grade potatoes in infested soils. Goldrush is susceptible to soil rot and has shown typical stunting of plants and rotting of roots in infested soils. However, Goldrush seems to do better than Porto Rico in infested soils.

Besides Heartogold, certain experimental seedlings have done well on infested soils. However, study adaptability and market demands of a particular area before choosing any variety to plant.

**Scurf or Soil Stain**

Scurf is a sweet potato disease caused by the fungus *Monilochaetes infuscans*. It affects underground parts of the plant, principally the potatoes, causing a dark-brown-to-black stain on the skins (Fig. 30). Scurf spots vary from very small to large ones that cover most of the potato.

The main damage caused is in appearance and grade of the potato. Potatoes with severe scurf are not U. S. No. 1 grade. The fungus does not penetrate into the flesh of the potato and eating quality is not affected. In storage, scurfy potatoes shrink more rapidly than others.

**How Scurf is Spread.** Scurf fungus is spread largely through affected mother potatoes. Slips produced by scurfy potatoes may be infected and the disease carried into the field in this manner. The fungus may live in the soil for at least a year.

Scurf may become very severe in some soils under conditions favorable for its development. Some crops of sweet potatoes have been found to be over 50 per cent below U. S. No. 1 grade because of scurf. Usually, however, such severe scurf is traceable to the use of scurfy mother potatoes. Scurf usually develops much more abundantly in soils with high organic matter.
Control of Scurf. 1. Select mother potatoes that are free from scurf. Take every precaution to avoid introduction of the disease on farms known to be free of it.

2. Treat mother potatoes as outlined under “General Procedures,” page 57.

3. Bed mother potatoes in soils that have not had sweet potatoes for at least three years.

4. Use vine cuttings as much as possible in making field plantings.

5. Do not plant in soils that produced scurfy potatoes at any time during the previous two seasons.

6. Do not plant sweet potatoes following turning under a heavy cover crop in heavier soils where scurf is commonly present.

Soft Rot

Soft rot is caused by the fungus *Rhizopus nigricans*, commonly called the bread-mold fungus, and other related species. It causes a soft, mushy rot in early stages of the disease. Under humid conditions, the fungus will grow on affected potatoes and appears as a gray-to-black moldy growth (Fig. 31). Eventually affected potatoes become dry and hard. This condition often is referred to as dry rot.

Soft rot fungus infects sound potatoes largely through cuts and bruises made at harvest, during handling for storage, and in packaging for market. Potatoes that have been exposed to a great deal of moisture before harvest often become severely affected. Those that have been exposed to improper storage or transit conditions, especially to chilling, may become badly damaged by soft rot. Losses from soft rot occur principally in storage, during transit of stored potatoes, and on the market.

Control of Soft Rot. Control measures for this disease are similar to those given under “Control of Storage Rots.” Be very careful to protect potatoes from chilling and overheating during transit and while they are on the market. Handle them in such a way as to keep bruises down to a minimum.

Recent studies have shown that soft rot develops to a much lesser extent in sweet potatoes washed in washing machines that are disinfected. This is done by spraying the brushes and rollers of the machines with a 2 per cent solution of Vancide 51, as described.
under "Control of Black Rot in Washed, Uncured Sweet Potatoes." To reduce soft rot development in washed sweet potatoes, disinfect the machinery with Vancide 51 after each 2 to 4 hours of operation.

**Internal Cork**

Internal cork, caused by a virus, produces brown-to-black corky lesions in the flesh of the potato. A purplish ring-spotting of the leaves seems to be associated in some way with the disease. The spotting appears on older leaves 8 to 12 weeks after planting. Depressions on the surface of affected potatoes occur now and then when there are large corky lesions near the surface of the potato. Lesions in the potato flesh, however, are the only known reliable symptoms of the disease. These diseased areas vary from very small to large ones that may affect most of the flesh of the potato.

At harvest the lesions usually are rather small and may not affect eating quality of the potato very much. In severely affected potatoes, the lesions at harvest may be quite large. However, they increase in number and size during storage. See Fig. 32 for potatoes severely affected after storage. Such potatoes are not edible.

The virus that causes internal cork seems to be carried from diseased potatoes to healthy ones by some unknown insect. The insects feed on the young potato leaves in the seedbed and in the field. Infected plants will produce infected potatoes and infected seed potatoes will produce infected plants.

**Control of Internal Cork. There** is no known method of ridding cork-affected potatoes of the virus. The best known means of fighting the disease is through the use of seed potatoes that are free from it. Since insects are suspected of carrying internal cork, it is very important that growers who have the disease get rid of all their diseased potatoes when they bring in new, cork-free seed stock.

Indications are that the rate of increase of internal cork during storage can be reduced greatly by keeping stored potatoes at 55° to 60° F. Under present sweet potato storage house conditions in Louisiana, it is not possible to maintain temperatures within that range in most cases. However, possibilities of this approach to the internal cork problem...
should not be overlooked, especially if internal cork increases and spreads as rapidly as studies indicate it may.

**Miscellaneous Sweet Potato Diseases**

**Sclerotial Blight.** Sclerotial blight may be quite destructive in seedbeds, particularly during or following very rainy periods. The disease occurs also under field conditions but generally less severely. The causal fungus lives over in the soil. Certain soils appear to be very badly infested.

It may be advisable for growers who constantly lose from this disease to bear the expense of fumigating soil used in hotbeds. (See “Seedbed Practices,” page 59.) Bed disease-free sweet potatoes after treatment (See “General Procedures,” page 57.)

**Charcoal Rot and Java Black Rot.** Charcoal rot and Java black rot (Fig. 33) are principally storage diseases. For their control, use disease-free seed potatoes and practice seed treatment. See also practices outlined under “Control of Storage Rots.”

**Foot Rot.** Foot rot has appeared in Louisiana but it apparently has not caused losses in this state.

**Growth Cracks and Enlarged Lenticels.** These are sometimes called water blisters (Fig. 34).

They are caused by improper moisture relations in the field during the growing season and shortly before harvest.

**Internal Breakdown.** Internal breakdown (Fig. 35) sometimes occurs in stored sweet potatoes.
It is caused by improper storage conditions and appears to be especially abundant when temperature and humidity fluctuate greatly during storage.

**Root Knot Nematodes.** Root knot nematodes, present in certain soils, cause some injury to sweet potatoes. However, Unit I Porto Rico ordinarily is not severely damaged, although it may become infected. Certain varieties, such as Allgold, are very susceptible. Other varieties, including Heart-gold, appear to be more resistant than Unit I Porto Rico.

**Leaf Blight and White Rust.** Leaf blight and white rust are fungus diseases commonly found on sweet potato leaves. Some varieties of potatoes appear to be more severely affected by them than the Porto Rico, but so far no evidence of severe damage has been observed as a result of the two.

**Control of Storage Rots**

Storage rots include soft rot, black rot, Java black rot, charcoal rot, etc. Follow these general practices for control:

1. Apply field control measures outlined for the various diseases.
2. Handle potatoes carefully at harvest and during storage to keep cuts and bruises to a minimum.
3. Thoroughly clean and disinfect storage houses several weeks before storing the new crop, according to directions under “General Procedures.”
4. Cure sweet potatoes at 80° to 85° F. and at 85 to 95 per cent relative humidity for 10 to 14 days to allow for proper healing of cuts and bruises.
5. Keep storage temperature as near to 55° to 60° F. as possible (not lower than 50° F.) and the relative humidity at 80 to 85 per cent.

**GENERAL PROCEDURES**

**Selection of Mother Potatoes.** Select disease-free mother potatoes. This is very important. There is no known fungicide that will kill black rot and scurf fungi inside affected potatoes without killing the potatoes. Recommended fungicidal dip treatments are effective only in killing spores of these and other fungi present on the surface of the potato; they will not kill fungi inside the potato tissues.

**Treatment of Mother Potatoes.** Any one of the treatments given below may be used:

1. **Mercuric Chloride Treatment.** This is the old standard treatment for mother sweet potatoes. It has stood the test of many years and all newer treatments have been compared to it. None of the new treatments is more effective in ridding the surface of the potatoes of fungi than this one. (The Semesan Bel or Van-
cido 51 treatment is preferred by some because the time required for dipping is shorter.)

a. Procedure to follow for using mercuric chloride. Dip the potatoes in a 1:1,000 solution for 10 minutes, remove, drain and bed immediately. A 1:1,000 solution of mercuric chloride is made by dissolving 1 part of the chemical in 1,000 parts of water. Use wooden, enamel or earthenware containers, because of the corrosive nature of mercuric chloride. Mercuric chloride is sold at drug stores in tablet form. One tablet dissolved in 1 pint of water makes a 1:1,000 solution. For several bushels of potatoes, it probably is cheaper to buy the chemical in crystalline form.

A handy volume to work with is about 30 gallons, which requires 4 ounces of mercuric chloride. To keep the solution at proper strength, after treating 19 bushels of potatoes add ½ ounce of chemical and enough water to have 30 gallons. After treating about 50 bushels, make an entirely new solution for treating other potatoes.

CAUTION. Mercuric chloride is a deadly poison! Do not eat treated potatoes! Do not feed them to animals!

2. Semesan Bel Treatment. Dip the mother potatoes in a solution made by mixing 1 pound of Semesan Bel with 7½ gallons of water (4 pounds in 30 gallons). Dip the potatoes for 1 minute, drain and bed. Make a new solution when ½ of the original volume is lost.

CAUTION: Do not eat potatoes treated with Semesan Bel! Do not feed them to animals!

3. Vancide 51 Treatment. This is a newly developed treatment. Its effectiveness compares very favorably with that of the above two mercurial treatments. It is much less toxic to human beings and animals and has been approved for this use by the U. S. Government authorities.

Carefully remove all defective roots and dip the “seed” sweet potatoes in a 2 per cent water solution of Vancide 51. Keep the roots in the solution long enough to wet them thoroughly. Allow the roots to dry or bed them immediately after dipping. When about ½ of the original solution has been used, discard it. Make a new solution for treating other potatoes.

Cleaning, Disinfecting Storage Houses. Storage rots of sweet potatoes are caused by various fungi, which produce numerous spores. You can get rid of many of these spores. Systematically remove all old sweet potatoes and trash from the storage house. Then disinfect the storage house to destroy remaining spores on the floor, walls, bins, crates, etc. Use one of the following methods:

1. Spray with Copper Sulfate (bluestone). Make a solution by dissolving 2 pounds of copper sulfate in 50 gallons of water. Thoroughly coat all walls, ceiling, floor bins, etc., with the solution. DDT, which is recommended for sweet potato weevil control, may be added. Add 4 pounds of 50% wettable DDT to 50 gallons of copper sulfate solution.

2. Fumigate with Formaldehyde Gas. This method calls for much more work but, if done properly, it should be very effec-
tive. It is necessary to keep the storage house airtight.

**CAUTION:** Formaldehyde is poisonous to human beings. Do not breathe it or let it get in your eyes. Get out of the house quickly after the gas is released.

**Procedure to follow for using formaldehyde gas:**

a. Determine the number of cubic feet of space in the house to be fumigated. For each 1,000 cubic feet of space, use 3 pints of commercial formalin and 23 ounces of potassium permanganate.

b. Get three or more deep containers (lard cans, garbage cans, open-end drums, etc.), depending on the size of the house. Space them along a line through the center of the house. The containers should be 5-gallon capacity or larger so that the mixture will not run over when the materials are mixed and foaming results. Put the required amount of formaldehyde in the containers. Be careful not to fill containers more than 1/10 full.

c. Weigh out the required amount of potassium permanganate for each container and place it near the container. Do not mix the permanganate with the formaldehyde until later.

d. Close tightly doors, windows and ventilators. Leave open one convenient exit door. Seal cracks and other openings with paper tape to prevent escape of gas.

e. Beginning with the container farthest from the exit door, add permanganate crystals quickly to the formaldehyde. Do the same with other containers. After the crystals have been added to all containers, leave the house very quickly and close the door. As the crystals mix with the formaldehyde, the mixture will foam and gas will come off.

f. Keep the house closed at least 24 hours; then open and ventilate thoroughly for at least 2 weeks before storing potatoes.

**CAUTION:** Gas generated when adding potassium permanganate to formaldehyde is very irritating to the eyes. Use goggles or a gas mask when working with it.

3. **Fumigate with Chloropicrin.** Some workers recommend this method. It also requires that the storage house be made airtight and that the house be fumigated for 24 hours, under proper conditions of temperature and humidity, if effective disinfection is to be obtained.

**CAUTION:** Chloropicrin is a poisonous gas. Closely follow instructions furnished by manufacturers when using it.

**Seedbed Practices.** Growers who use hotbeds for plant production should take care not to introduce diseases through the soil or mixture used. Where permanent hotbeds are in use, get soil from a source known to be free from sweet potato diseases. Do not use the same soil more than one season without sterilization. Sterilize with steam or chemicals soil that is to be used more than one season in a hotbed. Sterilization by steam requires expensive equipment which may be available in some cases. Sterilization by chemicals (chloropicrin or methyl bromide) may be quite effective, if done according to directions of manufacturers.
TOMATO

Damping-Off
(Caused by several soil fungi)
**Description.** See page 116 and Fig. 36.

**Control.** Treat the seed with Cuprocide or Arasan (see page 119 for method of seed treatment).

Fusarium Wilt
(Fusarium oxysporum f. lycopersici).

**Description.** This is by far the most serious tomato disease in the southern states. The disease is caused by a soil-inhabiting fungus which penetrates the roots of the plant and grows upward into the vascular bundles of the stem and leaves, causing the plant to wilt and eventually to die (Fig. 37). The lower leaves are the first to show the symptoms. They wilt, turn yellow, and die. The disease progresses upward gradually until the entire plant is killed. Dark brown discoloration of the inside tissue of the stems and leaf stalks is a characteristic symptom.

**Control.** The most practical way to control this wilt is to grow wilt-resistant varieties. There are many such varieties available. Resistance is relative; it ranges from complete susceptibility to immunity. The geographical region where a particular variety is to be grown also influences the degree of resistance. For example, the varieties Marglobe, Pritchard, and Rutgers, all good and desir-
able varieties, exhibit a high degree of resistance in the North but only a slight degree of resistance in the Deep South. The following varieties are very highly resistant under Louisiana conditions: Louisiana Pink, Pan America, Jefferson, Brookston, and a variety, as yet unnamed, developed by the Plant Pathology Department, Louisiana Agricultural Experiment Station. It is expected that this variety will be named and released in the near future. Grothen's Globe, the leading commercial variety in South Louisiana, shows considerable resistance.

It is not enough, of course, for a variety to be merely wilt-resistant. It must possess desirable market qualities to be acceptable for commercial growing. For example, the Jefferson is an excellent variety for home gardens. It is wilt-resistant, of good quality, productive, and bears over a long period. However, it is late-maturing and therefore undesirable for commercial growing.

Control of wilt can also be obtained by soil fumigation. Several chemicals (formaldehyde, chloropicrin, methyl bromide, vapam) are suitable for this purpose. However, soil fumigation is not only costly but difficult in application. (See under "Soil Fumigants," page 121, for more detailed information.

**Bacterial Wilt**

(*Pseudomonas solanacearum*)

**Description.** Bacterial wilt is similar to Fusarium wilt in that the plant wilts and dies. However, there are distinct symptom differences between the two. Bacterial wilt is a sudden wilt. The leaves wilt and the plant dies quickly within a few days after the appearance of the first symptoms, instead of gradually and slowly from the bottom leaves up.
ward as in the case of Fusarium wilt. This quick wilting and dying of the plant is a reliable symptom differentiating bacterial wilt from Fusarium wilt. The inside of the stem and leaf stalks show a brown discoloration similar to that of Fusarium wilt but of lighter shade. The brown discoloration usually extends to the pith of the stem. Bacterial wilt is not limited to tomato; it affects other solanaceous plants: potato, pepper, eggplant, tobacco.

Control. Control of bacterial wilt is very difficult. No resistant varieties of tomato are known. Furthermore, once a soil has become infested, the wilt bacteria persist for many years. Rotation is of little value. No wilt develops in the field if the temperature is 70°F. or lower. However, infection of the seedlings in the seedbed can take place at as low a temperature as 55°F. This fact is important to remember. If infested soil is used in the seedbed, many of the seedlings will become infected but will show no symptoms as long as the temperature is cool (70°F. or lower). It is therefore important to use non-infested soil (or sterilized soil) in the seedbed. This precaution will eliminate one of the principal sources of infection.

Soil fumigation practices may be used (see under Soil Fumigants, pages 121-127).

Early Blight and Nailhead Spot
(Alternaria solani and Alternaria tomato)

There is some disagreement among pathologists as to whether early blight of the tomato leaves and nailhead spot of the tomato fruit are two distinct diseases caused by two closely related fungi, or whether the foliage and fruit symptoms are expressions of one and the same disease, but it is generally accepted that two distinct species of Alternaria are involved, A. solani causing early blight and A. tomato causing nailhead spot. For practical purposes this question is not important, and in this bulletin early blight and nailhead spot will be treated as one disease.

Description. The disease may attack plants at any stage of their development, in the seedbed, cold frame, or field. When seedlings become infected in the seedbed or cold frame, lesions form at the ground line and extend above and
below for short distances. These lesions develop into cankers, “collar rot” (Fig. 38). The affected seedlings may be killed, or, if they survive, they usually do not develop into vigorous plants.

In the field early blight appears usually about blossom and fruit-setting time, but may appear earlier or later, depending on weather conditions. The first sign of the disease is the appearance of small brown spots on the lower leaves. These spots enlarge (Fig. 39), and the leaf gradually turns brown, dries up, and dies. The disease progresses upward, the lower leaves being killed first and later the upper ones. In a badly blighted plant all lower leaves are dead and the upper ones are covered with brown spots of different sizes. Spots also often develop on the stems, the fruit peduncles, and the fruit calyces.

On the fruit spots may develop only on the stem end and along cracks and other wounded areas usually as irregular brown to black spots, or be scattered all over the fruit as circular dark brown spots with yellowish margins. The spots may develop on the green or ripe fruit. They begin as shallow tan to gray specks which eventually enlarge. The term “nailhead spot” is used to designate these scattered circular spots on the fruit.

Control. See page 64.

Fig. 39. Tomato leaves spotted by Alternaria blight.
Gray Leaf Spot  
*Stemphyllium solani*

Stemphyllium, a fungus closely related to the one causing early blight, has become prevalent on tomatoes, particularly in the southern part of the State, during the past several years. The symptoms (spotting of the foliage) produced by this fungus are similar to those of early blight, and the two diseases are not easily differentiated in the field. For practical purposes, this is not important since the same control measures apply to both.

**Control.** See below.

Phoma Leaf Spot and Fruit Rot  
*Phoma destructiva*

This disease causes small, dark, irregular spots on the leaves and sometimes on stems. Infected leaves turn somewhat yellow and wither prematurely. The fungus also infects the fruit causing rot. In the field the fruit rot phase is not important, but infected fruit may develop rot spots in transit and storage, making it unmarketable.

**Control.** See below.

Leaf Mold  
*Cladosporium fulvum*

Leaf mold is an extremely destructive disease of winter tomatoes grown under glass. As a field disease it is of relatively minor importance. It occurs in Louisiana particularly on fall grown tomatoes.

**Description.** Large, irregular, yellow areas with indefinite margins appear on the upper surface of the leaves. The lower surfaces of these areas are covered with a velvety, olive-green mold made up of the spores and sporophores of the fungus. Affected leaves drop and the plant becomes progressively defoliated from the bottom upward.

**Control.** See below.

Late Blight  
*Phytophthora infestans*

Late blight is caused by the same fungus that causes the same disease on potato (see page 43). The fungus attacks leaves, stems, and fruit. It can attack the plant at any stage of its growth if favorable weather (cool, humid) prevails. On the foliage and stems the disease first appears as brown to purplish-black lesions. These, under cool humid conditions, enlarge very rapidly, causing severe blight. On the fruit, greenish-gray, water-soaked spots appear, more often on the stem end. These enlarge very rapidly, become dark brown in color, and have a rather firm, wrinkled surface and soft, watery interior.

**Control.** See below.

Buckeye Rot  
*Phytophthora spp.*

Buckeye rot of tomato fruit is caused by several species of soilborne Phytophthoras. These fungi live in the soil and the only way they can get to the fruit is by splashing rains. For this reason, this disease is of minor importance in Louisiana where tomatoes are staked. The rotting of the fruit is similar to that caused by the late blight fungus. However, the buckeye rot Phytophthoras do not attack the foliage.

**Control of Fungal Diseases of Foliage and Fruit**

Early and late blight, as well
as the other fungous diseases that affect the foliage and fruit of tomatoes, can be controlled by fungicidal sprays. Many different fungicides are effective. Before the advent of organic fungicides, copper fungicides (Bordeaux mixture, tribasic copper sulphate, Cuprocide, copper oxychloride, copper oxychloride sulphate, etc.) were used for this purpose. Copper fungicides are very effective against these diseases, but they, in general, seem to cause some injury to the plant which results in reduced yields. In most tests, plants sprayed with an organic fungicide have given higher yields than those sprayed with a copper fungicide. The following figures, obtained in tests at the Plaquemines Parish Agricultural Experiment Station, illustrate this point:

Yields of Marketable Tomatoes in Pounds Per Acre
Copper A, 4 lbs. in 100 gals. ........29,343
Captan, 2 lbs. in 100 gals. water . 30,541
Zineb (Dithane Z-78), 2 lbs.
in 100 gals. ................. ... 33,862
Maneb (Manzate), 2 lbs. in
100 gals. ...................... 33,154

Because of their better performance, in comparison with the copper compounds, organic fungicides, and particularly the carbamates (Dithane Z-78, Parzate, and Manzate), are preferred for spraying tomatoes and potatoes. Organic fungicides are somewhat more costly than the copper fungicides.

Both the copper and the organic fungicides are compatible with the insecticides that are used to combat tomato insect pests (fruit worms, aphids, red spider), such as cryolite, DDT, malathion, parathion, lindane, rotenone, nicotine, etc. Any of these insecticides may, therefore, be applied with the fungicide as a combination spray instead of separately.

**Southern Wilt (Southern Blight)**

*(Sclerotium rolfsii)*

This disease causes the death of an occasional tomato plant in the field, but it is of minor importance. (See under pepper, page 38.)

**Blossom-End Rot**

*(Non-parasitic)*

This is a disease of the fruit. For the most part it affects fruit that is about half grown, but it may be found on very young fruit (buttons) or on fruit that is nearly mature. It always affects the blossom-end part of the fruit. The rot starts as a water-soaked spot which enlarges, turns brown in color, and becomes dry, flat, or sunken. Later the killed tissue may be invaded by secondary organisms and become black and hard or soft and watery (Fig. 40).

Blossom-end rot is a physiological disease. It is caused by fluctuation in soil moisture, and particu-
larly when a period of excessive soil moisture is followed by a hot, dry spell, but the reverse situation, a dry period followed by a wet period, can also cause the disease. With susceptible varieties, this is a very serious disease. It may result in 25-50 per cent loss of the crop.

**Control.** The only satisfactory method of prevention of blossom-end rot is the use of resistant or tolerant varieties. Tomato varieties vary greatly in their susceptibility to this disorder, from highly susceptible to highly resistant. Marglobe and Pritchard are very resistant; Pan America is very susceptible.

Where facilities for irrigation are available, the disease can be prevented by judicious irrigation to prevent sharp fluctuations in soil moisture.

**Root Knot**

*Meloidogyne spp.*

Root knot is a disease familiar enough not to need description. It is caused by a soil-inhabiting microscopic worm (*nematode*) which invades the root tissues causing them to form the familiar galls or knots (Fig. 8). Nematodes occur almost universally in the soils of regions with mild winters such as those prevailing in the South. They attack a very large number of plants. Among the vegetable crops, tomatoes and cucumbers are very susceptible. Nematodes are especially troublesome in light sandy soils.

No easy control is known for nematodes under normal field conditions. As far as possible tomatoes should not be planted on light sandy soil which is infested with nematodes. This is especially true in the case of the fall crop of tomatoes. The spring crop is planted while the temperature of the soil is still relatively cool and the nematodes are not *very active*; thus the plants escape heavy nematode infestation in the early stages of their growth. For this reason the damage to the spring crop of tomatoes from root knot is usually not so severe as on the fall crop. If a piece of ground becomes heavily infested with nematodes, partial relief may be obtained by keeping the land clean-cultivated during the warm season of the year, or by planting a root-knot resistant crop such as corn, sorghum, velvet beans, peanuts, or the Iron Clay variety of cowpea for two or three successive years. When such a root-knot resistant crop is planted it is essential to cultivate between the rows to destroy the weeds because many of the weed plants are susceptible to the root-knot nematodes.

Control of root knot can also be obtained by the use of soil fumigants, and although soil fumigation is rather costly, it is a very effective and practical control measure particularly for home gardens. (See under Soil Fumigants, pages 121-127.)

**Virus Diseases**

Tomato is subject to a very large number of virus diseases. Not all of these occur in Louisiana. The two most important virus diseases of tomato in Louisiana are the *mosaic*, and a disease of recent origin known as "Gray Wall" or "Internal Browning."
Mosaic. Two distinct groups of viruses cause mosaic in tomato, the tobacco mosaic group and the cucumber mosaic group. As each one of these two groups is composed of a large number of virus strains, the symptoms on the affected plant vary considerably depending on the particular strain of virus, the age of the plant at the time it becomes infected, and climatic factors, particularly temperature. In general, the leaves of mosaic-infected plants become mottled with light green or yellow areas interspersed with the normal green color (Fig. 41). The leaflets may become stunted and considerably distorted and malformed. Sometimes the leaves become very narrow and ribbon-like. In some cases (particularly when infected with certain virulent strains of the cucumber mosaic virus) the plant becomes greatly stunted, yellowish, and with multiple shoots bearing small malformed leaves, assuming a bushy, rosetted type of growth (Fig. 42). The stage of growth at which infection takes place is important. If the plant becomes infected when young, before it has set fruit, it is practically worthless; if it becomes infected when full grown (after the setting of the first two clusters of fruit), the damage from mosaic is small.
Control. Mosaic is a systemic disease. By this is meant that the causal agent of the disease is in the sap of the plant. Sprays and dusts, therefore, are ineffective against mosaic. Prevention is the only practical control measure against this disease. Mosaic is very infectious. It is spread by insects and by the handling of the plants by the workers, especially during the transplanting and pruning operations. The following preventive measures are recommended:

1. Prevent infection in the seedbed and cold frame by spraying or dusting periodically with some aphicide such as Black Leaf 40, rotenone, Vapotone, or malathion. This step is very important because, as explained above, plants that become infected in the seedling stage are worthless.

2. Remove or kill all weeds around seedbeds and cold frames. Both the tobacco and cucumber mosaics go to many different weeds, and aphids feeding on them can pick up the viruses and
transfer them to the tomatoes.

3. Avoid the use of tobacco, chewing especially, when handling tomatoes. Tobacco mosaic virus survives in tobacco even if it is dried and cured, and it spreads very readily by contact.

4. Since mosaic can be spread very easily from diseased to healthy plants by means of the pruning knife, reduce the pruning operation to a minimum. Remove the side shoots up to the first flower cluster, then prune no more. Most of the suckers and side shoots can be jerked off by hand without using a pruning knife and without touching the rest of the plant.

5. Do not plant the fall crop of tomatoes near any surviving plants of the spring crop. By the end of the summer any surviving tomato plants from an early planting are almost invariably infected with mosaic which may easily spread to the new plants by insects. Also, the fall crop should, as far as possible, be planted away from peppers and from garden flowers such as petunias and zinnias, for the mosaic virus can infect all these, as well as many other plants.

Gray Wall (Internal Browning). This disease, which is also known as “core rot” and as “blotchy ripening,” is of recent origin. It was first reported from Texas in 1946. Since then, it has been reported from many other states—Florida, New Jersey, New York, Pennsylvania, Ohio. It was observed in Louisiana for the first time in 1952. Thus far it appears to be localized in St. Bernard and Plaquemines parishes, where it has caused severe losses in some plantings.

Description. Symptoms on foliage are not at all characteristic, just a few faint yellow spots. The symptoms on the fruit are very striking. Fruit is affected when it is nearing maturity. Affected fruit becomes hard and somewhat ridged. Irregular grayish to brownish blotches develop on the fruit wall as the fruit approaches maturity. These blotchy areas do not color normally. It is this feature that suggested the designation “blotchy ripening.” The tissue inside the wall is brown in color and may show pits or cavities, formed by the collapse of the tissue. In advanced stages, the brown discoloration extends to the core. Usually, only the first and second clusters of fruit are affected. The plant then recovers, and produces normal fruit. The damage of the early fruit constitutes a severe loss to the grower because it is the early crop that sells at a high price.

Cause. This disease is new and not all the facts about it are known. However, experimental evidence obtained elsewhere (Pennsylvania State University) indicates rather conclusively that the disease is caused by certain strains of tobacco mosaic virus. The disease on the fruit develops only when the plant becomes infected by the virus at the time the fruit is nearing ripening. This is interpreted as a “shock” reaction. If the plant becomes infected earlier, the foliage will show mosaic symptoms but the fruit will not be affected. After the initial shock, the plant becomes adjusted to the virus, and this is the reason
why fruit maturing later is not affected.

Studies on this problem are in progress by the Plant Pathology Department, Louisiana Agricultural Experiment Station, and it is hoped that in time we shall have more definite information about this important disease and its control.

Control. Follow the same preventive procedure as for mosaic.

Section II. Fruit Diseases

APPLE

Fire Blight
(\textit{Erwinia amylovora})

(See Pear, page 96.) Apples are more resistant to fire blight than pears.

Rust
(\textit{Gymnosporangium} spp.)

Description. The rust fungus passes part of its life on the apple and part on the cedar (Fig. 43). On the cedar it forms the well-known swellings or galls ("cedar apples"). On the apple it causes spots on leaves, fruit, and sometimes on young twigs. The spots on the leaves and fruit are orange-yellow in color and a blister or cushion forms in the center of each spot.

Control. Since the rust requires both the apple and the cedar to complete its life cycle, the most effective way to control it is to eliminate the cedar trees. In many of the commercial apple-growing regions, the general practice is to destroy all cedars for a distance of about one mile around the apple orchard. In Louisiana, where apples are not grown commercially, this method cannot be recommended, for the cedars are usually more valuable than the apples.
Fig. 43. Apple rust. (A) Rust spots on apple leaf. (B) Rust gall ("cedar apple") on red cedar.

Rust can also be controlled by spraying. Ferbam (Fermate) is the most effective fungicide against the apple-cedar rust.

Fruit Rots

Several fungous diseases affect the apple fruit at various stages of its development, causing spots and rots. The most important of these, in this part of the country are:

1. Blotch (*Phyllosticta solitaria*). Dark-brown to black blotches with irregular margins on the fruit. Small angular spots on the leaves, and cankers on the twigs. Apple varieties differ greatly in susceptibility, some being very susceptible and others highly resistant.

2. Black Rot. (See Pear, page 100).

3. Bitter Rot (*Glomerella cingulata*). This is the most important apple disease in the southern states. The disease affects the fruit as it approaches maturity. It forms sunken, more or less soft and watery, pinkish to brown rot spots on the fruit (Fig. 44). The rotted tissue has a bitter taste.

Control. In commercial apple orchards the various fruit rots are effectively controlled by following rigid spraying schedules. In small
home orchards where facilities for adequate spraying are usually lacking, control of these diseases is difficult. Sanitary measures are helpful in keeping them in check. All dead wood and all rotted and mummied fruit should be removed and burned.

**Spray Schedule for Apples**

(The spray schedule, if followed, will insure reasonably clean fruit, although it is not calculated to give complete control.)

<table>
<thead>
<tr>
<th>Time of Application</th>
<th>Spray Mixture</th>
<th>Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dormant, Dec.-Jan.</td>
<td>Oil Emulsion Water 2 gals. 50 gals.</td>
<td>San Jose scale, when present</td>
</tr>
<tr>
<td>2. Pink clusters, buds separated</td>
<td>Fermate Water 1½ lbs. 50 gals.</td>
<td>Scab Rust</td>
</tr>
<tr>
<td>3. Calyx (¼ petals fallen)</td>
<td>Fermate Hydrated lime Lead arsenate Water 1½ lbs. 3 lbs. 1½ lbs. 50 gals.</td>
<td>Scab Worms Rust</td>
</tr>
<tr>
<td>4. Two weeks after petals fall</td>
<td>Same as No. 3</td>
<td>Scab Worms Rust</td>
</tr>
<tr>
<td>5. When apples are well grown but not ripening</td>
<td>Copper sulfate Hydrated lime Lead arsenate Water 4 lbs. 4 lbs. 1½ lbs. 50 gals.</td>
<td>Blotch Bitter rot Worms</td>
</tr>
</tbody>
</table>

**BLACKBERRY and DEWBERRY**

**Leaf Spots**

There are several fungi which cause spotting of the foliage of blackberries and dewberries (Fig. 45). Two of these, *Cercospora rubi* and *Septoria rubi*, are the
most common ones in Louisiana. Sometimes these leaf-spotting diseases cause considerable defoliation of the plants by late summer and this naturally affects the vitality of the plants and their fruitfulness the following spring.

**Control.** No tests have been made in Louisiana aimed directly toward the control of blackberry and dewberry leaf spots. However, in the course of some spraying experiments for the control of the rosette disease (see below), it was noted that the 4-4-50 Bordeaux mixture controlled the leaf spots very well. The sprayed plants reached late summer with green foliage while the nonsprayed ones were badly spotted and defoliated. Whether or not it would be economically profitable to spray blackberries and dewberries for the control of the leaf spots is a matter for the grower to determine, but it would seem that one application of 4-4-50 Bordeaux before blooming and about two more applications later on, during June and July, should keep the leaf spotting diseases in check.

**Cane Blight**

In the spring, some of the fruit canes appear weak and have dead patches or cankers on the bark. As the weather warms, some of these die back. There are several fungi that can cause cane blight. *Leptosphaeria coniothyrium* is the most common one in Louisiana. Winter injury is a contributing cause. This is especially true in South Louisiana where the plants do not become dormant in the fall but continue active growth until there is a killing frost.

**Control.** Cut out and burn all the old canes as soon as the fruit is harvested. This will not completely control cane blight, but will help by eliminating the main source of infection.

**Rosette**

*(Cercospora rubi)*

**Description.** The rosette disease is very striking and very easy to recognize (Fig. 46). In the spring diseased canes give rise to multiple shoots which produce a bunchy type of growth (witches' brooms). The diseased flower buds are loose, puffy, and elongated, instead of being round and compact like the healthy ones. Diseased flowers do not set fruit and sometimes the flower parts become leaf-like in growth. After the flowers begin to wither they become covered on the inside with a white powder which is made up of the spores of the fungus.

**Control.** Control measures recommended for rosette will be better appreciated if a brief descrip-
tion is given of the cycle of development of the disease. The fungus (Cercosporella rubi) which causes the rosette disease produces spores only on the withered blossoms in the spring. When the spores fall on the new canes they germinate and grow inside the buds. Infected canes do not show any disease symptoms until the next spring. The period during which the new canes are susceptible to infection is limited. No infection takes place after about the first of June.

**Summary of Control Measures**

1. Do not allow any wild blackberries or dewberries to grow...
close to your berry plantings, as the rosette disease will spread from the wild to the cultivated vines.

2. Inspect the plantings in the spring and remove any rosette growth that may be present. This will eliminate the source of infection from the immediate vicinity of the plants. This cutting off of the rosette growth should be done early in the spring (preferably in February) before the opening of the blossoms, that is, before the spores of the fungus have been formed.

3. Prune all the new canes to the ground about the first week in May. This will eliminate all the canes that may have become infected up to this period.

4. Spray the new canes that develop from the time of pruning until the first week in June with 4-4-50 Bordeaux. The spraying should be done about every 10 days. Two to three sprayings should be sufficient.

5. Do not plant dewberry plants that come from tip layering of rosette canes.

**Rust**

**Description.** Two kinds of rust occur on blackberries and dewberries, the orange rust *(Kunkelia nitens)* and the yellow rust *(Kuhnella uredinis)*.

The orange rust forms orange-colored masses of spores on the undersides of the leaves. It occurs just as soon as growth starts in the spring and usually covers all the new growth of the plant.

The yellow rust appears later and occurs as scattered yellow pustules mostly on stems, but also on leaves, throughout the summer and fall.

**Control.** The yellow rust is not important and there is no need to attempt to control it. The orange rust, on the other hand, is very destructive. It is systemic within the roots and crown of the plant and therefore it cannot be controlled by sprays or dusts. The affected plants should be dug up, roots and all, and burned.

**Crown Gall**

(See Peach, page 92.)

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**CITRUS**

Citrus trees and their fruits are subject to a very large number of diseases. No attempt is made to describe or discuss all the citrus diseases in this bulletin. Only the most common ones are considered.

**Scab**  
*(Sphaceloma fawcettii)*

Scab is primarily a disease of satsuma orange, tangerine, grapefruit, lemon, sour orange, and *Citrus trifoliata*. It does not affect the sweet orange. Scab affects fruit, leaves, and young shoots, causing irregular, raised, corky, scabby, wart-like outgrowths (Fig. 47). Severely scabbed leaves and fruits become mis-shapen and distorted. The rind of scabbed fruit is thick and puffy.

**Control.** Scab control is based on the fact that infection occurs only on young, immature growth, provided there is sufficient moisture in the atmosphere and that the temperature is neither too high nor too low (about 59° to
Fig. 47. Scab on sour orange.

74° F. is the optimum). This combination of conditions usually prevails during the flush period of growth in the spring and it is during this period that the trees should be sprayed. (See Spray Schedule, page 79.)

Melanose  
(Diaporthe citri)

Description. Like scab, melanose is caused by a fungus (Diaporthe citri), and it also affects leaves, shoots, and fruit. It forms numerous, dark brown dots or spots on the leaves, young shoots, and fruit (Fig. 48). These spots are at first sunken, but later become raised so that the russeted area has a rough, sand-paper feel. The spots may be irregularly scattered on the surface of the fruit, or they may run in streaks (tear-stains). Like scab, melanose infection occurs only on young, tender growth. The fruit becomes progressively resistant with age. However, the same fungus that causes melanose can infect the ripe fruit after harvest. It is one of the two most common causes of the very destructive fruit decay known as stem-end rot. Control of melanose, therefore, helps to reduce the losses from stem-end rot.

Control. Two methods are used for the control of melanose—sanitation and spraying. To obtain effective control of melanose on the fruit, it is necessary to spray during the critical period of maximum susceptibility to infection; that is, within one to three weeks after fruit set.

1. Sanitation. The melanose fungus does not produce spores on the living parts of the plant (leaves, shoots, and fruit), but only on dead twigs and branches. Therefore, pruning and burning the dead wood is a great help in

Fig. 48. Melanose on sweet orange.
controlling this disease because the practice eliminates much of the source of infection.

2. Spraying. (See Spray Schedule, page 79.)

Sooty Mold

Description. The sooty mold fungus (*Capnodium citri*) is not a parasitic organism. It does not penetrate the tissue of the plant but grows superficially on the honeydew excretions of white flies, aphids, mealy bugs, and scale insects. Sooty mold causes a certain degree of injury when its growth is very thick by preventing the sunlight from reaching the leaf, and by making the fruit black and unattractive. Fruit that is covered with sooty mold is smaller in size and does not color well.

Control. Sooty mold is controlled indirectly by controlling insects (white flies and scale) which excrete the honeydew on which the sooty mold fungus grows. When these insects are killed the sooty mold disappears. (See Spray Schedule, page 79.)

Lichens

Description. Growth of different kinds of lichens (commonly called "moss," locally) often occurs on trunks, branches, and sometimes on leaves of citrus trees. Lichen growth is less abundant on healthy, vigorous trees than on neglected, weakened trees which are growing poorly. For this reason the presence of lichens is often blamed for the unthrifty condition of the trees, when in fact the reverse is true; the lichen growth is abundant because the tree is unthrifty from some other cause. Lichens are generally considered harmless. They are not parasitic, do not invade the tissue of the bark, and cause no damage to the tree. An exception to this general statement may be made in the case of one kind of lichen (*Melanotheca* sp.). This species, which makes a grayish, compact, pimply type of growth on trunks and branches, probably causes a slight damage. The bark underneath the lichen growth, although not killed, appears damaged. It is somewhat sunken and brownish in color.

Control. Lichens are easily controlled by spraying with Bordeaux or with other copper fungicides. The regular spray schedule (page 79) for the control of other diseases is usually sufficient to control the lichens also. If desired, stronger concentrations of Bordeaux mixture, 4-4-50 or 5-5-50, may be applied to the trunk and branches for the control of lichens.

Fruit Rots

Because the bulk of the fruit is sold locally, mostly on the New Orleans market, almost as soon as it is picked, the Louisiana citrus grower is not confronted with the serious problems of storage and transit rots that the citrus shipping states have to face. This does not mean that fruit rots are not important. Even though the grower may dispose of his fruit before it rots, some one along the line, whether it be the commission merchant, the grocery man, or the housewife, will suffer a loss if the fruit rots before it is consumed, and this loss will ultimately be passed back to the grower in the form of lower prices. Therefore, every effort should be made to prevent fruit decay.
In considering means of keeping losses from fruit rots to a minimum, the following facts should be kept in mind: (1) fruit rots are caused by parasitic fungi (molds) which invade the tissue of the fruit and cause it to rot; (2) these molds infect the fruit for the most part through cuts, wounds, bruises, thorn pricks; (3) the spores of these molds are produced in vast numbers on dead twigs and branches and on rotten fruits; and (4) moisture is necessary for the germination of the spores.

With these facts in mind, the precautions to be taken for preventing fruit rots are obvious. Fruit should not be picked when wet, or, if picked when wet, provisions should be made for drying it as soon as possible. No decaying fruit should be allowed to stay in or in the vicinity of the packing house. If the fruit is washed, it should be dried as rapidly as possible. Borax, at the rate of 5 to 8 per cent, either in the wash water or in a separate dipping tank, helps to keep down fruit rots, particularly the blue and green molds.

**Nutritional Troubles**

It is known that some nutritional troubles, caused by deficiencies of one or more of the so-called “minor” or “trace” elements (boron, copper, zinc, manganese) do occur in some of the citrus groves in Plaquemines Parish. These deficiency diseases are characterized by various chlorotic patterns on the foliage, by die-back of twigs, by growth abnormalities, and by some effects on the size, shape, and taste of the fruit.

Nutritional deficiencies are corrected either by soil or by foliar application of the needed element. Soil applications are not always effective. In certain soils, especially those with alkaline reaction, the needed element is “fixed” or “inactivated,” that is, it is taken out of solution, and cannot be absorbed by the roots. In such cases, the element can be applied as a spray to the foliage.

The copper fungicide sprays used for control of fungus diseases will also correct copper deficiency. Manganese and zinc deficiencies can be corrected by the addition of manganese sulphate and zinc sulphate to the fungicidal or insecticidal sprays (see Spray Schedule). However, nutritional sprays should not be used indiscriminately. They add to the cost of production. It should first be determined whether or not a deficiency of any particular “minor” element exists.

**Notes on Citrus Spray Schedule**

(a). The term “neutral copper” refers to several proprietary copper fungicides that are sold under different trade names, such as “Copper A,” “Copper K,” “C.O. C.S.,” “Tribasic Copper Sulphate,” etc. The copper content of these compounds varies anywhere from about 25 per cent to 50 per cent. Follow the directions of the manufacturer as to the proper amount to use. For example, if a particular compound contains 50 per cent copper, use it at the rate of 2 pounds in 100 gallons of water; if its copper content is 30 per cent, use 3 pounds per 100 gallons.

(b). Spray oils come either as emulsions or as clear (miscible) oil. The per cent of oil varies with
# Citrus Spray Schedule

(For a better understanding of the spray schedule, read carefully “Notes on Citrus Spray Schedule” beginning on page 78.)

<table>
<thead>
<tr>
<th>Time</th>
<th>Spray or Dust</th>
<th>For Control of</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Pregrowth.</em> January–February Stop before blooming</td>
<td>A. For satsuma, grapefruit, Temple Neutral copper(a) 3 lbs., wettable sulphur 8 ¹/₂ lbs., Malathion 1 1/2 pints, water 100 gallons, Nutritional mixture if desired. See notes(c)</td>
<td>Scab, Scale, Red Spider</td>
</tr>
<tr>
<td></td>
<td>B. Valencias Sulphur dust or spray</td>
<td>Rust Mites</td>
</tr>
<tr>
<td></td>
<td>C. For all other round oranges Oil emulsion 2–3 gals. per 100 gals.</td>
<td>Purple and Red Scale</td>
</tr>
<tr>
<td>2. <em>After bloom.</em> For satsumas when most petals have fallen. For other oranges when fruit is about pea size.</td>
<td>A. For satsuma, grapefruit, Temple Neutral copper(a) 3 lbs., wettable sulphur 8 ¹/₂ lbs., Malathion 1 1/2 pints, water 100 gallons, Nutritional mixture if desired. See notes(c)</td>
<td>Scab, Scales, Mealy Bugs, Aphids, Red Spider</td>
</tr>
<tr>
<td></td>
<td>B. For all other oranges Neutral copper(a) 2–3 lbs., wettable sulphur 8 ¹/₂ lbs., Malathion (e) 1 ½ pints, Ovotran (if oil in spray No. 1 has been omitted) 1 lb., Water 100 gals.</td>
<td>Melanose Scales, Rust Mites Red Spiders Aphids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <em>Middle</em> June–Middle July</td>
<td>For all citrus Oil emulsion (b) 1 to 1½ gals. Malathion(e) 1 pint Water 100 gals.</td>
<td>Scales White Flies Red Spiders Mealy Bugs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. August</td>
<td>For all citrus Sulphur(d) dust, or wettable sulphur spray</td>
<td>Rust Mites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. September</td>
<td>For all citrus Wettable sulphur 8 ¹/₂ lbs. Malathion(e) 1 ½ pints, Water 100 gals.</td>
<td>Rust Mites Red Spiders Scales White Fly Mealy Bugs</td>
</tr>
</tbody>
</table>

* The sprays marked with an asterisk are the most important ones for the home orchard.

† This schedule was prepared in consultation with Ralph Brown, superintendent, Plaquemines Parish Experiment Station, M. W. McEachern, county agent, Plaquemines Parish, and John A. Cox, horticulturist, Louisiana Agricultural Extension Service.

...the brand. Follow the directions of the manufacturer as to the proper amount to use.

(c). Nutritional Sprays. Deficiencies of zinc and manganese occur in some of the groves. In such cases the use of nutritional sprays may be desirable. A nutritional spray may be made with 3 pounds of zinc sulphate, 3 pounds of manganese sulphate, and 1.2 pounds of hydrated lime in 100 gallons of water.

(d). Sulphur and oil are not compatible and will cause severe injury if mixed. Never mix oil and sulphur in the same spray, and always allow at least three weeks interval between oil and sulphur applications.
(e). Parathion may be used instead of malathion. Parathion is very poisonous, much more poisonous than malathion, and should be used with extreme care. Follow exactly the directions on the container.

Spray No. 1 (pregrowth) may be omitted partly or completely. If scab infection is not heavy, the copper component of the spray may be omitted; if scab has been bad the previous season, but scale and red spider infestation is light, the oil component of the spray may be left out; if both scab infection and scale and spider infestations are light or absent, omit spray No. 1 completely.

**Virus Diseases**

Citrus is affected by a large number of diseases caused by viruses, some of them extremely destructive. The three most important ones, Scaly Bark (*Psorosis*), Bark Shelling (*Exocortis*) of *Trifoliata*, and Tristeza (Quick Decline) are treated in this bulletin.

**Scaly Bark**

(*Psorosis*)

This disease is also called "California scaly bark" in order to differentiate it from *Leprosis*, an entirely different disease that occurs in Florida and which, in that state, is commonly called "scaly bark."

**Description.** Psorosis virus is composed of several strains, and, because of this, symptoms vary somewhat depending on the particular virus strain and the particular citrus species. The most prominent characteristic of the disease is the scaling of the bark. This starts in the form of small blisters which usually appear first on the older bark of the branches or trunk of trees that are five years old or older. Soon after the appearance of the bark blisters, the bark begins to scale off in flakes of dry bark of varying sizes (Fig. 49). The scaly area increases in size gradually until it girdles the branch or trunk. Gumming may or may not accompany the scaling. In the early stages, the inner bark and the wood underneath are not affected, but as the disease progresses, the wood becomes filled with gummy materials and reddish brown in color. The part of the branch above the scaly lesion (or the whole tree if the lesion is on the trunk) begins to show symptoms of distress: sparse foliage and dieback of twigs. The foliage also exhibits symptoms, usually small light-green to yellow flecks. The leaf symptoms usually appear long before the bark symptoms.

![Fig. 49. Scaly bark ("Psorosis") on orange.](image-url)
Control. The disease can not be cured but it can be prevented. The only known method of spread of the virus is by budwood. Budwood should be taken only from trees that are free of infection, and, since young trees (under 5 years) usually do not show bark symptoms, budwood should be taken from older trees (preferably 10 years old, or older) that are free of bark symptoms.

Exocortis (Bark Shelling, Scaly Butt)

This disease is important only in trees grafted on trifoliate orange (*Poncirus trifoliata*) rootstock and some of its hybrids.

Description. The most prominent characteristics of exocortis are (1) the shelling of the bark of the rootstock portion of the trunk (Fig. 50), and (2) the severe stunting of the growth of the tree. Comparative measurements of exocortis-affected and healthy navel orange trees in California showed the trunk diameter of the affected trees to be only \( \frac{1}{2} \) that of healthy trees and the average volume of the tops about \( \frac{1}{5} \) that of the healthy trees. The outer bark separates from the inner live bark and peels off in narrow, dry strips.

The dwarfing of the growth of the tree becomes apparent early, usually from the second year on; the shelling of the bark, however, does not usually begin to develop until after the tree is eight years old. This fact is important to remember in connection with control.

Control. Exocortis can not be cured, but it can be prevented in planting new groves. Prevention is based on these facts: (1) the virus may be carried in any species of citrus, but symptoms show only on trifoliate orange rootstocks. (2) Bark shelling, the most reliable diagnostic feature, does not develop until the tree is eight years old or older. (3) The only known way of spreading the infection is the use of infected budwood or of infected trifoliate seedlings. The following preventive measures are recommended.

1. Budwood should be taken from healthy trees, growing on trifoliate rootstock, and not less than 10 years old.

2. Seed for rootstock propagation should not be taken from trifoliate trees showing exocortis.

Tristeza (Quick Decline)

Tristeza, or quick decline, is the most destructive virus disease of
citrus. It apparently originated in the Union of South Africa and from there has spread on transported citrus stock to practically all regions of the world where citrus is cultivated. It has destroyed most of the orange groves in Argentina and Brazil. It appeared in California about 1939 and has killed thousands of orange trees there. It was found in Louisiana in 1950, and in Florida more recently. There are indications that the disease had been present in both Louisiana and Florida several years before it was recognized, but, for reasons that are explained below, it has not spread so widely in this country as in other parts of the world.

Description. The symptoms of tristeza are rather indefinite and difficult to describe. As the name (Quick Decline) indicates, the disease causes the tree to go into a state of rather rapid decline. The leaves are smaller than normal and of a dull, pale-green to yellow color. Shedding of foliage, from the base of the shoot upward, often takes place. In older trees, there is a partial to complete suppression of flushes of new growth. There is a dying back of twigs and larger branches. In the early stages of infection, affected trees bloom profusely and set a heavy crop of fruit. The small feeding rootlets, first, and later larger roots, die and decay. The whole tree then may die within a few months or 2 to 3 years. In some cases, however, the disease becomes chronic; the tree may remain alive indefinitely but in a weak, unproductive condition. It is known that tristeza virus is composed of strains that vary in virulence, and it is believed that trees that survive the attack and go into a chronic unthrifty condition are infested with a mild strain of the virus.

Resistant and Susceptible Rootstocks. Tristeza is primarily a disease of sweet orange on sour orange rootstock. This is by far the most susceptible scion-rootstock combination. Several other scion-rootstock combinations are susceptible, but to a less degree. The following is a list of resistant and susceptible rootstocks:

<table>
<thead>
<tr>
<th>Resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trifoliate orange (Poncirus trifoliata)</td>
</tr>
<tr>
<td>Most mandarins (Cleopatra in particular)</td>
</tr>
<tr>
<td>Rangpur lime (a mandarin hybrid)</td>
</tr>
<tr>
<td>Sweet orange</td>
</tr>
<tr>
<td>Rough lemon</td>
</tr>
<tr>
<td>Some tangelos and citranges</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Susceptible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour orange</td>
</tr>
<tr>
<td>Grapefruit</td>
</tr>
<tr>
<td>Shaddock</td>
</tr>
<tr>
<td>Pummelo</td>
</tr>
<tr>
<td>Some acid lemons</td>
</tr>
<tr>
<td>Some limes</td>
</tr>
<tr>
<td>Some tangelos</td>
</tr>
</tbody>
</table>

Transmission of Tristeza Virus. In nature, the virus is spread by two means; (1) by insects (aphids), and (2) by the use of infested budwood.

The most efficient vector (spreader) of the virus is a species of citrus aphid (Aphis citricidus). This species is prevalent in many parts of the world, and is responsible for the very rapid spread of tristeza and the wholesale destruction of the citrus orchards in South America. Fortunately, this species of aphid is not known to occur in North America, and this accounts for the relatively slow spread of the disease in this country. Two other species of aphids, the melon aphid and the green
citrus aphid, which occur in this country, are capable of spreading the virus, but both of these are very inefficient vectors and, therefore, not of great importance.

Most of the spread of tristeza in this country has been due to the use of infected budwood. Many species and varieties of citrus growing on their own roots, or on tolerant rootstocks (sweet orange on trifoliate rootstock, for example) may carry the virus without showing any disease symptoms.

Control. From the preceding discussion, it becomes plainly evident that in areas where the tristeza has been introduced, the most practical means of control is the use of tolerant rootstocks. In Louisiana, the most common rootstocks in the past were sour orange, trifoliate orange, and shaddock. Of these, sour orange was most widely used because it is compatible with most species and varieties of citrus and resistant to root rot and foot rot. Now that the tristeza has been introduced into the Louisiana citrus area, both sour orange and shaddock are definitely out as rootstocks. This leaves the trifoliate orange as the only tried rootstock, and, while trifoliate possesses many admirable qualities, such as resistance to cold, root rot, and tristeza, it also possesses some disadvantages, such as incompatibility with some varieties and susceptibility to bark shelling (Exocorticis). Therefore, there is, therefore, a pressing need for a suitable tristeza-resistant rootstock to take the place of sour orange.

Of the tristeza-tolerant rootstocks listed above, sweet orange is not suitable to Louisiana conditions; it is susceptible to root rot and foot rot. Some mandarins, particularly the Cleopatra, and some citranges, appear promising. These, together with several other citrus species and hybrids, are being tested at the Plaquemines Parish Experiment Station, and it is hoped that suitable substitutes for sour orange will be found.

**Leaf Blight**

(Caused by several species of *Pellicularia*)

The Pellicularia leaf blight is the most serious disease affecting fig trees in Louisiana. There are three different species of Pellicularia that cause blighting of fig leaves. They are very much alike in general symptoms and the control measures are the same for all three types; for this reason they are grouped together.

Leaf blight usually appears late in May or early in June. The worst damage usually occurs during prolonged rainy spells. Leaves and fruit are attacked by the leaf blighting fungi. The injury is confined to the loss of leaves and fruit.

Description. The blight first shows up as irregular-shaped brown spots on the leaves. Infection usually starts at the base of the leaf and spreads in a fan-like manner, forming a large semi-circular brown discolored dead-spot.

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*The section on Fig diseases was prepared by Dr. E. C. Tims.*
Infected leaf tissues may shrivel up and fall cut, producing a shot-hole effect, or the edges of the leaves may slough off, leaving them ragged in appearance. Some leaves may have the white or light brown colored, powdery-looking fruiting layer of the Pellicularia on the lower surfaces. When conditions are favorable, large numbers of leaves may be completely killed within a few days, leaving some limbs completely bare. Most of the damage occurs before the fruit ripens. On the limbs where the leaves are killed the fruit usually shrivels up or does not ripen properly.

The three fungi that cause leaf blight of fig are: 

1. *Pellicularia koleroga* (the thread blight fungus) which produces small, brown, shiny hyphal threads on the small twigs, petioles, and leaves, and irregular-shaped, brown sclerotia on the twigs (Fig. 51). Leaves killed by this fungus usually hang on to the twigs by the small hyphal threads in a characteristic way. 

2. *Pellicularia filamentosa* is characterized by the production of large numbers of small, brown sclerotia about half the size of mustard seed on the twigs, fruit, and leaves. 

3. An undetermined species of *Pellicularia* which differs from the other two forms in the absence of any definite sclerotia or hyphal threads.

**Control.** The fig leaf blight can be controlled rather easily under most conditions by the use of copper sprays. One or two applications of Bordeaux mixture 4-4-50 between May 10 and June 1 are usually sufficient to keep the leaves on the trees until after the fruit has ripened. Bordeaux mixture should not be applied later than a month before the figs ripen because of possible objectionable staining of the fruit. Another compound that is easier to prepare than Bordeaux mixture has proved to be effective against leaf blight. Tribasic copper sulphate, 3 pounds to 100 gallons water, applied in late May or early June usually gives good control. In periods of rainy weather it may be necessary to make one or two additional applications.

**Rust**

(*Physopella fici*)

**Description.** Rust is caused by *Physopella fici*, a fungus which is widespread over the State. It first appears as small yellowish to reddish pustules on the lower surface of the leaves (Fig. 52),
which enlarge and become more numerous until almost the entire surface may be involved. Many fig trees are completely defoliated by rust before the end of the summer, although the disease seldom develops early enough to damage the leaves seriously before the fruit ripens. The only serious aspect of the disease is premature defoliation of the trees.

Control. The sprays used for the control of leaf blight will usually give sufficient protection against rust. If no spraying has been done for the leaf blight, a wettable sulphur spray (4 pounds in 50 gallons of water) applied in late May or early June (before fruit ripening) will give satisfactory prevention of rust. The same spray should be used after the fruit has been harvested to prevent premature defoliation of the tree by the rust.

Cercospora Leaf Spot

Description. This leaf spot, caused by *Cercospora fici*, is widespread in the State, but causes only slight damage. The spots are brown in color, roughly circular in shape, and vary in size up to about $\frac{1}{2}$ inch in diameter. The spots may coalesce to form larger areas of dead tissue.

Control. Control measures are usually unnecessary. Bordeaux mixture applied in May or early June will greatly reduce Cercospora leaf spot.

Limb Blight

Description. This disease is caused by the fungus *Corticium salmonicolor*. It is characterized by the sudden dying of twigs or branches up to 2 inches or more in diameter, with the production of bright pink color on the bark of the diseased twig (Fig. 53).
The leaves on the dead twigs usually turn a dark brown color and hang on for weeks after they are killed. This type of limb blight often recurs in the same trees year after year, sometimes causing considerable damage.

**Control.** Prune out the affected branches, making the cut about 6 inches below the dead bark, and either paint the cut surfaces with Bordeaux paste (see page 114) or spray the tree with Bordeaux mixture.

**Fig Canker**

The fig canker is caused by the fungus *Tubercularia fici*. It is widely scattered over the State and causes some damage to many trees. The cankers appear as irregular-shaped swellings with sunken areas in the center. They partially girdle the twigs and small branches, killing some and weakening others so they break easily.

**Control.** The cankers should be cut out.

**Stilbum Disease**

**Description.** This disease is caused by a fungus called *Stilbum cinnabarimum*. It causes a dying of twigs and even limbs on fig trees. Diseased areas are characterized by the presence of small pink fungus heads borne on short stalks growing on the bark. Infection takes place through wounds of various types, and may occur through the leaf scars on small twigs.

**Control.** Control measures are rarely necessary for the Stilbum disease, but where it occurs, the infected branches can be pruned out.

**GRAPE**

In discussing diseases of grapes, the varieties of grapes grown should be considered. Grapes are not grown commercially to any extent in Louisiana. In home gardens, two types of grapes are grown, the muscadines and the American bunch grapes.

From the practical standpoint, the muscadines are relatively free from diseases. The black rot fungus causes considerable spotting of the foliage, especially of the Scuppernong variety, but it does not affect the fruit to any appreciable extent. Two other fungi, *Cercospora* sp. and *Isariopsis clavispora*, also cause spotting of the leaves late in the season, but they are not serious. In general, it may be safely stated that none of the diseases affecting the muscadine grapes causes sufficient damage to justify control measures.

The bunch grapes, on the other hand, are subject to many serious diseases, and unless one is prepared to practice control measures, one should not attempt to grow bunch grapes in Louisiana. The following are among the most important diseases of bunch grapes.

**Black Rot**

(*Guignardia bidwellii*)

**Description.** The black rot fungus affects the leaves, berries, fruit stems, and sometimes the young canes. It causes numerous definite brown dead spots on the leaves. The berries are affected in all stages of their development.
but most severely when they are one-half to two-thirds grown. The rot on the berries starts as a purplish or brown spot which spreads fast and soon rots the entire berry, which turns black in color and later dries and shrivels. The dried, mummified berries remain attached to the stem (Fig. 54).

Control. Spray with Ferbam (Fermate), 1 pound to 50 gallons of water, (1) when new growth is about 1” long, (2) just before bloom, (3) two weeks after bloom, (4) two weeks after the third application, and (5) when fruit is about half-grown. Cryolite at the rate of 3 pounds per 50 gallons may be added to the Ferbam spray to control chewing insects.

**Anthracnose**  
*Elsinoe ampelina*  

**Description.** Like the black rot, the anthracnose fungus attacks the leaves, shoots, fruit stems, and berries. On the leaves the spots are small, angular, with pale-brown centers and reddish-brown margins. On the berries, the spots are circular, sunken, and each is surrounded by a purplish to dark-colored border (Fig. 55). The appearance of the rotted spots on the berries has given this disease the common name of “bird’s eye rot.” Spots, somewhat similar to those on the berries, develop also on the young shoots. Sometimes the spots are so numerous that the young shoots are girdled and killed.

**Control.** Same as for Black Rot.
PEACH and PLUM

Peach and plum are grouped together here for the reason that these two crops have many diseases and insect pests in common, and for the most part the same control measures are applicable for both.

Scab

Description. Scab is caused by a fungus, Cladosporium carpophilum. It is characterized by greenish to black spots on the peach fruit (Fig. 56, A). The spots are usually localized on one side of the fruit near the stem end. When the infection is severe, the scabby part of the fruit cracks. The disease also forms irregular blotches on leaves and small cankers on tender twigs.

Control. See Spray Schedule, page 93.

Bacterial Spot and Canker

(Xanthomonas pruni)

This disease, which is caused by bacteria, affects both peach and plum. It causes spots on the leaves and fruit and cankers on shoots and branches (Fig. 57). The dead tissue of the spots on the leaves often separates and falls out, leaving conspicuous “shot-holes.” On the fruit the spots are small, circular, dark brown, and somewhat sunken. Two kinds of cankers form on the shoots, spring cankers and summer cankers. The spring cankers develop on young, tender shoots of the previous summer growth. They appear as water-soaked somewhat darkened blisters about the time of leafing. At first they are small, but enlarge gradually to form brown to purplish lesions about ½ inch long. The summer cankers develop on the still green shoots in late summer. They are thick-edged, somewhat raised, and quite conspicuous. The summer cankers result from infection from bacteria in spots on the leaves. The bacteria
then over-winter in these summer cankers and infect new growth in the spring. Therefore, control of the disease by the use of fungicidal sprays is directed, for the most part, toward killing the bacteria in the twig cankers.

Control. No completely satisfactory control is known for bacterial spot. However, certain practices help to reduce the incidence of the disease and reduce losses. (1) As a preventive measure, nursery stock should be carefully inspected and any trees showing swollen cankers on the twigs should be discarded in order to prevent the introduction of the disease in the new orchard. As a rule, nurserymen take all possible precautions to keep their stock clean. The use of budwood from young, vigorous, clean trees is especially important. (2) The more vigorous the growth of the tree, the more resistant it is to this disease. Therefore, good growing conditions by cultivation and fertilization should be maintained. Nitrogenous fertilizers are especially helpful. (3) Spraying with zinc sulphate (4 pounds zinc sulphate, 3 pounds hydrated lime, 50 gallons of water) gives a certain degree of control.

Recent reports from Arkansas and Illinois indicate that after-harvest sprays (late summer to early fall) with copper sulphate without lime were successful in eradicating the bacteria in the cankers and thus preventing infection in the spring. The copper sulphate was first used in a rather concentrated form (4 pounds in 100 gallons of water), applied about the middle of October. This was effective, but caused some injury. Later, 3 split applications were made with a weak solution of copper sulphate (1 pound in 100 gallons) at 2-week intervals, beginning about the middle of August. This resulted in good control without injury to the tree. The copper sulphate spray seems
to be the most promising control measure as yet tried against this disease. However, since it has not been tested under Louisiana conditions, it is felt that it is not safe to recommend it at this time.

Leaf Curl

Description. This disease, which is one of the most serious diseases of the peach in most parts of the world, occurs only rarely in Louisiana, and it is of decidedly minor importance. It is due to a fungus \(Taphrina deformans\) which causes the young leaves to become thickened, twisted, curled, and distorted (Fig. 58). The thickened portions of the leaf are pinkish with a whitish surface. Affected leaves fall off, resulting in defoliation of the tree. The fruit and tender twigs may also be affected.

Control. Since leaf curl occurs only rarely in Louisiana, and when it does occur the infection is usually not severe enough to cause much damage, control measures are probably not justified. However, this disease can be controlled very easily by one application of a suitable fungicide, such as 4-4-50 Bordeaux or lime-sulphur, during the dormant season (December-January). In the spray schedule (page 93) a combination of Bordeaux mixture and oil emulsion is recommended as a dormant spray for scales and leaf curl.

Plum Pockets

Description. Two other species of the same genus of fungus which causes leaf curl on peach cause the well-known plum "pockets" or "bladders" on plum. One of these \(Taphrina communis\) affects the young plum fruits, causing them to enlarge and become spongy and hollow, bladder-like. The other species \(Taphrina mirabilis\) affects primarily the young leaf buds and the tips of the young twigs, distorting them and producing fleshy, spongy, hollow overgrowths. This is especially bad on the Chickasaw plum and its relatives.

Control. No completely satisfactory control is known for this disease. The sprays recommended in the spray schedule against other diseases will control this disease to some extent, but not completely.

Brown Rot

\(Sclerotinia fructicola\)

Description. Brown rot is by far the most important disease of...
peaches and plums in Louisiana. It affects the blossoms in the spring, causing blossom blight. It causes cankers on twigs and branches, and causes rot of the fruit on the tree and in storage. The fruit rot phase is the most serious and most destructive. It may affect the fruit in various stages of its development, but it is most prevalent as the fruit approaches maturity. On the fruit the rot starts as small, circular, soft, brown spots which enlarge very rapidly so that in a very short time the entire fruit is rotted. The spots usually start at points where the fruit skin has been broken in some way, such as by worms, rubbing, hail, bruising, etc. The surface of the rotted part of the fruit becomes covered with a brown to gray mass of fungus spores (Fig. 56, B). After the fruit has rotted, it dries up, shrinks, and forms a dry, hard, shriveled “mummy.”

Control. The brown rot fungus is carried over from one season to the next, (1) in cankers on twigs and branches, (2) on fruit “mummies” which may remain hanging on the trees, and (3) in fruit “mummies” which fall to the ground. With these facts in mind, it is easy to understand the control measures recommended for this disease.

1. Sanitation. Sanitary measures are very important because they eliminate much of the primary source of infection. All dead wood should be pruned out during the winter. All fruit that falls to the ground should be collected and either buried deep, burned, or fed to hogs. Hogs make a very clean job of picking up fallen fruit, and where the trees are conveniently located so that hogs can be turned loose under them, this is the most efficient and cheapest method of cleaning up.

2. Spraying or Dusting. Although sanitary measures are of great value, particularly in the home orchard where adequate spraying equipment is usually not available, the most satisfactory control of brown rot is by means of fungicidal sprays or dusts. (See Spray Schedule, page 93.)

Rust
(Tranzschelia discolor)

Description. This disease forms reddish pustules on the under side of the leaves and on the fruit. The upper side of rusted leaves show yellowish spots and affected foliage sheds prematurely. The premature defoliation, when it occurs year after year, has a decided weakening effect on the tree.

Control. The sulphur sprays recommended for brown rot control (see Spray Schedule, page 93) will also control the rust until harvest time. One postharvest application of wettable sulphur will normally keep the trees free of rust for the rest of the summer.

Root Knot
(Meloidogyne spp.)

Peach is very susceptible to root knot and is injured severely if planted in nematode-infested soil, especially if the soil is sandy. Two distinct species of root knot nematodes are involved, Meloidogyne incognita var. acrita and M. javanica.

Control. Peaches should not be planted on soils known to be
infested with nematodes. Planting an orchard is a costly undertaking that should not be gone into blindly. Before planting ask the aid of the nematologist of the Agricultural Experiment Station. He can determine whether or not your soil is infested and can advise you on the practicability of using a soil fumigant before planting.

Nematode-susceptible cover crops, such as Alyce clover, should not be planted in a peach orchard.

Some nematode-resistant rootstocks of oriental origin are available. The most promising ones are Shalil, Yunnan, and Bokhara. These are compatible with most of the peach varieties grown in the State. Unfortunately, these are resistant to only one of the two species of root knot nematodes that attack peaches. They are resistant to *M. incognita* var. *acrita*, but not to *M. javanica*.

Some recent work with soil fumigants has shown that “Nemagon,” a new nematocide (see page 124) injected into the soil around young peach trees, will kill the nematodes in the roots without damaging the tree. This is a costly control practice, probably economically impractical for treating large trees, but it may be of practical value in the case of young trees.

**Black Knot**

**Description.** This disease is striking in appearance and easily recognized by the large, black, warty swellings or knots on branches of the plum tree (Fig. 59). Peach is not affected. It is caused by a fungus (*Dibotryon morbosum*) which invades the woody parts of the tree.

**Control.** Prune out during the fall and winter all diseased branches and burn. The cut should be made several inches below the knot so as to remove that part of the fungus which is growing inside the tissue beyond the limits of the knot. Spraying (see Spray Schedule, page 93) also helps to prevent new infections from getting started.

**Crown Gall**

*(Agrobacterium tumefaciens)*

Crown gall is another disease caused by bacteria (see page 4). It is characterized by the formation of large, spherical or irregular, rough galls, usually on the crown and larger roots of the tree, although, not infrequently, the galls may form on the aerial parts, on the trunk, and on the branches. Crown gall affects a
very large number of different plants, both woody and herbaceous.

Control. Trees are injured by crown gall more if they become infected when young (in the nursery or soon after planting). Therefore, all nursery stock should be carefully examined before planting and any trees showing galls should be destroyed. Since crown gall bacteria can survive in the soil for many years, young trees should not be planted in soil from which old, diseased trees have been removed.

Root and Foot Rot

Oak root fungus, Clitocybe tabescens, (See description under Pear, page 100.)

Spray Schedules for Peaches and Plums
(Read carefully the explanatory notes at the end of the spray schedules before you mix and apply the spray materials.)

<table>
<thead>
<tr>
<th>Name and Time of Spray</th>
<th>To Control</th>
<th>Materials and Amounts to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dormant; after leaves are shed and before buds swell</td>
<td>Scales</td>
<td>Oil emulsion, 3% actual oil in diluted spray (See Note 4)</td>
</tr>
<tr>
<td>2. Petal-fall; when 75% of petals have fallen</td>
<td>Curculio Brown rot Plant bugs</td>
<td>To make different amounts of spray use as follows: Water 100 25 Gals. Gals. Lead arsenate 3 lbs. 12 ozs. Zinc sulphate 4 lbs. 1 lb. Hydrated lime 8 lbs. 2 lbs. Wettable sulfur 6 lbs. 1½ lbs. 50% wettable DDT 2 lbs. ½ lb. (See Note 2)</td>
</tr>
<tr>
<td>3. Shuck-fall or first cover; when 75% of shucks are off</td>
<td>Curculio Brown rot</td>
<td>Same as No. 2 (Petal-fall) except omit the DDT</td>
</tr>
<tr>
<td>4. Second cover; 2 weeks after shuck-fall spray</td>
<td>Curculio Brown rot Scab</td>
<td>Same as No. 3 (Shuck-fall spray)</td>
</tr>
<tr>
<td>5. Third cover; 2 weeks after second cover spray</td>
<td>Curculio Brown rot</td>
<td>Same as No. 3</td>
</tr>
<tr>
<td>6. Fourth cover; 4 weeks before harvest</td>
<td>Curculio Brown rot Scab Oriental fruitmoth</td>
<td>Same as No. 2</td>
</tr>
<tr>
<td>7. Pre-harvest; 7 to 10 days before harvest</td>
<td>Brown rot</td>
<td>Wettable sulphur 6 lbs. 1½ lbs</td>
</tr>
</tbody>
</table>

Notes pertaining to the above schedule, on page 94.
This program is based on Louisiana Agricultural Extension Service Leaflet No. 9, compiled by C. E. Smith, L. D. Newsom, and J. R. Roussel, Entomologists, Louisiana Agricultural Experiment Station, and Donald H. Spurlock, Associate Horticulturist, and K. L. Cockerham, Entomologist, Louisiana Agricultural Extension Service.

Note 1. Bordeaux mixture is first made and then the required amount of oil emulsion is added.

Note 2. If plant bugs are not a problem, that is, no cat-facing or ill-shaped fruits occur in the orchard, the DDT can be omitted. On the other hand, if this trouble is extremely bad in the orchard, follow the petal-fall spray in about 5 days with an application of 5% DDT dust.

Note 3. MIXING DIRECTIONS. (1) Place about one-half of the amount of water to be used in the tank; (2) dissolve the zinc sulphate in a small amount of water and pour into the tank; (3) add lime and agitate thoroughly; (4) add the wettable sulphur and lead arsenate and agitate until thoroughly mixed, and (5) add water to make the desired amount of finished spray.

Note 4. The following table shows amounts of different oil concentrates to use in making 3% oil spray.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Parts Required to Make</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 Gals.</td>
</tr>
<tr>
<td>66% Emulsion</td>
<td>4½ gals.</td>
</tr>
<tr>
<td>Water</td>
<td>95 gals.</td>
</tr>
<tr>
<td>75% Emulsion</td>
<td>4 gals.</td>
</tr>
<tr>
<td>Water</td>
<td>96 gals.</td>
</tr>
<tr>
<td>83% Emulsion</td>
<td>3½ gals.</td>
</tr>
<tr>
<td>Water</td>
<td>96½ gals.</td>
</tr>
<tr>
<td>97% Emulsion</td>
<td>3 gals.</td>
</tr>
<tr>
<td>Water</td>
<td>97 gals.</td>
</tr>
</tbody>
</table>
## Alternate Parathion Schedule

<table>
<thead>
<tr>
<th>Name and Time of Spray</th>
<th>Materials per 100 Gallons</th>
<th>To Control</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blossom</strong></td>
<td>Liquid lime-sulfur (32 degrees Baume) 1 gal., or wettable sulfur (sulfur 80% or more) 6 lbs.</td>
<td>Blossom blight caused by the brown rot fungus</td>
<td>Sulphur sprays during bloom may aid in reducing blossom blight. The blossoms must be kept covered with sulphur during the entire period of bloom for control. This will usually make necessary several applications to reduce brown rot at harvest. Wettable sulfurs with less than 80% sulfur may be used at rates to give at least 5 lbs. of actual sulfur in 100 gals. of spray.</td>
</tr>
<tr>
<td><strong>Petal-fall</strong></td>
<td>Wettable sulfur 6 lbs. Parathion (15%) 2 lbs.</td>
<td>Plum curculio Brown rot</td>
<td>Thorough spraying absolutely necessary if good control is expected.</td>
</tr>
<tr>
<td>After all petals are off and before peach is showing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shuck-fall or First Cover</strong></td>
<td>Wettable sulfur 6 lbs., plus Parathion (15%) 2 lbs.</td>
<td>Plum curculio Brown rot</td>
<td>Spray thoroughly trunks and larger limbs in addition to spraying tops of trees in each cover spray to aid in control of peach tree borers.</td>
</tr>
<tr>
<td>%4 shucks off</td>
<td></td>
<td>Scab</td>
<td></td>
</tr>
<tr>
<td><strong>Second Cover</strong></td>
<td>Wettable sulfur 6 lbs., plus Parathion (15%) 2 lbs.</td>
<td>Plum curculio Brown rot</td>
<td>These cover sprays are all important for the control of scab, curculio and brown rot.</td>
</tr>
<tr>
<td>7-10 days later</td>
<td></td>
<td>Scab</td>
<td></td>
</tr>
<tr>
<td><strong>Third Cover</strong></td>
<td>Wettable sulfur 6 lbs., plus Parathion (15%) 2 lbs.</td>
<td>Plum curculio Brown rot</td>
<td>Use Parathion only where curculios are present.</td>
</tr>
<tr>
<td>12-14 days after second cover</td>
<td></td>
<td>Scab</td>
<td></td>
</tr>
<tr>
<td><strong>Five Weeks Before Harvest, of each variety</strong></td>
<td>Wettable sulfur 6 lbs., plus Parathion (15%) 2 lbs.</td>
<td>Oriental fruit moth Plum curculio Brown rot</td>
<td></td>
</tr>
<tr>
<td><strong>Three Weeks Before Harvest, of each variety</strong></td>
<td>Wettable sulfur 6 lbs., plus Parathion (15%) 2 lbs.</td>
<td>Oriental fruit moth Plum curculio Brown rot</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-Harvest</strong></td>
<td>Wettable sulfur 6 lbs., or liquid lime-sulfur 2 to 3 qts. or Dusting sulfur (80% or more actual sulfur)</td>
<td>Brown rot</td>
<td>Additional sulfur, preferably as dusts, should be applied before and during harvest if brown rot is present or rainy humid weather occurs. Under certain conditions liquid lime-sulfur may cause injury, particularly to the leaves.</td>
</tr>
</tbody>
</table>

**CAUTION:** Parathion is an extremely toxic and hazardous material. It is poisonous if swallowed, inhaled, or absorbed through the skin. When handling or spraying with parathion, use an approved respirator. Do not spill material on clothing or skin. Change clothes and bathe in warm soapy water after handling.
The foregoing spray schedules are designed to control the principal insect pests and diseases which affect peaches and plums in Louisiana, San Jose scale, West Indian peach scale, plum curculio, oriental fruit moth, plant bugs, scab, and brown rot. For a description of the various insect pests of peaches and plums, and for directions for controlling peach borers, write to Louisiana Agricultural Extension Service for "Insect Pest Control Leaflet No. 9."

**Dusting Instead of Spraying.** For the small home orchard, where a spray machine is not available and where a duster (usually a small cotton duster) is available, it may be advisable to dust instead of spray for the control of curculio, scab and brown rot. Dusts are not so effective as sprays because they do not adhere to the foliage well and are washed off by rains. For this reason it is better to spray whenever possible. If facilities for spraying are not available, dusting is the second best thing to do. Use the following dusts: (1) When about \( \frac{3}{4} \) of the petals have fallen—5 parts of arsenate of lead and 95 parts hydrated lime. (2) About 10 days later—same as in (1). (3) Two weeks after the second application—80 parts of dusting sulphur, 5 parts of lead arsenate, and 15 parts of hydrated lime. (4) Three weeks after the third application—same as for (3). For best results, apply the dust either early in the morning when the air is still, or late in the evening.

**PEAR**

**Fire Blight**

Fire blight, which is caused by bacteria (*Erwinia amylovora*) is by far the most serious disease of pears and apples. It is because of the blight that the most desirable varieties of eating pears, such as the Bartlett, which is very susceptible, cannot be grown successfully in the State.

**Symptoms.** Blight is most conspicuous during blooming time. The blossoms and the leaves next to them turn black. The tips of twigs and branches die back, and the killed leaves which are dark brown to black in color remain hanging (Fig. 60). Bark cankers of various sizes form on branches and stems, or even on the main trunk of tree.

**Control.** Under the warm, humid conditions of our state, control of fire blight is very difficult. In regions with drier climate the blight can be kept in check by removing and burning the blighted twigs and by scraping the cankers on the branches and painting the wounds. This practice has been tried in Louisiana and has not proved effective. Furthermore, blight affects other related plants such as apple, crabapple, loquat (Japanese plum), pyracantha, etc., and the bacteria are spread by insects, especially bees, over long distances. For Louisiana conditions, the following recommendations will be found helpful.

1. **Resistant Varieties.** Pear varieties possess varying degrees of resistance to fire blight. Unfor-
Unfortunately most of the high quality eating pears, such as Bartlett, are very susceptible. Of the many varieties that show some resistance to blight, Pineapple and Richard Peters are the most resistant. The Pineapple, unfortunately, is a poor quality pear. Its fruit is satisfactory for cooking and preserving but not for eating fresh. The Richard Peters is a good quality pear, but it has the weakness of being self-sterile. It will not set fruit if planted by itself. The varieties Bosc, Seckel, Lincoln, and Douglas are good pollinators for Richard Peters, but, of these, only the Douglas is blight-resistant. If the Richard Peters is selected for planting, at least one Douglas tree should be planted close by to act as pollinator. The Pineapple is self-fertile and will set fruit if planted alone. Both Pineapple and Richard Peters are very susceptible to the Early Leaf Spot. (See page 98.)

Other varieties that are more or less resistant to blight are: Ayres, Baldwin, Carnes, Dabney, Douglas, Garber, Hood, Hoskins, Kieffer, LeConte, Maxine, Mooers, Old Home, and Orient. It must be understood that these varieties are not blight-proof. They possess sufficient resistance so that they are not killed by the blight, but, when wet weather prevails during the period of blooming, some of these may blight badly.

The Hood has fruit of fair quality, better than that of the Pineapple. It is an early bloomer, and its blossoms are often killed by frost. The Kieffer has the advantage of being resistant to the Early Leaf Spot.

2. Sprays. A weak Bordeaux mixture (2 pounds bluestone, 2 pounds hydrated lime, 100 gallons water), applied when the trees are in full bloom, reduces blight infection but does not prevent it completely.

In recent years, sprays or dusts of antibiotics (streptomycin, agrimycin) have been tried in some northern and western states. The use of antibiotics for blight control is still in the experimental stage, and is not recommended at this time. While antibiotics appear to be very effective, their
high cost (the price will probably come down eventually) makes their use economically impractical, for the home orchard at least, although they probably have a place in commercial orchards of high-quality pears. One commercial preparation of antibiotic spray is available on the market under the trade name of "ORTHO Streptomycin Spray."

3. Cultural Practices. The blight bacteria thrive on tender, succulent growth. For this reason the more vigorous the tree, the worse it will blight. Therefore, it is advisable not to over-fertilize, not to prune heavily, and not to cultivate the trees. This applies to both pears and apples.

Leaf Spots
Two leaf-spotting diseases, caused by two different fungi, occur commonly on pear. For convenience, these are termed here the "Early Leaf Spot" and the "Late Leaf Spot" and are discussed separately.

Early Leaf Spot
(Fabraea maculata)

The early leaf spot disease makes its appearance early in the spring, usually in April. The spots on the leaves are mostly circular in outline, dark-brown to nearly black in color, with purplish margins (Fig. 61, A). Spotted leaves turn yellow and shed. Defoliation usually starts on the lower branches and progresses upward. As new leaves are produced on the defoliated branches, they in turn become infected and fall off.

Thus the defoliation continues throughout the summer. It is common for the defoliated trees to bloom profusely in late summer.
or early fall, and to bloom only sparingly and set very little fruit the following spring. In some varieties (as the Garber for example) the disease affects the fruit also, causing black cankers and cracks on it.

**Control.** The early leaf spot fungus has many ways of overwintering. It produces two kinds of spores on the dead leaves on the ground. It also forms minute cankers on the bark of twigs and shoots from which spores arise in the spring. In Louisiana the first method of overwintering of the fungus is the most common. Infection in the spring starts from spores produced on dead leaves on the ground. With these facts in mind, the following recommendations are made for the control of this disease:

1. Remove the dead leaves from under the trees in the winter, either by plowing them under or, better still, by raking and burning. This will eliminate the main source of infection.

2. Spray with Ferbam (Fermate), 2 pounds in 100 gallons of water. Two spray applications, one in April, just as soon as spots are beginning to appear on the foliage, and a second one about three weeks later should prove sufficient, but if the disease is not checked, a third application about three weeks after the second, is advisable. Other organic fungicides, such as Zineb (Parzate, Z-78), or Captan, will probably be effective, but they have not been tested in Louisiana. Copper fungicides (Bordeaux mixture, Tribasic Copper Sulphate, C.O. C.S., etc.) are effective against the disease but sometimes cause injury (burning of the foliage and russetting of the fruit).

**Late Leaf Spot**

The late leaf spot disease is caused by another fungus (*Cercospora minima*). This disease makes its appearance late, usually in August. The spots are angular to indefinite in outline and brown to grayish in color (Fig. 61, B). When many spots develop, the leaves turn yellow and shed, so this disease also causes defoliation.

**Control.** Since this disease appears late in the season, after the crop is over, it does not usually cause enough damage to justify control measures. However, if the infection is severe, or if it starts earlier than usual (under favorable conditions it may start in July), and it is found necessary to control it, the same kind of sprays recommended for the early leaf spot will be found effective.

**Root and Foot Rot**

(*Clitocybe tabescens*)

During the summer (especially in late summer) pear trees are often seen with yellowish, unhealthy, wilting foliage. Such trees usually die before the end of the summer. Examination of trees thus affected will show that the bark of the trunk near the ground line and that of the crown and main roots is dead (Fig. 62). A creamy-white, matted fungus growth occurs between the bark and the wood and between layers of the bark. The disease is caused by the oak-root fungus (*Clitocybe tabescens*), which attacks a very large number of woody
plants. In Louisiana the disease has been found on pear, tung, peach, apple, weeping willow, grape, rose, photinia, and camellia. The fungus occurs naturally on the roots of various kinds of oaks, and when the land is cleared it persists for several years on roots which are left in the ground. This is the reason why foot rot is almost invariably found on trees which have been planted on recently cleared land.

Control. If the disease is discovered in time, before the bark has been killed completely around the trunk, the tree may be saved by scraping the killed part and painting the wound with Bordeaux paste. Unfortunately, by the time the tree becomes sick enough to be noticed, the trunk is usually completely ringed and then it is too late to save it. When planting on newly-cleared land, especially land occupied by oaks, an effort should be made to remove the large pieces of oak roots from the soil.

**Fruit Rots**

About the time pears are approaching maturity, spots which are at first brown but soon turn black, usually appear on some of the fruits. These rot spots usually start at worm holes or at places where the fruit has been injured by birds, hail, wind, etc. The rot increases rapidly so that in a short period large areas on the fruit, or even the entire fruit, rot and turn black.

Fruit rots are caused by several fungi (molds). The most common one in Louisiana is *Botryosphaeria ribes*. This fungus occurs on many woody plants in the South, causing bark cankers on many trees and shrubs.

**Control.** Sanitary measures offer the cheapest method of control. Dead wood should be pruned and burned. Fruit that falls to the ground should be picked and removed from the orchard. Spraying for codling moth (see Spray Schedule) will help to control black rot because much of the infection starts in holes of codling moth worms. Spraying the fruit about three weeks before harvest will prevent much of the black rot, but it is questionable if this is economically practicable.
Pear Spray Schedule

<table>
<thead>
<tr>
<th>Spray No. and Time</th>
<th>Kind of Spray</th>
<th>For Control of</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dormant</td>
<td>Oil emulsion</td>
<td>San Jose scale, if present.</td>
</tr>
<tr>
<td></td>
<td>Water 2 gals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 gals.</td>
<td></td>
</tr>
<tr>
<td>2. Full bloom</td>
<td>2-2-100 Bordeaux mixture</td>
<td>Fire blight. (Use only on varieties that blight.)</td>
</tr>
<tr>
<td>3. Calyx (¼ petals fallen)</td>
<td>2-2-100 Bordeaux mixture plus 3 lbs. lead arsenate</td>
<td>Coddling moth</td>
</tr>
<tr>
<td>4. About middle of April</td>
<td>Ferbam (Fermate) 2 lbs. Water 100 gals.</td>
<td>Early leaf spot</td>
</tr>
<tr>
<td>5. About middle of May</td>
<td>Same as No. 4</td>
<td>Early leaf spot</td>
</tr>
</tbody>
</table>

PECAN

The pecan is affected by a large number of diseases and insect pests. Only a few of the most common diseases are discussed here. For more complete information, write to the United States Department of Agriculture, Washington, D. C., for Farmer's Bulletin No. 1829 which contains a detailed account of all the diseases and insect pests of pecan and their control.

Scab

Description. Scab, caused by a fungus, *Cladosporium effusum*, is by far the most important pecan disease, especially in the more humid southern half of the State. In the drier, northern part of Louisiana, scab is less troublesome. Scab affects the leaves, shoots, and nuts. The spots are circular or elongated, olive-brown to black in color, raised at first.

Fig. 63. Scab on pecan nuts.
but becoming sunken with age. When numerous, the spots unite to form irregular black blotches on the nut husks (Fig. 63). Badly scabbed nuts fail to fill and usually drop.

Control. Scab, as well as other diseases and insect pests of pecan, can be effectively controlled by spraying (see Spray Schedule). The commercial pecan grower knows well that he can not grow this crop successfully without spraying and he is equipped with the necessary machinery for applying insecticides and fungicides to his trees. The difficulty is with the small grower who has a limited number of trees in the home yard or small farm; he can not afford the costly machinery needed to spray large trees.

Resistant Varieties. Pecan varieties differ greatly in their susceptibility to scab. For home and small farm planting, where means for spraying large trees are not available, the planting of resistant varieties is the only practical way to avoid scab. The following varieties are among the most resistant: Stuart, Desirable, Barton, Elliot, Jennings, Curtis, Dependable.

Unfortunately, resistance to scab is not absolute and unchangeable. Many of the varieties that are resistant at present may lose their resistance in the future. This happened before. Varieties, such as Teche, Nelson, Money-maker, and Success, that were highly scab-resistant in the past, scab badly now in some localities, particularly in the southern part of the State. Stuart was considered practically immune to scab in the past, but now it is known to scab badly in some localities. The explanation for loss of resistance is that the scab fungus changes, giving rise to new pathogenic races that are capable of parasitizing the resistant varieties.

Sanitary Measures. The scab fungus overwinters principally on husks left on the tree and on husks and leaves on the ground. If this debris is either plowed under, or raked and burned, a great deal of the early infection of the spring growth will be avoided.

Leaf Blights

Under the general heading of "leaf blights" are included several diseases which cause leaf spotting and premature defoliation. Some of these are:

1. Downy Spot (*Mycosphaerella caryigena*). The symptoms are greenish-yellow, downy spots on the underside of the leaves earlier in the season, which become visible on the upper side of the leaves as brown dead spots during the latter part of the summer. Delmas, Moneymaker, Stuart, and Frottscher are among the varieties more susceptible to this disease.

2. Leaf Blotch (*Mycosphaerella dendroides*). The first signs of this disease are a greenish-brown, velvety, tufted growth in spots on the underside of the leaves and faint yellow spots on the upper side. This disease makes its appearance usually in late June or early July. Later in the season the velvety growth on the underside of the spots disappears, and minute, black, pimple-like structures
appear on the affected surface. The spots enlarge and many unite to form large, irregular blotches. Severe defoliation occurs in late summer. The oldest leaves are shed first.

3. Vein Spot (*Gnomonia nervis-eda*). The spots occur along the veins. Those along the midrib are long in shape; those originating near a smaller vein are circular. Spots also occur on the petioles (leaf stems) and on the stems of the leaflets. Severely affected leaves are shed prematurely. The Van Deman, Frotscher, and Stuart are among the most susceptible varieties.

4. Brown Leaf Spot (*Cercospora fusca*). Circular to irregular reddish-brown spots, varying in size from one-eighth to one-half inch across, characterize this disease. The older spots become grayish in color. The disease usually appears in July and older leaves are affected first. In late summer the spotting increases rapidly and the trees become badly defoliated by the first part of October. All pecan varieties are susceptible to this disease, but the Stuart and the Money-maker are most affected. Brown leaf spot ranks next to scab in importance.

5. Liver Spot (*Gnomonia car- yae, var. pecanae*). This disease is characterized by dark brown circular spots on the lower surface of the leaves and located mainly along each side of the midrib. Later in the season the color of spots changes to cinnamon-brown. This disease is more prevalent in the northern part of the State. Like the other leaf blights, liver spot causes prema-

ture shedding of leaves if the infection is severe.

**Control of Leaf Blight.** Organisms causing the leaf blights are relatively weak parasites, and for this reason the blights are more prevalent and more destructive on neglected or weakened trees which have not been adequately cultivated and fertilized. Strong, vigorously-growing trees are not damaged appreciably. Proper care of the trees, adequate cultivation, and fertilization will in most cases be sufficient protection against the leaf blights. However, these diseases can also be easily controlled by spraying with Bordeaux mixture. If the trees have been sprayed for scab control, no additional spraying will be necessary. (See Spray Schedule for control of pecan diseases and insect pests, pages 104-105.)

**Rosette (Non-parasitic)**

Rosette is a nutritional trouble caused by zinc deficiency. This disease is characterized by a variety of symptoms. In early stages the leaves, especially those of the top branches, show a slight yellow mottling. In more advanced stages the leaflets become narrowed and crinkled, with reddish brown spots or holes between the veins. The internodes of the new shoots become shortened so that the leaves are borne close together, forming a bunched, rosetted type of growth. In the more advanced stages the foliage, as a whole, has a bronzed or rusty appearance. In still more advanced stages, there is a die-back of the shoots. Trees that are severely rosetted usually do not bear fruit.
## Spray Schedule for Pecans

(This schedule has been copied from the 1954 revision of United States Department of Agriculture Farmers' Bulletin 1829)

<table>
<thead>
<tr>
<th>Name of Spray and Time of Application</th>
<th>Insect or Disease to be Controlled</th>
<th>Spray Materials (per 100 gallons)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>First prepollination spray, when buds are bursting and first leaves are showing</td>
<td>Scab, downy spot.</td>
<td>4-1-100 Bordeaux mixture</td>
<td>To prevent foliage injury, apply only when temperature is above 55°F.</td>
</tr>
<tr>
<td>Second prepollination spray, when first leaves are half grown</td>
<td>Scab, downy spot, vein spot, nursery blight</td>
<td>4-1-100 Bordeaux mixture</td>
<td></td>
</tr>
<tr>
<td>First cover spray, when tips of small nuts have turned brown</td>
<td>Scab, downy spot, vein spot, leaf blotch, brown leaf spot, nursery blight</td>
<td>6-2-100 Bordeaux mixture or Ziram or zineb, 2 lbs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 percent DDT, 2 or 3 lbs. or 15 percent parathion, 2 lbs. or Nicotine sulfate, ½ pt. plus Summer oil 2 qts.</td>
<td>If pecan nut casebearer infestations are heavy, make a second application 1 week later with any of the insecticides listed. Use parathion if aphids and mites require treatment.</td>
</tr>
<tr>
<td></td>
<td>Pecan nut casebearer, pecan leaf casebearer, aphids, and mites.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosette</td>
<td>Zinc sulfate, 4 lbs. in Bordeaux mixture</td>
<td></td>
<td>Reduce zinc sulphate to 2 lbs. if Bordeaux mixture is not used.</td>
</tr>
<tr>
<td>Stage</td>
<td>Disease/Insect</td>
<td>Treatment 1</td>
<td>Treatment 2</td>
</tr>
<tr>
<td>-------</td>
<td>---------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Second cover spray, 3 to 4 weeks after first cover spray</td>
<td>Scab, downy spot, vein spot, leaf blotch, brown leaf spot, thread blight, nursery blight, powdery mildew</td>
<td>6-2-100 Bordeaux mixture or Ziram or zineb, 2 lbs.</td>
<td>If fall webworms or walnut caterpillars are abundant, add 50 percent DDT, 2 lbs. or 15 percent parathion, 2 lbs. or Lead arsenate, 3 lbs. per 100 gals.</td>
</tr>
<tr>
<td>Third cover spray, 3 to 4 weeks after second cover spray</td>
<td>Scab, brown leaf spot, liver spot, thread blight, nursery blight, powdery mildew, Pecan leaf casebearer, aphids, and mites</td>
<td>6-2-100 Bordeaux mixture or Ziram or zineb, 2 lbs.</td>
<td>50 percent DDT, 2 lbs. or 15 percent parathion, 2 lbs. or Lead arsenate, 3 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth cover spray, 3 to 4 weeks after third cover spray</td>
<td>Scab, powdery mildew</td>
<td>6-2-100 Bordeaux mixture or Ziram or zineb, 2 lbs.</td>
<td>50 percent DDT, 6 lbs. or 40 percent toxaphene, 6 lbs.</td>
</tr>
</tbody>
</table>

Parathion is deadly poison. Treat it with great respect. Follow the precautions of the manufacturer, printed on the container.
Rosette is more prevalent on alkaline or neutral soils, on soils poor in organic matter, and on badly eroded soils, but may occur on other types of soil.

**Control.** Rosette can be easily corrected by the use of zinc (usually in the form of zinc sulphate). Zinc sulphate may be applied in three different ways—in the soil, in holes bored in the trunk, or as a spray.

Applications of zinc sulphate to the soil at the rate of ½ to 1 pound for each year of the tree’s age should be made in late winter (February or March). The chemical should be broadcast evenly under the tree, and it is well to disc it in. The soil application method has a long-lasting effect. The only drawback to this method is that with certain soil types (alkaline soils especially) it does not work. Some soils have the power of immobilizing the zinc so that the roots cannot take it up. The soil-application method works well with acid soils.

A second method is to bore holes in the trunk and insert zinc sulphate in them. Holes 7/16 inch in diameter and 2½ to 3 inches deep are bored at intervals of about 4 to 6 inches spirally around the trunk. A heaping teaspoonful of dry zinc sulphate is inserted in each hole, and the holes are then plugged with cork stoppers. This method should be used only where it is known that soil applications are not effective and where the trees cannot be sprayed, for boring the holes in the trunk injures the trees somewhat.

Where facilities are available for spraying, the easiest and cheapest way to control rosette is to spray with zinc sulphate at the rate of 2 to 4 pounds per 100 gallons of water. Where spraying for the control of scab or other diseases or insect pests is practiced, zinc sulphate may be mixed with the other spray materials. See Spray Schedule, page 104.

**STRAWBERRY**

**Leaf Diseases**

**Leaf Spot.** The leaf spot disease (which locally is called “rust”) is caused by a fungus (*Mycosphaerella fragariae*) which enters the leaf and kills some of the leaf tissues. When the spots first appear they are small and purplish, but the typical mature spot has a grayish to white center with a reddish border and is about 1/8 inch in diameter. In the spring, when infection occurs on rapidly-growing tender foliage the spots are light-brown in color and have no reddish borders. In cases of severe infection the spots are so numerous that they cover the greater part of the leaf area and often kill the leaf (Fig. 64). Spots occur also on the petioles, on the fruit stalks, on the calyces, and occasionally on the green berries. On susceptible varieties, like the Klondike, leaf spot is an extremely destructive disease. Fortunately, most of the new strawberry varieties grown in Louisiana are tolerant to leaf spot (see under control, page 108).

**Leaf Scorch.** The scorch is
caused by another fungous parasite, Diplocarpon earliana. Scorch makes its appearance first as minute purplish spots on the upper surface of the leaf. The spots enlarge rather rapidly, forming angular to irregular spots or blotches (Fig. 65). The center of the scorch lesions never becomes gray or white. In this respect scorch differs from the leaf spot (rust). When infection becomes general, the leaves “scorch,” that is, they dry up as if scorched by fire. The disease also occurs on the petioles, fruit stalks, and calyces. The calyces dry up, making the fruit very unattractive. The scorch is much less common than the leaf spot in Louisiana.

**Purple Leaf Spot.** The symptoms of this disease are almost
identical with those of the leaf scorch, but the disease is caused by a different fungus, *Mycosphaerella lousianae*. This is of relatively small economic importance.

**Angular Leaf Spot** (leaf blight). The spots are large, first purplish, then brown in color, and usually, but not always, triangular in shape, their margins being delimited by the larger leaf veins. This disease, caused by the fungus *Dendrophoma obscurans*, occurs for the most part during the hot summer months when the plants are in a weakened condition. It does very little damage.

**Cercospora Leaf Spot** (*Cercospora* sp.). The spots are small (smaller than those of any of the other leaf diseases) and round. They are purple when young, becoming white with purplish borders when older. This disease also occurs only during the summer months and is of minor importance.

**Control of Leaf Diseases.** The following measures are recommended for the control of strawberry leaf diseases:

1. **Resistant Varieties.** Most of the varieties presently grown in Louisiana are resistant to the two principal leaf blights, leaf spot and scorch, and normally do not require spraying. However, they are not immune; under favorable weather conditions they may blight rather badly. The new promising selection 188, that is being released for commercial planting, apparently possesses very little resistance to leaf spots and will probably require spraying.

2. **Sprays.** All leaf blights can be controlled by the use of fungicides. Spraying, naturally, adds to the cost of production.

**Bordeaux mixture**, 4-4-100, is very effective. Other copper fungicides, such as "Tribasic Copper Sulphate," "Copper A," "C.O.C.S.," etc., are also effective and more convenient to use, although perhaps somewhat more costly than homemade Bordeaux. The copper content of these proprietary copper fungicides varies from about 24 per cent to 53 per cent. Those that contain 53 per cent copper should be used at the rate of 3 pounds in 100 gallons of water; those with 24 per cent copper at the rate of 6 pounds in 100 gallons.

Some of the organic fungicides, such as Captan and Zineb, also appear to be very effective against the leaf blights, but these have not been tested sufficiently in Louisiana. In a limited number of tests, Captan proved superior to other organics. The organics are more costly than the copper fungicides, particularly homemade Bordeaux, and no information is available at present on whether or not they are sufficiently more effective than the copper fungicides to justify the extra cost. If Captan is used, it should be used at the rate of 4 pounds per acre. That is, 4 pounds should be added to enough water (probably about 100 gallons) to spray one acre.

Regardless of the fungicides used, it is recommended that spraying should begin in the latter part of January or early in February and continue, at approximately 10-day intervals, un-
til the fruit begins to ripen. If Captan is used, the spraying may be continued during harvesting. (See under fruit rots, page 111.)

3. Sanitation. Since the two main leaf blights, the leaf spot and the leaf scorch, do not spread very rapidly during the hot summer months, these can be almost completely eliminated from the plant bed by sanitary measures. In early June the plants that have been selected for plant production should be gone over carefully and all the old, "spotted leaves should be removed and burned. This procedure should be repeated once or twice during the summer. This method of obtaining clean plants is especially effective with isolated small patches in home gardens.

Crown Rots

Two common soil-inhabiting fungi are responsible for a disease known as crown rot which, under certain conditions, may result in serious losses. These fungi attack the plant at the crown. The bases of the leaves are killed and the leaves damp-off (Fig. 66). The plant may be killed outright or it may recover. Recovering plants push out a number of secondary buds below the killed crown and produce small, spindly leaves.

One of these fungi (Sclerotinia sclerotiorum) is a cool weather fungus, and for this reason it is active only during winter and early spring. The disease caused by this fungus is favored by prolonged cool, cloudy, rainy or foggy spells and by bushy growth of the plants.

The second fungus (Rhizoctonia) is active both winter and summer. In the winter, this fungus is most likely to attack plants in low spots in the field, plants that have been planted so deep that their crowns are partly covered by soil, and especially plants that have been injured by frost.

The symptoms produced by both these fungi are similar. However, in the case of the first fungus (Sclerotinia sclerotiorum), numerous black, hard bodies (sclerotia) are usually found on the decaying leaves and crowns of the affected plants. These sclerotia constitute the resting stage of the fungus, and they remain inactive in the soil during the summer months.

Control. No satisfactory method of control is known.

Dwarf

The dwarf disease, which also goes by such local names as "blind plant," "wild plant," "crimp," etc., is caused by the bud nematode, Aphelenchoides besseyi. The nematodes occur in large numbers inside the buds and produce the injury by feeding on the young unfolded leaves.

The symptoms of dwarf are very striking (Fig. 67). The leaves are narrow, brittle, twist-
ed, and vary in color from somewhat bronzed to even deeper green than the healthy ones. The petioles are very short, and the young leaves are greatly reduced in size. Usually all the runner plants from a dwarf mother plant are diseased. Dwarf is a summer disease, the symptoms disappearing during late fall and winter. The reason for this is that the nematodes are inactive during the cold months.

**Control.** Even though dwarf is not a serious disease in Louisiana because the diseased plants recover during the winter and produce fruit in the spring, it causes injury to plants and a certain degree of reduction in yields. The disease can be easily kept in check by digging and destroying the diseased plants during the summer and early fall.

**Root Knot**  
*(Meloidogyne hapla)*

Root knot is caused by another nematode. This nematode attacks the roots, causing numerous very small knots or galls and a breakdown of the roots (Fig. 68). The root injury interferes with the absorption of water and nutrients and this results in weak growth and reduced yields. The yield data presented in the accompanying table illustrate very strikingly the marked reduction in fruit production that can be caused by the root knot nematode. These data were obtained in a test at the Fruit and Truck Experiment Station at Hammond.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Klonmore plants raised on fumigated plant bed and transplanted on fumigated soil</td>
<td>211</td>
</tr>
<tr>
<td>B. Klonmore plants raised on fumigated plant bed and transplanted on non-fumigated soil</td>
<td>137</td>
</tr>
<tr>
<td>C. Klonmore plants raised on non-fumigated plant bed and transplanted on fumigated soil</td>
<td>140</td>
</tr>
<tr>
<td>D. Klonmore plants raised on non-fumigated plant bed and transplanted on non-fumigated soil</td>
<td>82</td>
</tr>
</tbody>
</table>
Control. Control of root knot is difficult and expensive. There are many soil fumigants available, but, in general, they are costly and somewhat difficult to apply. The cost of fumigation will run to about $15 per acre. This cost is not prohibitive if the fumigation will result in yield increases comparable to those shown in the table above, but it should be kept in mind that these figures represent only one year's results of a test on one field. We have no assurance that yield increases of this magnitude will be obtained in every case. Not every field in the strawberry-growing area is infested. A limited survey indicated that about 42 per cent of the fields tested were infested to a greater or less extent.

This problem has not been sufficiently investigated to justify a general recommendation of soil fumigation at this time. The limited studies made thus far indicate that it will be profitable to fumigate in cases in which it is known that a particular field is heavily infested with the root knot nematode. Those interested may obtain information on the kind of fumigant to use and on methods of application from the Department of Plant Pathology, Louisiana State University, Baton Rouge, or from the Fruit and Truck Experiment Station in Hammond.

Berry Rots

There are several fungi which can cause rotting of the berries in the field if conditions for their development are favorable during the picking season. Warm wet weather, especially if prolonged for several days, is very favorable for the development of berry rots. When such weather prevails during harvest the losses from fruit rots are tremendous because the rots not only destroy the berries in the field but they affect the market price of the fruit, for the rots continue to develop in transit. On the other hand, if cool dry weather prevails during the picking season, losses from rots are negligible.

The following different kinds of berry rots are the most common ones in Louisiana.

Gray Mold (Botrytis sp.). This is one of the most common and most destructive of berry rots. It starts as a soft brown spot, usually on the side next to the ground or where a berry touches another rotten berry, which soon enlarges and covers the entire berry. After the berry is completely rotted, it dries up and its surface becomes covered with a gray powder, the spores of the fungus.

Tan Rot (Pezizella lythri). This is also a common and destructive berry rot in Louisiana during rainy weather. It starts as a tan-colored spot, often very inconspicuous. Later the rotted part of the berry becomes sunken, and it separates easily from the sound part of the berry.

Leather Rot (Phytophthora cactorum). This rot is not generally common, but occasionally it assumes epidemic proportions in certain fields and causes severe losses locally. It affects both green and ripe berries. The texture of the rotted berries is tough and leathery, and the taste is bitter. This characteristic makes it
easy to differentiate this from other kinds of berry rots.

**Hard Rot** (*Rhizoctonia* sp.). This is the least common and the least destructive of the berry rots. It affects berries that touch the ground, forming a hard, brown rot, usually with soil particles adhering to it, on one side of the berry.

**Control.** Berry rots are difficult to control. The fungi causing these rots are everywhere, in the soil and on dead plant parts, and when weather conditions are favorable (warm and wet) they multiply and spread very rapidly. Heavy mulching, so that the fruit will be kept high above the ground and well ventilated, helps to keep the rots down, particularly the leather and hard rots.

Since rot is caused by pathogenic fungi, fungicidal sprays or dusts would be expected to give satisfactory control. However, before the organic fungicides were developed, there was no suitable fungicide available for spraying ripe fruit. The fungicides then available were either poisonous and therefore unsafe, or they would stain the fruit, making it unmarketable. The organic fungicides are not very poisonous, and, at the recommended rate, they do not leave an objectionable residue on the fruit. Several of these have been tested both in Louisiana and in other states and some of these appear very promising. Of those tested in Louisiana, Captan has given the best control. Use Captan at the rate of 2 pounds per 100 gallons of water, and begin spraying about two weeks before picking and about once a week during the picking season. Spray thoroughly the foliage, the fruit, and the mulch. It is well to spray immediately after the day’s picking because, in the process of picking the fruit, the pickers spread the spores of the rot fungi.

**Caution.** Spraying is expensive and adds to the cost of production. Therefore, spraying should be resorted to only when needed. Weather conditions determine whether or not rots will be bad in a particular season. If the prevailing weather during the harvest season is dry and cool, rots will not be bad enough to justify spraying. During the 1956 season, for example, there was hardly any roting of berries, because dry and relatively cool weather prevailed during harvest.
Section III. Some Methods and Materials Used in Plant Disease Control

The plant pathologist has many different methods and many different chemicals at his disposal for the control of plant diseases. No attempt is made in this bulletin to list or describe all the methods and chemicals employed in plant disease control. Only the ones most commonly used, and particularly the ones which are applicable to the diseases of the crops treated in this bulletin, are considered.

Fungicides Used As Sprays or Dusts

The majority of materials used as sprays or dusts for controlling plant diseases fall within these three groups: (1) copper compounds, (2) sulphur and its compounds, and (3) organic fungicides.

Copper Compounds

1. Bordeaux Mixture. In the past, Bordeaux mixture was the universal fungicide. Although it has been displaced to a large extent by the organic fungicides in many instances, it is still one of the cheapest and most effective fungicides against many plant diseases and is still used extensively.

Bordeaux mixture is made with copper sulphate (bluestone), lime, and water. In writing the formula for Bordeaux, the amount of bluestone (in pounds) is given first, the amount of lime (in pounds) second, and the amount of water (in gallons) third. Thus, a 4-4-50 formula means 4 pounds of bluestone, 4 pounds of lime, and 50 gallons of water. Bordeaux mixture is relatively easy to make, and yet certain care is necessary in its preparation. To make 50 gallons of the standard 4-4-50 Bordeaux, the following method will be found satisfactory.

(a) Fill a 50-gallon wooden barrel about 2/3 full of water. Put 4 pounds of bluestone in a sack, or cloth bag, and suspend it in the water to dissolve. Bluestone dissolves very slowly if placed at the bottom of the barrel, but rather rapidly (20-30 minutes) if suspended near the top of the water. Never dissolve bluestone in a metal container because it corrodes metals, and it will not only ruin the container, but will change the chemical composition of the spray mixture.

(b) Place about 5 gallons of water in another container, and stir into it 4 pounds of fresh hydrated lime. Stir well to make a fine, milky suspension. Lime does not corrode metals, and so a metal container such as a galvanized iron wash tub may be used for the lime suspension.

(c) After the bluestone has dissolved, pour the lime suspension into it and stir. Add enough water to bring the volume of the mixture to the 50-gallon mark. The spray mixture is now ready to use.

Bordeaux mixture deteriorates rapidly, and for this reason should be used the same day it is made.

Although the 4-4-50 formulation (4 pounds bluestone, 4 pounds hydrated lime, 50 gallons water) of Bordeaux is the one
most commonly used, other formulations are sometimes used for certain purposes. For pecan scab control, for example, a low-lime Bordeaux (2 pounds bluestone, \(\frac{1}{2}\) pound hydrated lime, 50 gallons water) is used, and for controlling the leaf blights of strawberry a 2-2-50 mixture is satisfactory.

2. **Bordeaux Paste.** If Bordeaux mixture is prepared in the form of a thick paste, it makes an effective, safe, and cheap dressing for painting pruning wounds and other cuts on trees. It is made as follows: Dissolve 4 pounds bluestone in 3 gallons of water, stir 8 pounds of hydrated lime in another 3 gallons of water, and mix the two together. This makes a thick paste which can be applied by means of a brush.

3. **“Fixed” or “Insoluble” Copper Compounds.** A great many copper compounds in the form of dry but wettable powders are on the market as substitutes for Bordeaux mixture. These are made by several manufacturers and sold under a variety of trade names (Cuproicide, Microgel, Copper A, Cupro-K, Tribasic, Spraycop, Basicop, C.O.C.S., to mention only a few). Chemically, these materials are, for the most part, either simple copper compounds (oxides, hydroxides), or complex copper salts (tribasic sulphates, oxychlorides, oxychloride sulphates).

Compared with homemade Bordeaux, the following advantages and disadvantages may be stated in general for the fixed compounds.

**Advantages.** (1) They come in powder form, usually in weighed packages, and they are easy to mix. All one has to do is put the required amount of the dust in the required amount of water, stir, and the mixture is ready to use. (2) Since these compounds contain, in general, less soluble copper than Bordeaux and no free lime, they cause less injury to the plant than Bordeaux.

**Disadvantages.** (1) In general, these compounds are less effective fungicides than Bordeaux. (2) They are less adhesive to foliage than Bordeaux. (3) They tend to settle in the spray tank. If the spray tank is equipped with an agitator, this point is not important, but if the sprayer does not have an agitator (as is the case with most of the small knapsack type of sprayers in use in Louisiana) the settling of the spray material is a serious drawback.

Several of these copper compounds are diluted with some inert filler, with or without the addition of insecticides, and used as dusts.

Since the percentage of copper in these different compounds varies, follow the recommendations of the manufacturer as to the amount to use in preparing a spray or a dust.

**Sulphur**

1. **Dusting Sulphur.** Sulphur possesses both fungicidal and insecticidal properties and is used effectively against such diseases as the powdery mildews, some rusts, brown rot of stone fruits, etc., and against red spider, rust mite, some leafhoppers, etc. The effectiveness of sulphur depends on the fineness of its particles.
Dusting sulphur should be 300 mesh or finer. Most brands of dusting sulphur meet this specification. Sulphur may cause injury on some plants, especially under hot and dry conditions. Sulphur should not be used on cucurbits (cucumber, cantaloupe, watermelon) because these plants are sulphur-sensitive and severe burning will result. Sulphur may be used on squash because this plant, although a cucurbit, is tolerant to sulphur and is not injured by it.

2. Wettable Sulphur. Sulphur by itself does not mix with water. However, if some wetting agent, such as glue, casein, or lime, is mixed with it, the sulphur becomes wettable and it can be used with water as a spray. Wettable sulphur is easily available on the market. Wettable sulphur has an advantage over dusting sulphur in that it adheres to the foliage and is not readily washed off by rains.

Sulphur, both dusting and wettable, is compatible with most fungicides and insecticides and can be safely used in combination sprays or dusts. It is compatible with Bordeaux mixtures and with other copper compounds and with most of the organic fungicides. It is compatible with such commonly used insecticides as calcium arsenate, lead arsenate, cryolite, rotenone, DDT, BHC, chlordane, etc. It is not compatible with oil. Sulphur should never be used with oil emulsion. If plants have been sprayed with oil emulsion, at least 3 weeks should elapse before sulphur can be used on these plants.

3. Lime-sulphur. Lime-sulphur is made by boiling together quicklime and sulphur (50 pounds quicklime, 100 pounds sulphur, 50 gallons of water). In the past, lime-sulphur was, next to Bordeaux mixture, the most important fungicide. It was also used as an insecticide, particularly against the San Jose and other scales and red spider mites. At present, lime-sulphur is hardly used anymore. As an insecticide it has been displaced by oil and several of the organic insecticides and miticides (parathion, malathion, ovotran, etc.) and as a fungicide by wettable sulphur and by some of the organic fungicides.

Organic Fungicides

Organic fungicides are relatively new. The first ones came out only about 15 years ago. Since then, hundreds of organic chemicals have been tested and found to possess fungicidal properties. Of these only a few have made the grade. Some of these have proved so effective against a variety of plant diseases that they have come into wide use and have displaced the copper and sulphur fungicides to a very large extent. The organic fungicides have certain advantages over the old copper and sulphur fungicides and this accounts for their wide popularity. They are more effective against some diseases and less injurious to plants than the old fungicides; they are less poisonous than the copper fungicides, and may therefore be used on food crops close to harvest or even during harvest; since they are effective in relatively small concentrations, they do not leave a conspicuous residue.
It is impractical to list all the organic fungicides in this bulletin. Only the ones that have found wide application in disease control, and particularly the ones that are recommended against the diseases discussed in this bulletin, are included. It will be noted that the same fungicide may have two or more trade names. This is confusing but understandable. The same fungicide is often made by several different manufacturers under a different trade name. To get around this confusion, common names have been coined for these fungicides. In the list, both the common and the trade names are given.

Some of the Common Organic Fungicides Used as Sprays or Dusts:

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captan</td>
<td>Captan 50-W, Orthocide 50 (Wettable)</td>
</tr>
<tr>
<td>Chloranil</td>
<td>Spergon</td>
</tr>
<tr>
<td>Ferbam</td>
<td>Fermate, Karbam Black, Ferradow, Ferberk</td>
</tr>
<tr>
<td>Maneb</td>
<td>Manzate, Dithane M-22</td>
</tr>
<tr>
<td>Nabam</td>
<td>Dithane D-14, Liquid Parzate</td>
</tr>
</tbody>
</table>

Thiram—Arasan, Thiram-50, Thylate
Zineb—Dithane Z-78, Parzate
Ziram—Zerlate, Zirberk, Karbam White

In using organic fungicides, follow carefully the recommendations of the manufacturer as to the amounts to use and method of mixing. These directions are printed on the container.

Organic fungicides are compatible with most insecticides and may thus be used as combination fungicide-insecticide sprays or dusts. Follow the directions of the manufacturer, printed on the container.

Organic fungicides may be mixed with a suitable diluent (clay, talc, pyrophyllite) usually at the rate of 10 pounds of fungicide to 90 pounds of diluent and used as dusts. Insecticides may be incorporated in the dust (see cucumber dusts, page 22). Many such dusts, “tomato-potato dust,” “rose dust,” etc., are sold in small or large packages for the home garden.

SEED TREATMENTS

Various methods have been devised for treating seed. The purpose of seed treatment is twofold, first to kill the pathogenic organisms that are carried on or in the seed, and second to protect the plant against pathogenic organisms in the soil. Damping-off of the seedlings is one of the most common and most serious diseases caused by soil-borne parasites.

The term “damping-off” is used to designate a disease of plants in the seedling stage. Two distinct phases of damping-off are recognized, namely, pre-emergence damping-off and post-emergence damping-off. In the first phase, the seed and young seedlings rot in the soil and never reach the surface; in the second phase, the stems of the young plants rot at the soil line, and the plants collapse and die suddenly. With some plants, a seed treatment is sufficient to give protection against both pre-emergence and post-emergence damping-off; with others, two treatments, a seed treatment and a soil treatment, are necessary for satisfactory control of the two phases.

It is also very important to
make clear the distinction between seed treatments designed to control damping-off, which is caused primarily by soil-borne parasites, and treatments designed to control seed-borne diseases, because the same treatments will not always control both. For example, Arasan or Semesan will give very effective control of damping-off of crucifer (cabbage, cauliflower, broccoli) seedlings, but will not control black rot or blackleg because the organisms causing these diseases are borne inside the seed where the chemicals can not reach them. Similarly, Arasan or Cuprocide will protect pepper seed and seedlings against damping-off (a soil-borne disease) but these chemicals are not strong enough to kill the seed-borne bacteria that cause the bacterial blight of peppers.

In order to apply seed treatment intelligently and effectively, it is necessary to know if the organisms we wish to control are soil-borne or seed-borne, and, if seed-borne, whether they are carried on (externally) or inside (internally) the seed. For soil-borne, and externally seed-borne pathogens chemical treatments of the seed are effective. For internal seed infections, it is necessary to use a more drastic method of control, the hot-water treatment.

The list of chemicals used for treating seeds of various kinds is very long. No attempt is made to include all of them in this bulletin; only the ones most commonly used for treating vegetable seeds are given. These are:

1. Mercury bichloride (corrosive sublimate)

2. Organic mercurials (Semesan, New Improved Semesan Bel)

3. Formaldehyde

4. Copper oxide (Cuprocide, Metrox, Curedamp)

5. Chloranil (Spergon)

6. Thiram (Arasan, Arasan-50, Arasan 75)

7. Dichlone (Phygon Seed Protectant)

8. Captan (Captan 50-W, Orthocide 75)

With these preliminary remarks in mind, we can proceed to list and discuss some of the most common methods of treating vegetable seeds for the control of seed-borne and soil-borne diseases.

1. Mercury Bichloride
   (Corrosive Sublimate)

This chemical is most commonly used in the concentration of 1 part to 1,000 parts of water. Unless a large volume is required, it is most convenient to buy corrosive sublimate in the tablet form (it can be purchased at any drug store). One tablet dissolved in 1 pint of water makes a 1-1,000 solution. For larger volumes of solution, use 8 tablets to 1 gallon or 60 tablets (1 ounce) to 7½ gallons.

CAUTION. Mercury bichloride is a deadly poison and great care should be used in handling it and in disposing of it after it is used. It should be kept away from children and farm animals. Also, the chemical is corrosive to metals and it should never be dissolved in, or placed in, a metal container. Use wooden, glass, enamel, or earthenware containers.
particularly potato or sweet potato) treated with bichloride should not be used for food or feed.

Pepper. For control of bacterial spot (see page 36), soak the seed in a 1:1,000 solution for 5 to 6 minutes. Wash thoroughly in running water, or in several changes of water if no running water is available, and spread out to dry.

NOTE. Seed dealers often treat pepper seed with some dust fungicide such as Cuprocide or Arasan. This treatment is for preventing damping-off, but will not control bacterial spot. Therefore, such seed should first be given the mercury bichloride soak, washed, dried, then treated again, either with Arasan (treatment 3) or with Cuprocide (treatment 4).

Irish Potato. For Louisiana conditions the hot formaldehyde method (page 120) is recommended for treating seed potato tubers. In some areas of the country, mercury bichloride is used for treating seed potatoes. The following two methods are used:

(a) Cold mercury bichloride, 1-1,000. Soak tubers (uncut) for 1½ hours. Plant immediately, or dry and store.

(b) Acid-mercury bichloride (6 ounces to 25 gallons of water plus 1 quart of commercial hydrochloric acid). Dip seed for 5 minutes, plant immediately, or dry and store. Do not store while wet. Twenty-five gallons of the solution will treat effectively about 40 bushels of potatoes, after which a new solution should be prepared.

Sweet Potato. Use 1-1,000 solution. Soak the potatoes for 8 to 10 minutes, then bed without washing. This treatment kills the spores of the black rot fungus (and of other pathogens) on the surface of the potatoes, and thus it helps to keep the disease in check. It does not kill the infection inside the potato, and so it does not provide complete protection against the black rot.

The seed certification service of the State Department of Agriculture requires that, for the production of certified sweet potato seed or plants, the potatoes be treated with mercury bichloride before bedding.

2. Organic Mercury Compounds

There is a long list of organic mercury compounds, sold under different trade names, which are used for disinfecting various kinds of seed. Two of these, "Semesan" and "New Improved Semesan Bel" are the ones most commonly used for treating vegetable seeds.

Semesan. This chemical may be used either as a dust to coat the seed, or in the liquid form in which the seeds are soaked.

(1) Dust. Semesan dust at the rate of ½ level teaspoonful per pound of seed may be used for the following: beet, broccoli, brussels sprouts, cabbage, cauliflower, collard, carrot, cucumber, cantaloupe, eggplant, mustard, pea, radish, spinach, squash, Swiss chard, turnip, and watermelon.

For onion, parsley, and tomato, use the dust at the rate of ¼ level teaspoonful per pound of seed.

Place the seed and the dust in a tight container and shake well
until the seeds are thoroughly coated. Screen off the excess dust. Plant immediately, or store in a dry place.

Under certain conditions (planting in dry soil, for example) Semesan may cause injury to the treated seed. Therefore, for such seeds as tomato, pepper, eggplant, beet, carrot, pea, spinach, etc., which are copper-tolerant, the copper oxide treatment (page 119) should be used in preference to Semesan.

(2) Liquid Form. Soak the seed in a solution made by stirring 1 ounce of Semesan in 3 gallons of water (1 level tablespoon in 1 gallon of water). The time of soaking varies from 15 minutes to 1½ hours, depending on the kind of seed to be treated. Follow the directions on the container.

New Improved Semesan Bel. In some parts of the country this chemical is used instead of the hot formaldehyde for treating seed potatoes, even though it is not perhaps so effective as the hot formaldehyde. For Louisiana, the hot formaldehyde method (page 120) is recommended for treating seed potatoes. However, if one buys seed that has not been treated with hot formaldehyde, one can treat it with New Improved Semesan Bel. The method is easy and cheap.

Directions. Mix 1 pound of the powder with 7½ gallons of water. Dip (do not soak) the uncut potatoes in this solution, drain, cut, and plant immediately.

CAUTION. The organic mercury compounds are very poisonous and should be handled with care. In treating seed with the dust it is preferable to work outdoors and to avoid breathing the dust. Treated seed should be kept away from farm animals. Treated potatoes should not be used for food or feed.

3. Thiram (Arasan)

This organic fungicide is a safe and effective material for treating all kinds of vegetable seeds for preventing damping-off. It is recommended at the rate of about 1 teaspoonful per pound of seed. Actually, in treating small quantities of seed, it is not important to measure the fungicide any too accurately. Place the seed in a small jar, add enough of the dust to coat the seed well, shake for about 1 minute, and if necessary screen off the excess dust.

4. Cuprous Oxide (Cuprocide)

This is one of the most effective materials for treating vegetable seeds, particularly pepper, tomato, eggplant, spinach, and beet.

Directions. Place the seed to be treated in a tight container, add the Cuprocide powder at the rate of 1½ level teaspoonfuls per pound of small seed (such as tomato, pepper, eggplant) and ½ teaspoonful per pound of large seed (such as pea), shake well until all seeds are thoroughly coated, then screen off the excess powder. Treated seed may be planted immediately, or it may be stored if kept dry.

CAUTION. Seed treated with Cuprocide should not be planted in pure sand or in soil too dry for good germination, for under these conditions injury may result.

Seeds that are benefited by the Cuprocide treatment: beet, carrot,
celery, cucumber, eggplant, muskmelon, pea, pepper, pumpkin, romaine, spinach, squash, Swiss chard, tomato, calendula, cosmos, pansy, salvia, zinnia.

For all the above-named seeds, except eggplant, seed treatment alone is usually sufficient to prevent both pre-emergence and post-emergence damping-off. However, if the seedlings begin to damp-off after emergence, the disease can be stopped by watering the plants once or twice with a suspension made with 1 1/4 ounces (6 level teaspoonfuls) of Cupro-cide to one gallon of water.

In the case of eggplant, the Cupro-cide treatment of the seed will control the pre-emergence phase of damping-off but will not protect the young seedlings against the post-emergence phase of the disease. For this reason, eggplant seedlings should be watered with a Cupro-cide suspension in water as explained above.

5. Formaldehyde

This chemical is used in either liquid or dust form for treating seed and for disinfecting soil.

For treating seed potatoes the hot formaldehyde method is extensively used. A solution is made by mixing 1 quart of commercial formalin (40% formaldehyde) with 30 gallons of water which is kept at a temperature between 124° and 126° F. while the potatoes are being treated. The potatoes are dipped in this solution for 4 minutes, then are removed and spread out to dry. After treating every 50 bushels of potatoes, a pint of formaldehyde should be added to the tank of solution to compensate for loss of strength.

Hot Water Method for Treating Seed

The hot water treatment is a most effective method of disinfecting seed because it kills seed-borne pathogens both on and in the seed. At the same time, this method is very drastic, and unless due care is exercised in controlling the temperature of the water, in correct timing of the treatment, and in drying the treated seed, the germination of the seed may be considerably impaired. This is especially true in the case of old or weak seed. For this reason, the hot water treatment is recommended only for those seed-borne diseases against which no other effective treatment is known. For Louisiana, the hot water method is especially recommended for the control of black rot and blackleg of crucifers (cabbage, cauliflower, collard, brussels sprouts, broccoli, kale, kohlrabi, turnip), and the downy mildew of spinach.

As has been explained in the text (page 17) seed grown in the Puget Sound district or in other regions with rainless summers, as in California, is usually free of black rot and blackleg infection. Such seed need not be treated. If seed is known to have been produced in an area where black rot and blackleg occur during the growing season, or if the source of the seed is not known, it is recommended to treat it with the hot water method.

Directions. Place the seed in a loosely-woven cloth bag, which should be only about one-half full, and immerse it in hot water at a temperature of 122° F. Keep the
water stirred during the operation and have extra hot water handy to add to it as it begins to cool, in order to maintain the temperature at 122° F. After the required exposure, remove the bag and plunge it in cold water to cool the seed quickly. Drain, and plant immediately, or spread the seed out to dry. Quick drying is essential.

Cabbage seed should be treated for 25-30 minutes; seeds of cauliflower, brussels sprouts, broccoli, collards, kale, kohlrabi, and turnip for 15 to 18 minutes. Spinach seed should be treated for 25 minutes.

After the seed has been treated with hot water and allowed to dry, it can be treated with the appropriate fungicide dust (Semesan, Arasan, Cuprocide) as recommended for the control of damping-off.

TABLES OF MEASURE

The following tables will be found useful in preparing small amounts of fungicides and insecticides for the home garden.

I. Liquid Measures

| 3 teaspoons | 1 tablespoon |
| 2 tablespoons | 1 fluid ounce |
| 8 fluid ounces | 1 cup |
| 2 cups | 1 pint |
| 2 pints | 1 quart |
| 4 quarts | 1 gallon |

II. Approximate Quantities to Weigh 1 Ounce

- Bluestone (copper sulphate) — 5 level teaspoons
- Hydrated lime — 3 level tablespoons
- Sulphur — 3 level tablespoons
- Cryolite — 2 level tablespoons
- DDT wettable powder — 6 level tablespoons
- Malathion wettable powder — 4 level tablespoons
- Chlordane wettable powder — 3 level tablespoons
- Nicotine (Black Leaf 40) solution — 5 level teaspoons

SOIL FUMIGATION

In the past, soil fumigation was practiced in greenhouse culture and to a small extent in the field in special cases in which high-priced crops were grown on limited land. The use of soil fumigation in general farming was considered too costly to be practical. This concept has changed. Many factors have contributed to bring about this change. Extended research in nematology has brought to the fore the importance of nematodes as disease-inducing agents. New and better fumigants and improved methods and machinery for their application have been developed. These new developments have lowered the cost of application to the point at which it is practical and profitable to use soil fumigation on a large scale, even in the case of low-price crops under certain conditions. Soil fumigation certainly has a place in home gardens and small farms where enough land is not available for rotation. There are a very large number of chemicals that possess fumigant properties. Many of these are still in the testing stage. No attempt is made in this bulletin to include all the chemicals with nematocidal or fungicidal properties. Only the few chemicals that have come in—

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8 These figures were taken from U.S. Department of Agriculture Home and Garden Bulletin No. 46, "Insects and Diseases of Vegetables in the Home Garden."
to practical use as soil fumigants are included. Some of these chemicals are fungicidal and bactericidal but not nematocidal. Others are nematocidal but not fungicidal or bactericidal, and still others possess nematocidal, fungicidal, and bactericidal properties. Practically all kill weed seeds, and this is of great value because it eliminates weeding in the treated beds.

**Common Soil Fumigants**

I. Fungicidal but not Nematocidal
   1. Formaldehyde (formalin)
   2. Allyl alcohol

II. Nematocidal but not Fungicidal
   1. "D-D" mixture or "Nemafume" (Dichloropropane-dichloropropene)
   2. Ethylene dibromide
   3. "Nemagon" (1, 2-dibromo-3-chloropropane)
   4. "V-C 13 Nemacide"

III. Both Nematocidal and Fungicidal
   1. Chloropetrin ("Larvacide," Tear gas)
   2. Methyl bromide ("MC-2")
   3. "Vapam" (Sodium monomethyl dithiocarbamate)

This grouping of fumigants may not be strictly correct. Some of the chemicals listed as nematocidal but not fungicidal ("D-D" and ethylene dibromide) may kill some fungi, especially at high rates of application. However, these chemicals are normally considered to be nematocides and not fungicides. Conversely, some of the chemicals listed as fungicidal but not nematocidal (formaldehyde, for example) possess some degree of nematocidal activity.

The following is a more detailed discussion of soil fumigants and methods of application.

1. **Formaldehyde** (*commercial formalin*). Formalin is the oldest soil fumigant, and one of the cheapest. It is an effective fungicide that kills most pathogenic soil fungi and bacteria that cause wilts, root rots, and damping-off. It has the disadvantage that it is not effective against nematodes.

   **Method of Application.** Prepare the soil ready for planting, pulverizing the clods as much as possible. Dilute 1 gallon of commercial formalin in 49 gallons of water and apply this dilution with a sprinkling can at the rate of 1/2 gallon per square foot of soil. Cover the treated soil with wet burlap sacks. After 48 hours, remove the cover to allow the gas to escape and the soil to dry. When the soil has dried sufficiently to be workable, stir it to facilitate the escape of the gas. Wait 10 to 14 days before planting.

2. **Allyl Alcohol.** This is one of the newest materials to be used for soil fumigation. Like formaldehyde, allyl alcohol is not effective against nematodes. It is a powerful herbicide, killing all weed seeds, thus eliminating weeding of seedbeds, and also a good fungicide. Thus far, allyl alcohol has been used extensively as a drench for tobacco seedbeds. It is used at the rate of 6 quarts diluted in 100 gallons of water and applied at the rate of 1 gallon of the dilution per square yard of soil. No cover is needed. Allow 10 to 14 days for the material to escape from the soil before planting.

3. **"D-D" Mixture** ("Nemafume"). This material is one of the most widely used nematocides. It is not a fungicide at the recommended rates of application. It comes in liquid form and it is injected into the soil. Various types of injectors have been devised.
These range from large tractor-drawn rigs that can treat several acres in a day, to small hand-operated ones. For small plots, such as in home gardens a fruit jar may serve the purpose of an injector (Fig. 69).

Spade and rake the soil ready for planting, taking care to break the clods and remove trash. The soil temperature should be not lower than 40° F. and not higher than 80° F. when the chemical is applied. The soil should be in good tilth, neither too dry nor too wet.

With a hoe make furrows in the prepared soil 12 inches apart and about 8 inches deep. Take a fruit jar with a metal cap and punch 2 holes on opposite edges of the lid with a No. 8 nail, one for pouring the fumigant and the other for an air hole.

Apply one pint of the fumigant for about 150 to 175 linear feet of the furrow. Rake the soil to cover the fumigant, and pack the soil lightly after covering the furrow. The packing helps to seal the gas in the soil. No cover is nor-

![Fig. 69. The "fruit-jar" method of applying nematocides to the soil. (Photo by Dow Chemical Co.)](image)

mally needed, but if the surface of the soil is rather dry, it is advisable to sprinkle it with water to form a tight seal and prevent the gas from escaping too fast. Wait at least two weeks before planting. Do not treat soil within about 3 feet of growing plants.

4. Ethylene Dibromide. This fumigant, like D-D, is a nematocide
but not a fungicide. It is sold under several trade names, “Dowfume W-40,” “Dowfume W-85,” “Soilfume 40,” “Soilfume 85.” The percentage of active ingredients varies in the different formulations, so follow the directions on the container as to the amounts to use.

The method of application of ethylene dibromide is the same as for “D-D” mixture (see above).

Ethylene dibromide (and some other fumigants) is also sold in the form of capsules. This form is more costly than the liquid and perhaps impractical for large scale application, but easy and convenient to handle for the home gardener. The capsules are dropped into holes in the soil, and after some time the capsule melts, releasing the gas. One difficulty with this type of application is that all the capsules may not dissolve at the same time, especially if the soil is somewhat dry. Some of the capsules may dissolve after planting, and this will result in injury or death of the plants. To get around this difficulty, it is suggested that the capsules be punctured with a sharp, heavy needle before they are dropped into the holes.

5. “Nemagon” (1, 2-dibromo-3-chloropropane). This fumigant is sold in three formulations, as a liquid, as an emulsion, and as dry granules. The granular form can be mixed with the fertilizer and applied to the soil. This form is especially advantageous to the small farmer and home gardener.

Nemagon is an excellent nematocide but not a fungicide. Its greatest virtue is that it can be applied to the soil around living plants, and it will kill the nematodes in the roots without harming the plants. However, not all species of plants can take this treatment; some plants are injured. Chrysanthemum, for example, is extremely sensitive and is severely injured by Nemagon.

Before using Nemagon, be sure to read carefully the recommendations of the manufacturer, which are printed on the container, regarding dosages, methods of application, and tolerance of particular plants.

6. “V-C13 Nemacide.” This chemical, which, like the preceding one, is a nematocide but not a fungicide, is a newcomer. We have not tested it in Louisiana and are not ready to make any recommendations. Its strongest point, according to its manufacturers, is its tenacity. It remains effective in the soil for long periods, 2 to 3 years. It acts as a preventive against nematode infection and not as a quick killer. It can be used around certain species of established plants without causing injury. Thus far, its use is limited to ornamental plants. It should not be used in connection with food crops (fruits or vegetables) because its possible toxicity to humans has not been fully determined.

7. Chloropicrin (“Larvicide,” tear gas). This is a powerful soil fumigant. It kills nematodes, soil insects, fungi and bacteria, and most weed seeds. It should be the ideal soil fumigant except for the fact that it is a very disagreeable material to handle. Its fumes are very irritating to the eyes and
nose, and if the liquid is spilled on the skin it will cause burns unless it is washed off promptly. It requires special applicators to inject it into the soil; it can not be applied by simple means, such as a fruit jar, as in the case of "D-D" mixture and ethylene dibromide.

The method of application, i.e., preparation of the soil and injection of the chemical 8 inches deep, is the same as that for "D-D" mixture and ethylene dibromide, except that a special applicator is needed. After injection, the surface of the soil should be sprinkled thoroughly to form a water seal to confine the fumes. Allow 10 to 14 days for the fumes to dissipate before planting.

8. Methyl Bromide (MC-2). Methyl bromide is a powerful fumigant. It kills nematodes, soil insects such as grubs and wireworms, fungi, bacteria, weed seeds and Bermuda, Johnson and nut grasses. It differs from all other chemicals used for soil fumigation in the method of application. It is not injected or drenched into the soil; it is released on the surface of the soil under a gasproof cover. Application is easy and fast, once you have acquired the necessary equipment (an applicator and a gasproof cover). The applicator is inexpensive, costing probably under $2. The plastic cover is more expensive. It sells at about 3c per square foot. Thus, a cover 12' x 15', which is about the right size for treating an area of 200 square feet at one time, will cost around $9. However, with proper care, a cover should last 3-4 years.

Method of Application. Spade and pulverize the soil ready for planting. The soil should be in good tilth, neither too wet nor too dry, and the temperature relatively high, preferably above 60° F. Dig a trench about 6 inches deep around the area to be treated. Place some supports, such as flower pots or boards set on edge, on the surface of the soil to keep the plastic cover from lying flat on the soil surface and thus facilitate the movement of the gas. Place the loose end of the applicator plastic tube at approximately the center of the area to be treated (if large areas are to be treated, several such tubes should be used, placed not more than 30 feet apart). Place a shallow pan under the outlet of the tube so that the liquid, as it comes through the tube, will vaporize rather than sink into the soil in one spot. Now, put the plastic cover over the area, place its edges in the trench, and cover them with dirt (Fig. 70). Be sure to pack the dirt well around the edges of the plastic cover to prevent the gas from escaping. Now you are ready to release the fumigant. The fumigant comes in small pound cans. Open the applicator clamp, place the can in the ring, and press the clamp. The pressure will puncture the can, and the fumigant will flow under the cover. The can will empty in 2-3 minutes. The empty can is then removed, a new one is placed in the applicator, and the process is repeated. Use the material at the rate of 2 cans per 100 square feet of area.

Let the cover stay for 48 hours. Allow a week to ten days for the
gas to leave the soil before planting.

Methyl bromide is very toxic to living plants. Do not use it any closer than about 2 feet to the roots of growing plants.

9. "Vapam" (*Sodium monomethyl dithiocarbamate*). This fumigant is new, and consequently, more information than now available about its action is needed before it would be safe to recommend it without reservations. It appears extremely promising. It possesses nematocidal, fungicidal, and herbicidal properties, and it is easy to handle and apply to the soil. No special applicators and no cover are needed. In a limited number of tests in Louisiana, Vapam gave excellent results when used to fumigate plant beds of pepper, tomato, and eggplant. In these tests, damping-off of seedlings was completely prevented. This means that Vapam is effective against the damping-off fungi. It is not definitely known whether or not it is effective against all kinds of pathogenic soil fungi; in fact, some of the available evidence indicates that, at the presently recommended dosages, it is not completely effective against the vascular wilt fungi (Fusarium wilt of tomato, for example).

*Method of Application.* Vapam is very easy to apply. Prepare the seedbed (or the garden) for planting. Dilute 1 quart of Vapam in enough water (about 3 gallons) in a sprinkling can to sprinkle evenly 100 square feet of area. Immediately sprinkle the treated area with enough water (about 20
gallons) to soak this solution down deep into the soil. No cover is necessary. Wait at least 3 weeks before seeding or planting. Heavy soils require a longer interval from treatment to planting than light, sandy soils.

CAUTION. All soil fumigants are poisonous, and some of them (methyl bromide and allyl alcohol, for example) extremely poisonous. Therefore, they should be treated with care and respect. In using any of these chemicals, be sure to read carefully and follow the recommendations of the manufacturer as printed on the container.
Section IV. Plant Injury As Caused by Herbicides and Defoliants

During the last 10 years there have been many new chemicals developed for use as herbicides (weed killers) and defoliants (agents for removal of leaves from different crops). Whereas these chemicals are designed for the above uses, they will injure or kill most other plants. Therefore, extreme precautions must be taken in order to prevent injury to desired plants. The following discussion on injury will be limited to plants or crops other than those to which the herbicide treatment was applied.

How Injury May Occur

In most areas there are weeds growing either in crops or on roadsides, ditches, railroad right-of-ways, utility right-of-ways, fences and many other locations near desired plants. Chemical herbicides may be used by custom applicators, public service agencies or individuals to control the above vegetation. During and after application of herbicides desired plants may be injured in one or more of the following ways:

1. by improper application techniques
2. by using a dangerous herbicide in the vicinity of valuable plants
3. by drift of herbicides due to wind
4. by volatilization of the herbicide
5. by rainwater washing herbicides
6. by other methods such as dust, animals or humans
7. by using equipment (sprayers, buckets, mixing containers) for insect or disease control that had been previously used for application of herbicides.

While some of the methods of causing injury mentioned above may appear rather farfetched they do occur quite commonly. In most cases there is little or nothing that can be done to overcome the injury once it has occurred. Therefore the only solution to the problem is to avoid contamination of desired vegetation.

How Injury May Be Avoided

Care and common sense are of extreme importance in preventing injury to desired plants by herbicides; however, some knowledge about the behavior of the herbicides is necessary. One of the first points to consider in using a herbicide is to read carefully the label on the herbicide container. Manufacturers are required by both state and federal laws to give certain information on the label of their product. Most manufacturers make direct statements on their label in regard to the use of their material near desired vegetation. If there are any questions in interpreting a label, consult the company representative, county agent, or the Extension Service. If the label suggests that a herbicide not be used around certain plants, do not use it.

(This section was kindly prepared by Dr. Walter K. Porter, Jr.)

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Improper application techniques account for a large part of the injury caused by herbicides. For example, herbicidal application by air or by high pressure spray equipment may allow large quantities of the herbicide to be deposited on desired plants. Similarly, the above methods may allow injurious quantities of the herbicides to be moved by the wind (drift) for some distance from the treated area. Extreme caution should be exercised when high pressure application of herbicides is made in the vicinity of desired vegetation. Application should be made only when there is a low velocity wind blowing from the direction of desired vegetation.

All herbicides are dangerous to some degree; however, by the proper selection the chance of injury can be reduced. Some herbicides are volatile and should not be used near valuable plants. Similarly, certain herbicides may be moved long distances by run-off water and, as a result, cause injury or death to desired plants. Thus these materials should be used only in areas in which there will be no run-off.

Spray equipment that has been used for herbicide application should not be used for insecticide or fungicide application. The same is true for all mixing containers. While it is true that certain herbicides can be removed from spray equipment by various washing methods, this procedure is not recommended. All equipment for herbicide application should be carefully labeled (red paint to indicate danger is a good method) and stored separately from other spray equipment.

Since herbicides may be packaged in containers similar to those used for packaging insecticides and fungicides, it is very easy for laborers to become confused as to the identity of the containers. Therefore, herbicides should not be stored in the same buildings with insecticides and fungicides.

**Herbicides Which May Cause Injury to Desired Plants**

The following list includes some of the more common herbicides in use at the present:

1. **Phenoxy Type**
   - (a) 2, 4-D (2, 4-dichlorophenoxyacetic acid)
   - (b) 2, 4, 5-T [2 (2, 4, 5-trichlorophenoxyacetic acid)]
   - (c) 2 (2, 4, 5-TP) (2, 4, 5-trichlorophenoxypropionic acid)
   - (d) M.C.P.A. (2-methyl-e-chlorophenoxyacetic acid)

2. **Urea Type**
   - (a) Monuron or Karmex W or Telvar W [3-(p-chlorophenyl)-1, 1-dimethyl urea]
   - (b) Dluron or Karmex D, or Karmex DL, or Telvar D [3-(3, 4-dichlorophenyl)-1, 1-dimethyl urea]

3. **Chloroacetic Acid Type**
   - (a) TCA (trichloroacetic acid)
   - (b) Dalapon (2, 2-dichloropropionic acid)

4. **Miscellaneous Herbicides and Defoliants**
   - (a) chlorates (sodium or magnesium salts of chlorate)
   - (b) borate (various borates or mixtures)
   - (c) P.C.P. (pentachlorophenol)

**Some Types of Injury Caused By the Above Herbicides**

It is not possible to give complete details of injury types caused by the various herbicides. Therefore, only some of the more general types of plant reactions will be discussed. These dis-
cussions will be restricted to broadleaf type plants.

The phenoxy type materials at high rates will cause leaf burns, discolorations, leaf shed, and possible death of desired plants. At lower rates (generally caused by drift or minor contaminations from equipment) they may cause stem twisting, petiole twisting, leaf discolorations, leaf malformations, and stunting (Fig. 71). Most of the symptoms caused by low rates of phenoxy materials are confined to the new growth following contamination of the plant. The phenoxy materials, (namely 2, 4-D, 2, 4, 5-T and MCPA) will also cause leaf malformation in some plants which may be called "crazytop"—that is, the new plant leaves may be strap shaped or sawtooth edged. If only a few leaves are twisted or malshaped and recover in a short time the plants will most likely produce a normal yield. If for a long period—several weeks—the plant continues to produce malshaped leaves, the yield will most likely be reduced. Many factors may play a part in determining the seriousness of the injury—the age of plant, stage of development, and weather conditions following contamination. For example, less than \( \frac{1}{2} \) gram (.001 pound) of 2, 4-D per acre may reduce the yield of cotton as much as 20-25 per cent if it contaminates the plant in the seedling stages.

The urea type herbicides are powerful plant killers and remain in the soil for lengthy periods. They should not be used in areas in which the run-off water is likely to come into contact with desired vegetation. Also they should not be applied in an area

Fig. 71. 2, 4-D injury to cotton.
in which the roots of desired trees might contact the treated area. The roots of trees may cover an area many times that of the branches. The general symptoms of urea injury are leaf tip yellowing followed by progressive dieback of the new leaves. On older leaves the symptoms are yellowing along the veins followed by leaf shed. New leaves following leaf shed will respond according to the general symptoms. Small succulent plants may die rapidly, whereas trees may show symptoms two or three years before death.

The chloroacetic acid herbicides are most likely to injure young succulent plants. Since the life of these herbicides in the soil is rather short, little injury to trees will be caused by them when low general spray rates are used. However, high rates, sprayed either on the soil or on the plants, may severely injure or kill them. Typical symptoms to plants are leaf burn and chlorosis (Fig. 72) followed by leaf deterioration.

Many so-called contact herbicides or defoliants will kill or injure many different plants. Since most defoliant applications are made by air, the likelihood of damage is great. Defoliant drifts are particularly troublesome in the cotton producing area. In most cases, on trees, defoliants cause leaf burn followed by leaf shed with little or no permanent damage. Small valuable shrubs, especially those that are rapidly growing, may be killed.

![Fig. 72. TCA (Trichloroacetate) injury to bean.](image-url)