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Diseases of Ornamental Plants

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CONTENTS

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DISEASES OF ORNAMENTAL PLANTS

PAUL E. TILFORD

General Discussion of Disease and Control Measures

Ornamentals are grown by a greater number of people than is any other class of cultivated plants. There are few homes where some ornamental can not be found on the lawn, in the garden, in porch boxes, or at the living-room window. In addition to the flowers grown on the homegrounds, commercial floriculture has advanced to the extent that almost every village and town has one or more florists, and most cities have several large greenhouses devoted to flower growing.

Unfortunately, ornamental plants, like all others, are subject to disease. The satisfaction derived from a beautiful, home flower garden or the financial profit expected by the commercial florist many times is unrealized because of the ravages of disease. Since flowers are cultivated because of their beauty, most of the diseases affecting them are serious from the standpoint of the cultivator even though the life of the plant is not threatened. Diseased plants are never welcome in a flower garden and, likewise, are never profitable in a commercial planting.

Scientific research has yielded considerable knowledge concerning the nature and control of plant diseases. Although not as much work has been done on the diseases of ornamentals as on those affecting the food plants, yet satisfactory preventive and control measures have been worked out for many of the more serious troubles. This information, however, is scattered and is generally unavailable to the home gardener or the florist. Considerable work has been done at the Ohio Experiment Station on the control of the diseases of ornamental plants. It is the purpose of this bulletin to present the results of these investigations and to bring together the available information in the literature on the subject.

An attempt has been made to keep the discussions as brief and as simple as possible, devoting most of the space to symptoms of the diseases and to control measures. Citations are given to published treatises on most of the diseases so that, if more complete and technical information is desired, it can easily be obtained.

DISEASE AND ITS CAUSES

A plant disease is defined as "any variation from the normal structure or function of plants, or plant parts, sufficient to threaten their life or impair their economic usefulness". Obviously, several things, such as insects, certain animals, fungi, bacteria, viruses, and unfavorable environmental conditions, may produce disease. Our modern concept of plant pathology, however, assigns the abnormal growth conditions caused directly by insects to the science of entomology.

Fungi and Bacteria.—Fungi and bacteria are simple forms of plant life which differ greatly in structure and mode of living from the higher plants. They are not organized into roots, stems, and leaves; neither do they contain the green coloring matter of leaves known as chlorophyll. Bacteria generally consist of single cells; whereas fungi are made up of thread-like filaments known as hyphae. The hyphae may be intricately branched and may or may not be traversed by cross-walls. Since neither bacteria nor fungi contain chlorophyll, they can not manufacture their food from minerals, water, and carbon dioxide as the higher plants do but are forced to obtain their nourishment from either living things or dead organic matter. Parasites are organisms which attack living things and cause disease; whereas, saprophytes live on dead material and cause decay.

Both fungi and bacteria reproduce very rapidly under favorable conditions. Bacteria reproduce by division. A single bacterial cell is divided into two bacteria by the formation of a wall through the mother cell. Each of the newly formed bacteria is capable of dividing to form other bacteria, and in this way reproduction progresses rapidly. Fungi produce various types of spores. Most fungi, when growing under favorable conditions, produce spores in great abundance, enabling the fungi to reproduce; but these spores are not usually very resistant to adverse conditions. When the environment becomes unfavorable, another type of spore is usually produced which is resistant to low temperatures, drying, and other unfavorable factors. It is the latter type of spore that enables many fungi to live through the winter and other adverse periods. Spores may be formed on special branches of the hyphae, or they may form inside special structures called fruiting bodies. Air currents, water, insects, and many other agencies carry spores from plant to plant. When environmental conditions are favorable, the spores germinate, and, if they happen to be on a susceptible plant, infection may occur.

Resting bodies known as sclerotia are also formed by many fungi. These structures assist the fungi in living through unfavorable periods since they are much more resistant than the other parts of the fungus.

The fungous threads and the bacterial cells grow through and between the cells of the plant tissue to obtain their nourishment. They injure and cause the death of the cells and often kill the entire plant. It is in this way that they produce disease.

Variations in structure and physiological reactions occur among fungi and bacteria the same as among higher plants and animals. These differences are distinct and constant enough to furnish a basis for classifying these organisms into groups and further into species.

Variations also occur in regard to parasitism. Frequently, a single bacterial or fungous species will cause disease in only one particular variety of plants and will not attack even closely related varieties. Other species are more general in their ability to cause disease and may attack several different and unrelated varieties. Some organisms may change from a saprophytic to a parasitic stage of growth, or vice versa, depending on conditions; others are strictly parasites and cannot grow under any conditions as saprophytes.

The ability of a parasitic organism to produce disease in higher plants depends to a large extent on the environment. Under certain favorable environmental conditions the parasite may be very active; whereas, under less favorable conditions, it may become practically dormant and cause no damage. The parasite may be present and growing as a saprophyte in the soil and not attack susceptible plants until the environment becomes suitable. Undoubtedly, the ever changing environment also exerts an influence on the organisms which grow entirely as saprophytes. New parasitic forms are found each year, and it seems only logical to assume that occasionally a saprophytic organism, due to some environmental influence, may become a parasite. Definite proof is available to show that members of certain groups of the fungi are capable of hybridizing, and very likely new parasitic forms also may originate in this manner.

Viruses.—A large group of plant diseases, including the mosaics, is caused by an infective principle called virus. The virus particles can not be seen by the most powerful microscopes; yet they are always present in the juice of diseased plants, as shown by the fact that when the infected sap is transmitted to a healthy

plant, it becomes diseased. Sucking insects, such as aphids, commonly transmit virus on their mouth parts when they feed first on diseased and then on healthy plants.

Nematodes.—Nematodes are microscopic eel worms which live in the soil and in plant tissue. They bore into the roots of a great variety of plants and cause the development of knots or galls on the roots, Figure 1. The roots soon become so malformed that they can not function properly, and then the plant stops growing and may finally die. Affected plants that continue to live are seldom profitable because they are always stunted and can not be forced to grow normally.

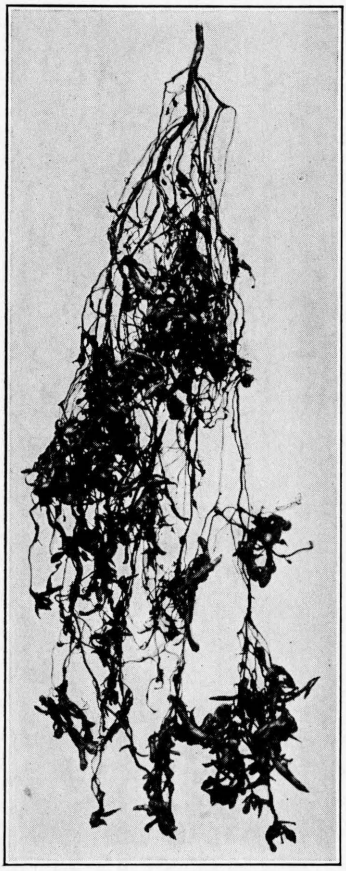

Fig. 1.—Nematode galls on rose roots

Certain species of nematodes affect the above-ground parts of plants. Small, thickened areas develop in the leaves, often causing them to curl and twist and to appear badly deformed.

In northern climates nematodes are largely greenhouse pests, but in the roots of certain plants and in some soils they seem to survive the outdoor winters. They do, however, live through the winter in the South and are a serious cause of disease in plants grown out-of-doors in that region.

Unfavorable environment.—Plants often encounter many unfavorable environmental conditions which cause them to become unthrifty and grow abnormally. Climatic factors which react adversely are extremes in temperature, excessive rainfall, drouth, and improper light conditions. Soil influences, such as poor aeration, unfavorable reaction, excess of soluble material, the presence of poisonous substances, or a shortage of any of the essential elements for plant growth, may all cause ill health in plants. Diseases caused by such factors are said to be physiological in nature.

An accumulation of soluble salts in greenhouse soils often occurs to the extent that plants will not grow properly. The water from some sources contains considerable soluble material which gradually accumulates in the soil. Fertilizers, both organic and inorganic, are often used in large amounts, and, after several applications, the residues may be present in quantities sufficient to cause injury. This is especially likely to occur if drainage is not adequate enough so that the soil can be leached occasionally. Many times, the soluble salt content of heavily fertilized greenhouse soils is increased by steam sterilization to the point where plants will not grow well for some time after sterilization.

RELATION OF ENVIRONMENT TO DISEASE

Environmental factors, such as moisture and temperature, are so closely related to the occurrence and development of fungous and bacterial diseases that often the grower believes that these conditions are the direct cause of disease. Fungous spores require considerable moisture before they can germinate and infect a plant. This explains why some diseases are more numerous and destructive during seasons when there is abundant rainfall. Diseases are also more serious in the greenhouse when the plants are over-watered and poorly ventilated, because the excessive humidity is ideal for the growth of fungi and bacteria. Heavily shaded plants are more subject to disease than those growing in full sun, partly because of the greater humidity in the shaded location. Root rots are ordinarily more severe in poorly drained soils than in soils which are well drained and aerated.

Many fungi and bacteria are able to infect plants and cause disease only at certain temperatures. This is especially true with most of the pathogens which cause the wilt diseases. Temperature may also exert an indirect influence on disease because of its effect on atmospheric humidity. Cool air holds much less water than warm air; hence, the relative humidity of a given environment is greater and more favorable for the development of disease when the air is cool than when it is warm, if humidity is the limiting factor.

In the greenhouse the proper control of temperature and humidity by correct watering, ventilating, and firing is one of the most effective disease-preventive measures which can be practiced. Locations should be selected out-of-doors where the light and aeration are good and where the soil is well drained for growing plants. Low, poorly drained, and shaded areas should always be avoided.

PREVENTION AND CONTROL OF DISEASE

Satisfactory control measures for the diseases of ornamental plants are preventives rather than cures. Practically all diseases can be prevented if the grower understands that control measures must usually be used before the appearance of disease. When once a plant becomes affected, often the only remedy is to destroy it and start over.

The use of fungicides, soil sterilization, proper growing conditions, healthy propagating stock, and strict sanitary measures are the most important practices which the grower can put into effect to prevent disease.

Fungicides.—The fungicides commonly used on the aerial parts of plants can be divided into two groups, those containing sulfur and those containing copper as the toxic agent. Several mixtures containing one or the other of these elements are available commercially or can be prepared by the grower for use as a spray or a dust. Unfortunately, no one fungicidal compound has yet been found which is effective in the control of all diseases and satisfactory to use on all plants. To obtain effective control, the correct fungicide must be used and must be properly applied. Thoroughness is extremely important in applying either sprays or dusts; the entire surface of leaves and stems must be covered.

Fungicides are generally more effective when applied before rains rather than after. It is during wet periods that spores germinate, and, unless the plant is protected by a fungicide, it becomes diseased.

Suitable sprayers and dusters can be obtained for use either in the outdoor garden or in the greenhouse. Since thoroughness of application is very essential, it is important to have good equipment. A common mistake is to use too small a sprayer or duster, because it is a few dollars cheaper, and the usual result is poor control of disease because the plants are not properly covered. Most commercial greenhouses can well afford to have a good power sprayer which will apply the spray under high pressure. Low pressure sprayers do not break the spray up into a fine mist and, in general, are not nearly as effective as high pressure machines.

Lime-sulfur.—Lime-sulfur is an old standard spray which can be purchased either in the liquid form or as a dry powder. For spraying deciduous trees and shrubs in the dormant state, 1 gallon of the liquid is diluted with 7 gallons of water, or the dry form is used at the rate of 1 pound to 4 gallons of water. When plants are

in leaf, 1 gallon of the liquid or 3 pounds of the dry lime-sulfur are used with 50 gallons of water (1 quart to 12½ gallons or 1 ounce to 1 gallon).

Lime-sulfur is compatible with lead or calcium arsenate and with nicotine sulfate.

Colloidal and wettable sulfurs.—A true colloidal sulfur preparation is now on the market in paste form. Because of the extreme fineness of the particles this form of sulfur covers exceptionally well and generally is an effective fungicide where sulfur is needed.

So-called wettable sulfurs are dry preparations which mix readily with water to form a spray mixture. The particle size is much greater in the wettable than in colloidal sulfur; hence, the covering capacity of the wettable forms is less, and they also settle out of suspension a great deal more rapidly than the colloidal form.

Potassium sulfide.—This material is commonly known as liver of sulfur and is one of the oldest sprays used by florists in combatting mildews. It is generally used at the rate of 1 ounce to 3 gallons of water and should be put on immediately after being made up.

Sulfur dusts.—The sulfur dusts used as fungicides are dry, powdered forms of sulfur and should be fine enough to pass through a 300-mesh screen. Their effectiveness seems to depend on the fineness of the particles; hence, ordinary sulfur, in which the particles are fairly large, is not a good fungicide. Dusting sulfur may be mixed with lead arsenate at the rate of 9 parts of sulfur to 1 of arsenate to form a dust effective in the control of both diseases and chewing insects. Special preparations of dusting sulfur which are colored so that they do not leave an objectionable stain on the foliage of plants are on the market.

Vaporized sulfur.—A common greenhouse practice to prevent mildew is to paint the heating pipes with a mixture of sulfur and lime. Equal parts of the sulfur and hydrated lime are mixed with enough water to give a creamy mixture. The heat from the pipes slowly vaporizes the sulfur into the atmosphere of the greenhouse where it condenses and then settles on the plants.

Bordeaux mixture.—This is one of the oldest and most commonly used of our present fungicides. It can be purchased ready prepared so that diluting with water is all that is necessary, or it can be prepared by the grower. It is generally made by using 4 pounds of blue vitriol (copper sulfate) and 6 pounds of good, hydrated, spray lime to 50 gallons of water. The blue vitriol can be dissolved by suspending it in a cheese cloth bag in 4 gallons of

water. The lime should be mixed with sufficient water to form a thin cream and should be strained through cheese cloth or a screen into the spray tank. Water should be added until the lime is diluted to at least 40 gallons; then the blue vitriol solution and enough water to make the total volume 50 gallons should be added. As soon as the mixture is stirred, it is ready for use.

Five gallons of bordeaux can be prepared by dissolving one-half of a measuring cup of blue vitriol in 2½ gallons of water, as described above, and mixing 2½ measuring cups of hydrated lime in 2½ gallons of water, and then pouring the two solutions together and stirring.

Lead or calcium arsenates and nicotine sulfate may be used with bordeaux mixture.

Ammoniacal Copper Carbonate.—This spray solution is often used in place of bordeaux mixture since it does not stain the foliage. It does not adhere nearly as well as bordeaux, however, and is not as efficient in preventing disease. It is prepared by dissolving 1 level teaspoonful of copper carbonate in 2 tablespoonfuls of ammonia and adding 1 gallon of water. The spray must be used immediately after it is prepared.

Spreaders.—The leaves of many ornamental plants are covered with a waxy bloom. Most sprays do not wet the surface of such leaves but collect in droplets and run off, leaving the leaf almost entirely free of the fungicide. When spraying such plants, it is necessary to add a spreader to reduce the surface tension of the spray solution so that it will wet and cover the leaves.

The spreaders commonly used are soaps, calcium caseinate, and oil emulsions. The oils are usually not desirable on ornamentals because they often destroy the bloom.

Potash fish-oil soap is a very effective spreader when used with lime-sulfur solutions or bordeaux mixture. It is used at the rate of 1 ounce, or 2 tablespoonfuls, to 1 gallon of spray. Ordinary laundry soaps are fairly satisfactory and should be used at the rate of 1 ounce to the gallon of spray.

When calcium caseinate is used, it is generally added to the spray at the rate of ½ pound to 50 gallons.

It is usually best to dilute the spray with the required amount of water and then add the spreader.

Copper-lime dust.—Copper-lime dusts can be bought ready to use, or they can be mixed at home. The usual mixture contains 80 parts by weight of hydrated lime and 20 parts by weight of monohydrated copper sulfate. Arsenate of lead, when needed, can be

included in the mixture by replacing 10 parts of lime with 10 of the arsenical. The dust must be kept in air-tight containers, since it takes up water from the air and becomes valueless when left exposed.

Plants should be wet when copper-lime dust is applied to obtain its maximum value and to insure against injury. In the presence of water the dust is immediately changed to bordeaux mixture.

The monohydrated copper sulfate can not usually be bought locally but must be purchased from chemical companies dealing in spray materials.

Corrosive sublimate.—Corrosive sublimate solution is an excellent disinfectant for sterilizing the surface of bulbs, corms, rhizomes, and other plant parts. It can be purchased at any drug store in either tablet or powdered form. The tablet form is usually prepared so that it dissolves readily in water. Powdered corrosive sublimate dissolves very slowly in cold water but can be dissolved quickly in hot water. A small amount of water should be heated to near the boiling point and then transferred to a wooden vessel or a crock before the corrosive sublimate is added. After the material is dissolved, it can be diluted to the necessary volume with cold water.

The most commonly used dilution is 1-1000, which is at the rate of 1 ounce to 7½ gallons of water. Sometimes a dilution of 1-2000 is desired, which is at the rate of 1 ounce to 15 gallons.

Wooden or crockery containers should be used since corrosive sublimate reacts chemically with metals.

Corrosive sublimate is poisonous if taken internally.

Proprietary fungicides.—A large number of proprietary fungicides is on the market. Some of these preparations have considerable merit; whereas many others have little or no value. They are seldom equal to the standard fungicides which have been discussed in the preceding paragraphs. The florist will usually find that diseases can be controlled better and much more economically by using the standard materials rather than proprietary compounds.

Soil sterilization.—Some form of soil sterilization is usually necessary to control diseases caused by fungi, bacteria, and nematodes, which live in the soil from one crop to the next. Several methods for sterilizing soil are in general use, and the individual grower must choose the one that is the most adaptable to his particular needs. No one method can be suitable for the great variety of conditions necessitating soil sterilization.

Steam.—The most effective soil sterilizing agency is steam, and, whenever facilities are available for steaming, this method of sterilization should be used. Ground beds in greenhouses are sterilized by forcing steam through 3-inch tiles or perforated pipes buried 12 to 15 inches deep in the soil and in parallel lines 15 to 20 inches apart. The surface is covered over with boards or canvas, and the steaming is continued until all the soil has been heated to a temperature of 140° F. for a period of 2 hours. Loosening the soil by spading or plowing before steaming is important, since this enables the steam to permeate the soil much more completely than if it is packed.

Another common way of steaming soil in ground beds or benches is by means of an inverted, shallow pan. The pan is constructed of sheet iron or wood, its size being determined by the capacity of the boiler. Suitable hose connections are made through the wall of the pan so that steam can be turned in under pressure. A section of the bed or bench is covered with the pan, the soil is banked around the edges, weights are placed on top, and then the steam is turned in. The length of time required for thorough sterilization depends upon the pressure of the steam.

More detailed information concerning steam sterilization of soil is given in Ohio Agricultural Experiment Station Bulletin 451.

Hot water.—Soil in flats, benches, or pots can be fairly well sterilized by drenching with boiling water. Enough of the boiling water must be added to saturate the soil completely. More satisfactory results are assured if, after the soil dries out, it is treated a second time.

Even though the hot water treatment is effective in killing nematodes, as well as fungi and bacteria, it can not be used extensively because of the large amount of boiling water required. Another objection to the hot water treatment is that some soils are badly puddled and put in such a physical condition that they are difficult to work afterwards.

Baking.—Small lots of soil can be sterilized for starting a few plants by baking in the oven. Place the soil in a shallow pan and put a medium sized potato in the center. When the potato is baked through, the soil is sufficiently sterilized.

Formaldehyde drench.—Formaldehyde is a powerful disinfectant and can be used to sterilize soil out-of-doors where steam is not available. The soil is loosened up well by spading and is then saturated with a solution made by diluting 1 gallon of commercial formalin with 50 gallons of water. From ½ to 1 gallon of the solution should be applied to each square foot of the soil. The

amount that can be applied depends on the depth, dryness, and composition of the soil. After treatment, the ground should be covered with boards, paper, or canvas for 24 hours and then allowed to dry and air out. It may require from 10 days to 2 weeks for all the formaldehyde to escape so that the bed can be planted. As long as any odor of formaldehyde can be detected in the soil, it is not safe to plant.

This method of soil sterilization, like the hot water treatment, is objectionable because some types of soil are badly puddled.

Formaldehyde dust.—Soil mixtures which are to be used in flats, pots, or benches can be most conveniently freed of the damping-off pathogens and most of the organisms causing root rots by treating with formaldehyde dust. This treatment does not kill all the soil bacteria or the more resistant fungi; this is a desirable feature since many times plants do not grow well in a soil that has been completely sterilized.

The dust can be obtained on the market ready for use, or it can be prepared if the necessary materials are obtainable. It is made by adsorbing formaldehyde on a carrier so that the resulting mixture contains 6 per cent of formaldehyde. Such materials as ground charcoal, dried sifted muck, and infusorial or diatomaceous earth are satisfactory carriers. Hydrated lime is not suitable since it reacts chemically with the formaldehyde. Fifteen parts of commercial formalin, containing 40 per cent of formaldehyde, are mixed with 85 parts by weight of the carrier. The mixing must be thoroughly done, and the mixture should be screened to break up any lumps. Since formaldehyde is volatile, the dust must be kept in an air-tight container.

Eight ounces of the 6 per cent dust are mixed with each bushel of soil or 6 ounces with each cubic foot of soil by shoveling it over several times. The soil may be placed in flats, pots, or benches, and seeds may be planted immediately if the soil is watered well after planting. If rooted plants are to be set in the soil, it cannot be used until all odor of the formaldehyde is gone. In most soils it is safe to set plants after 72 hours, if the soil has been spread out in flats or in a bench and has been held at a temperature of 65° F. or above.

Sanitation.—The practicing of strict sanitary measures in the home flower garden and in the floral greenhouse is a great aid in preventing fungous and bacterial diseases. Sick plants should not, as a rule, be tolerated in the garden or greenhouse, since a diseased plant is a source of contagion which may spread to the healthy individuals.

In the fall of the year all annuals in the flower garden should be destroyed by burning. Most diseases live over winter in the soil and on old plant parts. If diseased plants are left in the garden over winter, an early outbreak of disease can be expected the following season. The leaves of shrubs should be raked up and burned after they have fallen. Herbaceous perennials should be cut close to the ground in the fall and the tops destroyed.

The grower must constantly bear in mind that fungous and bacterial diseases are infectious and that diseased plants are a source of contagion. Spores form quickly on plants affected with certain diseases and may spread the trouble through the entire planting. If diseased individuals are removed when they first appear and a suitable fungicide applied, the disease usually can be checked.

CONTROL OF DAMPING-OFF OF SEEDLINGS

The fungi which cause seed to rot and young plants to damp-off are present in practically all soils. The young seedlings are usually attacked at and below the soil line. The stem shrivels up at this point, and then the plants topple over, wilt, and die.

It is usually necessary to sterilize the soil mixture before planting the seed to control damping-off. Formaldehyde dust, when used as suggested on Page 13, kills the damping-off pathogens and is the most practical and convenient method of treating the soil for starting seedlings. The seed may be planted immediately after the soil is treated if the soil is watered well after planting.

The treatment is effective and non-injurious with practically all seedlings and in almost all types of soil, Figure 2. There are, however, a few kinds of seed which are injured if planted in heavy, alkaline soils, especially if the seed is weak. This danger is eliminated by planting good, viable seed in soil mixtures containing a high percentage of peat moss and sand. A mixture of ⅓ soil, ⅓ sand, and ⅓ peat moss is very satisfactory. Seed of hybrid varieties which are known to be weak and of low vitality should not be planted until 24 hours after the soil has been treated and placed in flats.

No matter how thoroughly the soil is sterilized at planting time, damping-off of the seedlings may occur later if they are not properly cared for. The seedlings should be watered carefully and must not be kept too wet. It is best to water them in the morning so that the soil partially dries out before night.

The cold frame or greenhouse in which the seedlings are growing must be properly ventilated to keep the humidity down. It is always better to plant the seed in rows than to broadcast them.

Tilford, Paul E. 1931. Control of damping-off of flower seedlings. Ohio Agr. Exp. Sta. Bimo. Bull. 152, 167-175.

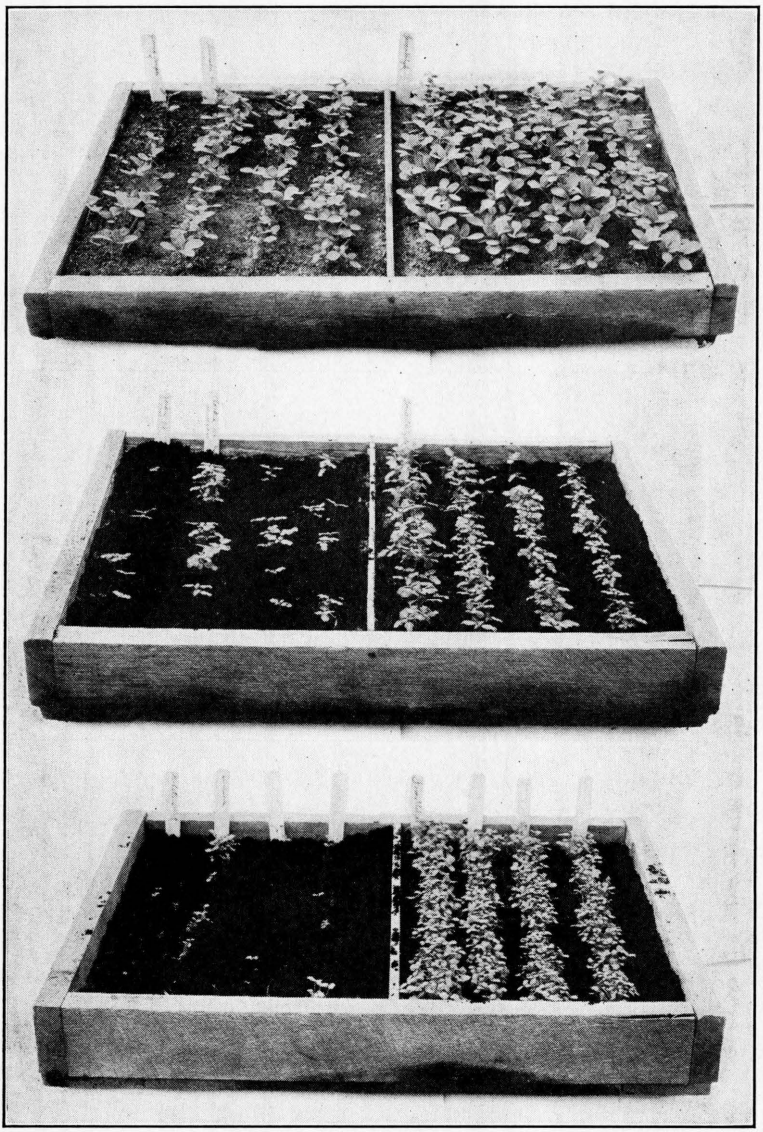

Fig. 2.—Control of damping-off of seedlings by use of formaldehyde dust. Soil in the right side of flats treated; left side, untreated

CONTROL OF ROOT KNOT CAUSED BY NEMATODES

Soil sterilization is necessary to control nematodes. Steam sterilization is the most practical and effective method in the greenhouse, if steam is available (See Page 12). It is usually impossible, however, to eradicate them completely from ground beds, and, while it may not be necessary to steam every year for nematode control, the process must be repeated at least every 2 or 3 years. Drenching the soil with boiling water is effective, but this method is usually limited to small quantities of soil (See Page 12).

A 6 per cent formaldehyde dust thoroughly mixed with the soil, at the rate of 1 pound of dust per bushel of soil, is effective in eliminating most of the nematodes if not many root galls from nematode-infected plants are present (See Page 13). After treating the soil with this amount of formaldehyde dust, seed should not be sown or plants set until all odor of the formaldehyde is gone. The practicability of this treatment is limited to bench, flat, or potting soils. The formaldehyde drench method of soil sterilization also greatly reduces the nematode population in the soil (See Page 12). Drenching the soil is undesirable, however, if any other method can be used, since it puddles the soil and leaves it in poor physical condition.

New soil brought into the greenhouse from outside, in the North, is ordinarily free from nematodes, but before being placed in benches in which infected plants have been grown, the benches should be thoroughly scalded with boiling water or washed out with a formaldehyde solution 1-50. Nematodes commonly live over from one crop of pot plants to the next in the sand in the bottom of the benches. The sand should be changed or thoroughly scalded before nematode-free pots are set on the bench, in the event that the preceding crop was affected. Pots in which affected plants have been grown should be sterilized with boiling water or steam before being used again.

Great care should be taken to guard against bringing nematodes into houses which are free from them. They are most frequently brought in on tools and propagating stock from infested houses, or they may even be carried on the shoes of a person going from one house to another.

When perennials growing out-of-doors become affected with nematodes, about all that can be done is to remove the plants with the roots and the surrounding soil and to destroy them by burning. In some special cases treatments are of some value; these are discussed in that part of the text dealing with the diseases of the particular host affected.

ASTER

(Callistephus chinensis)

Yellows *(Virus)*

This is, without doubt, the most destructive disease of the China aster. It occurs throughout North America but has not been found, up to the present, in any other part of the world.

The first visible symptom is a slight yellowing along the veins in the leaves. Later, the newly formed leaves appear yellow or chlorotic. The plants are stunted, and a large number of spindly, yellow shoots develop with upright leaves, giving the diseased plants a bushy appearance, Figure 3.

The flowers are peculiarly affected and, in general, appear as if they were being changed into vegetative growth. The petals contain an abnormal amount of green sap and do not develop the natural color. Frequently, only one side of the flower is affected.

A leafhopper, *Cicadula sexnotata* Fall, is the only known transmitting agent of yellows. A great variety of perennial weeds is affected with the disease. The virus lives over winter in the root systems of these plants and, in the spring, is carried from them to aster plantings by the leafhopper. Young aster seedlings are always free of yellows since the virus is not transmitted by the seed.

Control.—Since the leafhopper is the only transmitting agent of yellows, if it can be kept off the plants they will remain free of the disease. Growing asters in screen or cloth cages, where it is practicable, is an effective control. Cloth with 22 threads to the inch or screen with 18 wires to the inch will turn leafhoppers. Screening is the only known means of absolute control.

Bordeaux mixture is an effective insecticide against some species of leafhoppers. To the writer's knowledge, its effect on the particular leafhopper which spreads yellows has not been determined, but, in his experiments, asters sprayed once a week from the time they were set out-of-doors until the blossom buds formed showed less yellows than those in unsprayed plantings.

The asters should be inspected closely at frequent intervals, and, as soon as a plant shows any symptoms of yellows, it should be pulled out and destroyed by burning.

Jones, L. R. and Regina S. Riker. 1931. Wisconsin studies on aster diseases and their control. Wis. Agr. Exp. Sta. Res. Bull. 111.

Kunkel, L. O. 1926. Studies on aster yellows. Am. Jour. Bot. 13: 646-705.

Wilt (*Fusarium conglutinans* var. *callistephi* Beach)

Wilt may cause the young seedlings to damp-off, or the young plants may become infected and not show symptoms until later.

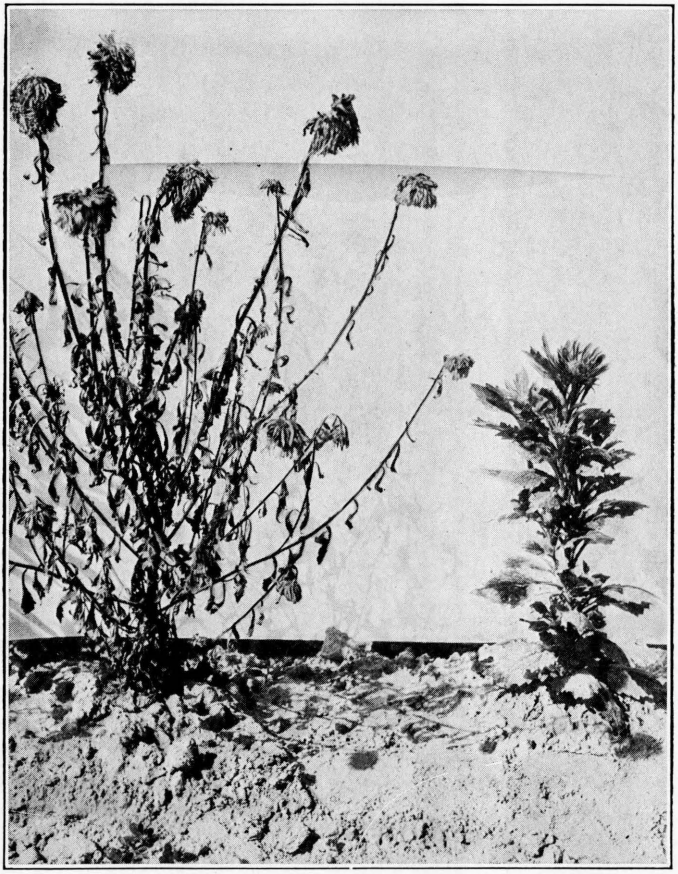

Fig. 3.—Fusarium wilt of aster on the left. Aster yellows on the right

In older plants the lower leaves wilt, turn a yellowish-green in color, finally die and become black. Dark brown to black streaks, which may extend to the petioles of the leaf, develop in the cortex of the stem. The stem is usually badly rotted near the soil line, and a dark streak may extend up one side of the stem, starting from the rotted area near the ground. In wet weather, a pink fungous growth usually develops on the rotted stem near the soil. The black decay may also involve the root system. The whole plant finally dies about flowering time, Figure 3.

Control.—The wilt organism lives in the soil from one year to the next, making it necessary either to sterilize the soil or change the location of the aster planting when the disease becomes serious. Asters should never be planted where the disease occurred the previous year unless the soil is sterilized (See Page 11). Some commercial growers adopt the practice of growing asters for 2 years in the same soil and then moving the aster planting the third year to a new location. Just how long the fungus will remain in the soil in the absence of asters is not known.

The wilt organism is usually introduced into the soil by transplanting diseased plants or by planting seed which carries the wilt fungus. Sterilizing the seed before planting is a worth while precaution. This can be most conveniently and satisfactorily done by planting the seed in a soil freshly treated with formaldehyde dust (See Page 13).

Recently, considerable work has been done to obtain strains of asters that are resistant to wilt. Undoubtedly, in the near future, wilt-resistant strains of practically all varieties of China asters will be available. The grower should keep this in mind, and, as soon as these resistant strains are put on the market, he should plant them.

Beach, W. S. 1918. The Fusarium wilt of China aster. 20th Rept. Mich. Acad. Sci., 282-307.

Gloyer, W. O. 1931. China aster seed treatment and storage. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bull. 177.

Jackson, A. B. 1927. The Fusarium wilt of China asters. Scien. Agr. 7: 233-247.

Jones, L. R. and Regina S. Riker. 1931. Wisconsin studies on aster diseases and their control. Wis. Agr. Exp. Sta. Res. Bull. 111.

Rust (*Coleosporium solidaginis* [Schw.] Thuem.)

The most striking symptom of aster rust is the development of orange-red rust pustules on the under side of the leaves. If the rust is serious, the leaves turn yellow and die. It is likely that some perennial species of Solidago are, in part, responsible for the over wintering of the rust. Rust, in certain stages in its development, occurs on several species of pine; hence, it is likely to be serious on asters growing near pines.

Control.—Keeping the plants thoroughly sprayed with bordeaux mixture, as suggested under control measures for yellows, will prevent rust from becoming serious (See Page 17).

LEAF SPOTS

Other minor diseases which sometimes occur on asters are leaf spots caused by *Septoria callistephi* Gloyer, *Ascochyta asteris* Gloyer, and *Botrytis* sp. The botrytis may occasionally cause a

stem blight. The spores of these fungi may be carried on the seed. Planting the seed in soil freshly treated with formaldehyde dust (See Page 13) and spraying with bordeaux mixture, as suggested for yellows, will effect control (See Page 17).

Gloyer, W. O. 1931. China aster seed treatment and storage. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bull. 177.

AQUILEGIA (COLUMBINE)

(*Aquilegia* spp.)

Crown Rot (*Sclerotinia sclerotiorum* [Lib.] Massee)

The stems of the plants rot at the surface of the soil causing the tops to die slowly. Finally, the whole top dies. Often, the white fungous threads can be seen on the rotting stems near the ground, and, sometimes, small, dark structures can be found in the decayed tissue; these are the resting bodies, or sclerotia, of the fungus.

Control.—It is usually most satisfactory to remove the diseased clump and destroy it. The soil should also be removed and new soil filled in before setting other plants in the vacant spot.

Keeping the soil well cultivated around the crowns so that it will dry rapidly helps to prevent the disease. If the soil is heavy, it should be removed from around the crowns of the plants and replaced with sand.

Watering the diseased plants with a corrosive sublimate solution, 1 ounce in 20 gallons of water, will sometimes enable sick plants to recover (See Page 11).

Taubenhaus, J. J. 1916. A wilt disease of the columbine. Phytopath. 6: 254-257.

BEGONIA

(*Begonia* sp.)

Blight (*Botrytis* sp.)

Both leaves and flowers may be affected by blight. The diseased areas enlarge rapidly under favorable conditions and cause the leaves to turn black. Usually, the affected flowers and leaves become covered with a brownish-gray mold.

Control.—Thorough sanitation is one of the most effective means of controlling this disease. Keeping all rubbish, such as dead plants and fallen leaves, cleaned up and burned is essential. Ventilating the greenhouse properly and keeping the tops of the plants dry is important. If necessary, spraying with bordeaux or ammoniacal copper carbonate will check the disease (See Page 9).

Root Knot or Nematodes (*Caconema radicicola* [Greef] Cobb)

The plants are stunted and will not grow properly even though they are given the best of treatment. When the roots are examined numerous nodules or knots are found.

Control.—See Page 16.

CALLA LILY

(*Zantedeschia* spp.)

There are two common diseases of the calla lily, root rot and soft rot. The control measures for both diseases are the same and are given following the discussions.

Root Rot (*Phytophthora richardia* Buisman)

The plants appear normal for a time, then the outer leaves begin to yellow along the margins, and, gradually, the whole leaf yellows and droops. Other leaves are affected progressively inward, but new leaves may continue to develop. If the plants flower at all, the tip of the spathe turns brown and does not open up properly.

When the roots of these plants are examined the source of the trouble is seen. The feeder roots start rotting at the tips, and the rot progresses backward to the corms, Figure 4. The infected roots have a water-soaked appearance, and all that finally remains of them is the epidermis which appears as a hollow tube. New roots are sent out from the corms, and these in turn rot.

Sometimes the corm is attacked but usually not extensively. The rot in the corms is more or less dry and spongy but never wet and slimy.

Soft Rot (*Bacillus carotovorus* Jones)

The top of the corm, at or just below the surface of the soil, is the part of the plant usually attacked first. The plant may be completely rotted off at this point, in which case the leaves droop and die. Decay in the corm may spread upward or downward. If downward, a soft, mushy rot with a foul odor develops in the corm and finally spreads to the roots where it destroys the internal structure, leaving only the epidermis. The leaf stalks are often attacked near the base, and a water-soaked area, which at first retains its normal green color but later becomes dark and slimy, develops. The leaf blade yellows at the tip and along the margins, and, when the infection on the stalk becomes extensive, the leaf droops, yellows, shrivels, and dies. Flower stalks may be attacked, in which case the flower turns brown and eventually the stalk falls over.

Control of root rot and soft rot.—The organisms which cause these diseases are carried from one crop to the next on the corms, making it necessary to sort the corms carefully, discard any that show rot, and disinfect the remaining ones. Treating the sorted corms by soaking for 2 hours in a 1 to 1000 solution of corrosive sublimate (See Page 11) or for 1 hour in a 2 per cent formaldehyde solution is effective, Figure 4. Treated corms start growing slower than untreated ones, and, because of this, it is advisable to plant about 2 weeks earlier than would be necessary otherwise.

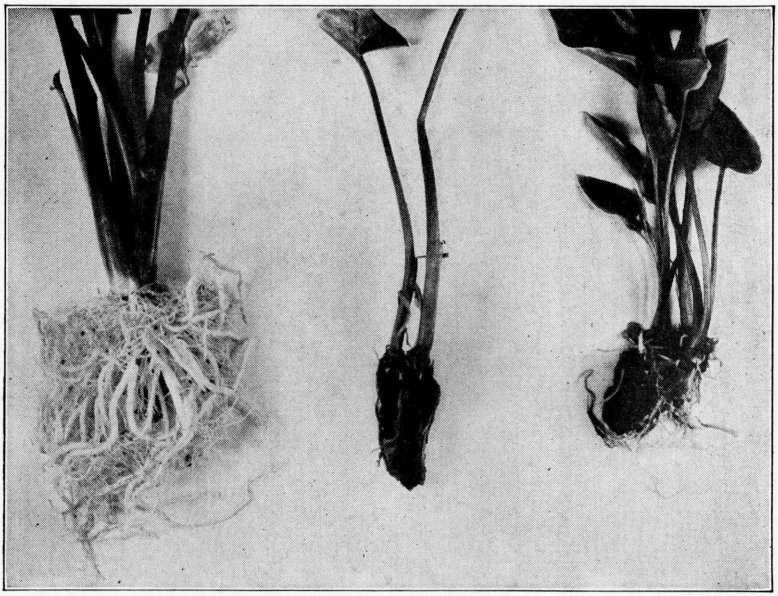

Fig. 4.—Phytophthora root rot of Calla Lily. All three plants grown from corms affected with the disease. Plant on left grown from corm treated in corrosive sublimate solution and planted in new soil. Plant in center grown from untreated corm but planted in new soil. Plant on right grown from treated corm planted in soil contaminated with the root-rot fungus.

Growing the callas in pots rather than in benches is advisable from the standpoint of disease control. When root rot starts in a bench it spreads through the soil and may infect all the plants; whereas, if pot culture is practiced and a few plants become diseased, they can be removed.

The organisms live in the soil for long periods of time; so it is necessary to sterilize the soil or to use soil that has not grown callas before (See Page 11).

If pot culture is practiced, the pots should be sterilized before the corms are planted, especially if diseased callas were grown in them the year previous. They can be sterilized by steaming or by immersing them for 30 minutes in the disinfecting solutions mentioned above.

Buisman, Christine J. 1927. Een wortelziekte van calla, veroorzaakt door een Phytophthora-soort. Tijdschr. over Plantenziekten. 33: 17-22.

Tilford, Paul E. 1932. Calla lily root rot and its control. Ohio Agr. Exp. Sta. Bimo. Bull. 157: 138-140.

Townsend, C. O. 1904. A soft rot of calla lily. U. S. D. A., Bureau of Plant Ind. Bull. 60.

Weiss, Freeman. 1930, April 19. A root rot of the white calla new to the United States. The Florist's Exchange 73: 11.

CALENDULA

(Calendula officinalis)

Stem Rot (*Sclerotinia sclerotiorum* [Lib.] Massee)

The stem is affected with a soft rot, usually near the ground, and the rot may involve the lower leaves. Crowded conditions which occur in greenhouse beds are very favorable for the disease.

Control.—Stripping the lower leaves from the plants is a practice used by many greenhouse growers of calendulas, and it seems to help prevent the disease. Sterilizing the soil before setting the plants will eliminate the trouble. If the plants are given plenty of space in outside plantings, usually they remain free from stem rot.

Yellows *(Virus)*

The yellows disease of calendula is similar to yellows of asters (See Page 17).

CANNA

(Canna indica)

Bud Rot (*Bacterium cannae* Bryan)

Bud rot is primarily a disease of young tissues, infection usually taking place while the leaves are still rolled in the bud. When the points of infection are numerous and the disease has not progressed far, the leaf appears covered with minute, white spots when it opens. However, at other times, the infection may have progressed to the extent that the leaf is wholly, or partly, blackened when it unfolds. The whole stalk may be killed. The lesions do not enlarge in the older leaves, but these leaves show the effects of the earlier attack in the form of brown spots, streaks, and a distorted condition.

If the shoot has not been killed by the early attack, often the flowers are ruined either by infection of the young buds or by the decay of the stem.

Control.—Selecting root stalks from healthy plants is the first control measure to consider. Surface sterilization of the dormant corms by soaking them for 2 hours in a 1-1000 corrosive sublimate solution is advisable (See Page 11). If the plants are started in the greenhouse, they should be watered carefully to keep the young growth dry, ventilated properly to keep the humidity down, and given plenty of space. Set only disease-free plants out-of-doors and space them well apart.

Varieties seem to vary in their susceptibility to bud rot. The disease is severe on Princeton, Gayety, City of Portland, Charles Lutz, Yellow King Humbert, Carmine Beauty, Fire Bird, and Mrs. Alfred Conard.

Bryan, Mary K. 1921. A bacterial bud-rot of cannas. Jour. Agr. Res. 21: 143-152.

CARNATION

(Dianthus caryophyllus)

Carnation rust, Alternaria leaf spot, fairy-ring, and bacterial leaf spot may all be controlled by the same practices, and, for this reason, the control measures are given after the descriptions of these diseases.

Rust (*Uromyces caryophyllinus* [Schrank] Wint.)

The characteristic yellowish-brown pustules of rust on the leaves and stems make its diagnosis easy and its confusion with other carnation diseases unlikely, Figure 5. Individual leaves may be killed by the rust, or whole plants, if they become heavily infected, may be injured to the extent that they are unprofitable.

Varieties vary greatly in their susceptibility to rust. Betty Lou, Early Dawn, Harvester, and Enchantress Supreme are very susceptible. Early Rose, Super Supreme, Beacon, Akehurst, Boston Ward, Jewel, Pink Matchless, Matchless, and Radiolite may be classed as somewhat less susceptible. Scepter, Maine Sunshine, North Star, Pink Delight, Dark Rose, Morning Glow, Sophelia, Red Matchless, Spectrum, Winsom, White Ward, White Eldora, Jones, Hilda, and C. W. Ward are only slightly susceptible. Pink Abundance, Ivory, Donald, White Matchless, Fairy Queen, Eldora, Pink Eldora, and Golden Glow are fairly resistant.

Fig. 5.—Rust pustules on carnation leaves

Alternaria Leaf Spot (*Alternaria dianthi* Stevens and Hall)

This disease appears as spots on the leaves and sometimes on the stems, especially at the nodes. These spots are white, with the center occupied by a black fungous growth, Figure 6. When the stem is affected, the part of the plant above the infected area dies. Lower leaves are usually more seriously affected than leaves in the top of the plant. The leaves often become infected near the tip and die back.

Fairy-ring (*Heterosporium echinulatum* [Berk.] Cke.)

Bleached spots develop on the leaves, and in these areas minute black bodies (the fruiting structures of the fungus) appear in ring formation—hence, the name fairy-ring.

Leaf Spot (*Septoria dianthi* Desm.)

Light brown spots with purple margins appear on the leaves, and in the center of these spots can be seen minute black specks, the fruiting bodies of the fungus. The stem may also be attacked, in which case the part of the plant above the point of attack is usually killed.

Bacterial Leaf Spot (*Bacterium woodsii* E. F. S.)

The bacterial spots are more or less water-soaked, and a slimy ooze often exudes from their surface.

Young lesions with their water-soaked margins can be seen better if the leaves are held up to the light. As the lesion enlarges, the center of the spot becomes brown and dry. Leaves which are badly affected soon wither and die.

Control of rust, Alternaria leaf spot, fairy-ring, and bacterial leaf spot.—Cuttings should be free of disease when they are placed in the bench since conditions in a cutting bench are very favorable for the development of disease. If cuttings must be taken from affected plants, they should be sprayed after they are set in the sand.

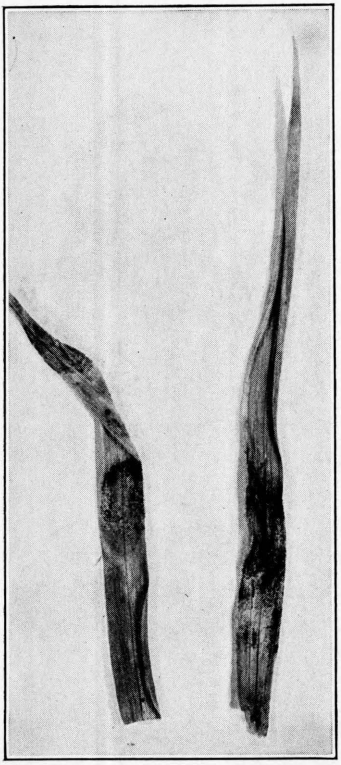

Fig. 6.—Alternaria blight on carnation leaves

Both field- and pot-grown plants should be sprayed regularly at 2- to 3-week intervals. The spraying should be continued every 2 or 3 weeks after the plants are benched until the crop is taken out. When blooming starts, care should be used not to spray the blossoms; spray after picking rather than before.

Either bordeaux mixture or lime-sulfur is satisfactory as a spray for carnations (See Page 8). With either spray a good spreader must be used, since carnation leaves are coated with a waxy bloom which is very difficult to wet (See Page 10).

Syringe the plants as few times as possible and still keep them growing well. Water and syringe during the morning on bright, sunny days. When watering, apply the water on the surface of the soil and keep the tops of the plants dry. Ventilate properly to keep the humidity down.

When two varieties are of equal value otherwise, choose the one which is more resistant to rust.

Stevens, F. L. and J. G. Hall. 1909. Carnation alternariose. Bot. Gaz. 47: 409-413.

Tilford, Paul E. 1930. Carnation rust. Ohio Agr. Exp. Sta. Bimo. Bull. 147: 191-195.

Woods, A. F. 1903. Bacterial spot. A new disease of carnations. Science 18: 537-538.

The control measures for stem rot, wilt, branch rot, and die-back are the same and are given after the descriptions of the diseases.

Stem Rot (*Rhizoctonia solani* Kühn = *Corticium vagum* B. and C.)

Stem rot is a very common disease of carnations and one with which all growers are more or less familiar. Cuttings may be attacked in the cutting bench, or plants may be affected after they are put in pots, in the field, or in the bench. Damping-off of the cuttings in the sand and of the rooted plants in the pots is typical of stem rot. Field-grown carnations are especially susceptible. The affected plants either die while in the field or soon after they are benched. On these older plants the rot usually starts at an injury in the cortex of the stem and extends around the stem until it is girdled; the plant then wilts and dies. The rot in the cortex is more or less dry and corky in nature.

Wilt, Branch Rot, and Die-back (*Fusarium* spp.)

The main stem of the plant may be attacked and rotted above and below the soil, after which the plant wilts. Usually, if the stem of the wilted plant is cut across, a brown discoloration is seen in the wood.

If the point of attack is one of the branches, the disease is termed "branch rot". A white, dry rot develops in the cortex of the branch, and, if it is girdled, the above parts wilt and die. The rot may extend downward and finally involve the main stem, thus killing the whole plant.

Many times, the rot starts at the end of a shoot that has been pinched back or where a flower has been removed. The rot extends back from this point and is termed "die-back".

Control of stem rot, wilt, branch rot, and die-back.—Cuttings should be taken from healthy plants, since the fungi which cause these diseases may be transmitted by the cuttings. Either new or sterilized sand should be used in the cutting bench (See Page 11). The cutting bench should be properly cared for with respect to temperature, shading, and watering.

If the plants are field-grown, they should be set in a new location each year. Either new or sterilized soil should be used in the benches (See Page 11).

Pot-growing the plants until benching time decreases the losses from these diseases. A number of plants always succumb in the field, and, when they are taken from the field for benching, they are injured to some extent; as a result, many more plants become infected than if they are taken from pots to the benches. It is necessary to water the freshly benched plants from the field more heavily in order to prevent wilting than if they were taken from pots; this makes conditions more favorable for infection.

Select a time for benching when the weather is cool so that the freshly benched plants need not be watered excessively. After benching, water the soil around each individual plant but do not soak up all the soil until the plants are well established and have started growing.

Keeping the tops dry by surface watering and ventilating is important in preventing branch-rot infection.

When cutting blossoms, cut the stems back to a node so that stubs are not left which may become infected.

Dawson, W. J. 1929. On the stem-rot or wilt disease of carnations. The Annals of Applied Biology **16**: 261-280.

Peltier, Geo. L. 1919. Carnation stem-rot and its control. Univ. of Ill. Agr. Exp. Sta. Bull. 223.

Van Der Bijl, P. A. 1916. Wilt or crown-rot disease of carnations caused by Fusarium sp. The Annals of Applied Biology **2**: 267-291.

Bud Rot (*Sporotrichum poae* Pk.)

Outwardly, the affected buds may appear almost normal, but the interior is brown, decayed, and generally moldy. Mites are often associated with the rotted buds, and the fungous spores are carried by the mites when they go from a diseased to a healthy bud.

Control.—Picking the diseased buds and burning them will usually prevent serious losses.

Stewart, F. C. and H. E. Hodgkiss. 1908. A bud-rot of carnations caused by Sporotrichum. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bull. 7.

CHRYSANTHEMUM

(Chrysanthemum indicum)

Wilt and Stem Rot (*Fusarium* sp.)

The lower leaves turn yellow, wither, and, finally, the whole plant wilts and dies. Usually, the stem is black near the ground, and a brown discoloration extends in the wood of the stem for a considerable distance above the ground.

Control.—When wilt becomes serious in hardy chrysanthemums grown out-of-doors, the plants should be destroyed and disease-free plants started in a new location.

In the greenhouse, the soil must either be changed or sterilized (See Page 11). Propagating stock should be saved from healthy plants. Only good, healthy specimens should be set, and they should not be over-watered.

Leaf Spot (*Septoria chrysanthemella* Cav.; *Cylindrosporium chrysanthemi* Ell. and Dearn.)

The Septoria leaf spot is the most common and is recognized by small, dark brown spots on the leaves, which increase in size until they coalesce. The affected leaves drop off, thus weakening the plants, and, as a result, poor flowers are formed.

The Cylindrosporium disease is characterized by the appearance of dark blotches, ½ to ¾ of an inch in diameter, on the leaves. Infected leaves soon die, shrivel, and cling to the stem. Lower leaves are usually affected first and then those higher, in order.

Control.—Proper ventilation, keeping the tops dry at night and during cloudy weather, picking diseased foliage, and spraying the young plants with bordeaux mixture, if necessary, will control the leaf spots.

Rust (*Puccinia chrysanthemi* Roze)

The appearance of chrysanthemum rust is very spasmodic. It may suddenly appear in a greenhouse and become serious for a season or two and then disappear completely.

Small blisters about the size of a pin-head appear, mostly on the under sides of the leaves. Several of these blisters may coalesce to form large blisters, which soon break open and expose a dark brown, powdery mass of spores. Infected leaves usually yellow and drop off, thus weakening the plant.

Control.—Inspect newly purchased stock critically and reject any shipment which shows rust. When the disease appears in a greenhouse, the infected leaves should be removed and burned before the blisters break open and release the spores. If rust is present, ventilate and water so that the tops are kept dry. Dusting with sulfur or spraying with a sulfur fungicide is also advisable (See Page 8). After the flower crop is removed, clean off all above-ground parts of the propagating plants and destroy them by burning. Start the young plants in another house.

Arthur, J. C. 1900. Chrysanthemum rust. Ind. Agr. Exp. Sta. Bull. 85, 143-150.

Mildew (*Erysiphe cichoracearum* D. C.)

The leaves become covered with a white, powdery growth and are deformed and stunted.

Ordinarily, mildew does not show up in greenhouse chrysanthemums until late in the fall when the nights are cool and after the foliage has become dense.

Control.—Ventilating to keep an even temperature and low humidity, with proper watering to keep the foliage dry, will usually prevent mildew in the greenhouse. If mildew develops, dust the plants with a sulfur dust or spray with a sulfur fungicide (See Page 8).

Outdoor chrysanthemums should be kept covered with a light application of sulfur dust if mildew is troublesome.

Yellows *(Virus)*

Aster yellows may attack chrysanthemums and cause symptoms on the flowers much the same as those occurring on asters. The foliage may show slight yellowing but not to the extent that aster foliage is yellowed.

Control.—Destroy diseased plants as soon as they are detected. Regular fumigation should be practiced to control insects which spread the yellows. It is not advisable to grow asters near a greenhouse devoted to chrysanthemum growing. See aster yellows, Page 17.

Nelson, Ray. 1925. Chrysanthemum yellows. Mich. Agr. Exp. Sta. Quart. Bull. 7: (No. 4) 157-160.

Ray Blights (*Ascochyta chrysanthemi* Stevens; *Botrytis cinerea* Auct.)

The Ascochyta blight attacks the flower, usually on one side, either in the bud or later in various stages of bloom. In severe cases, where the bud is attacked, the head will not open. The affected buds or blossoms turn straw-colored or brownish and wither.

The Botrytis blight is first noticed as small, water-soaked, brown spots on the petals. These enlarge rapidly, and soon the whole blossom is covered with a grayish mold.

Control.—Give the plants plenty of space, since over-crowding encourages these diseases. Proper ventilation, care in watering to keep the tops dry, and prompt removal of infected heads will control the troubles.

Stevens, F. L. 1907. The chrysanthemum ray blight. Bot. Gaz. 44: 241-258.

Spaulding, P. 1910. Botrytis as a parasite upon chrysanthemum and poinsettias. Mo. Bot. Gard. An. Rept., 185-188.

Root Knot or Nematodes (*Caconema radicicola* [Greef] Cobb)

See Pages 6 and 16.

CLEMATIS

(*Clematis* spp.)

Stem Rot and Leaf Spot (*Ascochyta clematidina* [Thuem] Gloyer)

The disease may appear either as a leaf spot or a stem rot in the greenhouse, but in the field the stem near the soil line is usually the only part of the plant affected. The spots on the leaves at first are mere dots, then water-soaked, and on drying become tan-colored with red margins. Finally, the fungus grows down the leaf petiole to the node, the stem is girdled, and the more distal portion of the shoot dies. When the main stem near the soil is girdled, all the shoots gradually wilt and die.

Control.—Supporting the vines in the greenhouse and in the field or spacing them far enough apart so that they do not mat together will often prevent the disease from becoming serious. Spraying with a good sulfur fungicide also has been found helpful in checking the disease (See Page 8). Select cuttings from disease-free plants, or, if seed is planted, grow the young stock in new beds.

Gloyer, W. O. 1915. *Ascochyta clematidina*, the cause of stem rot and leaf spot of clematis. Jour. Agr. Res. 4: 331-342.

COSMOS

(Cosmos bipinnatus)

Stem Blight (*Phomopsis stewartii* Pk.)

Stem blight is a disease of mature cosmos; young plants are not affected. The plants are attacked anywhere along the stem or branches but never on the leaves or roots. A brown lesion or canker develops and may girdle the stem, causing the above parts to wilt and die. A section of stem several inches long may be involved, and the minute, black fruiting bodies of the fungus may develop in great abundance on the canker surface.

Control.—No control is known except to remove the diseased plants.

Stewart, F. C. 1911. Notes on New York plant diseases. N. Y. (Geneva) Agr. Exp. Sta. Bull. 328, 222.

CYCLAMEN

(*Cyclamen* spp).

Stunt (*Cladosporium cyclaminis* Massey and Tilford)

Diseased plants are conspicuously stunted but not quickly killed. The leaf blades are small, petioles and peduncles are shorter than normal, and the flowers characteristically open below

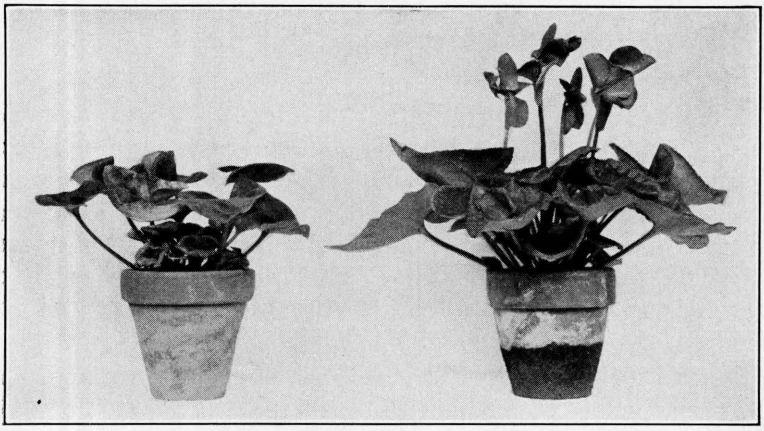

Fig. 7.—Cyclamen "Stunt". Healthy plant on the right

the leaves, Figure 7. Necrotic areas, reddish-brown in color, occur in the corm tissues of the diseased plants, Figure 8. These necrotic areas are more abundant in the crown of the corm but may extend through the entire corm and into the petioles, peduncles, and larger roots.

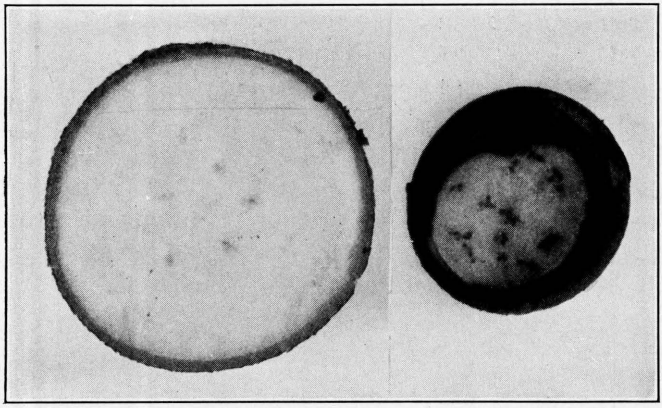

Fig. 8.—Sections through healthy and diseased cyclamen corms. Note necrotic areas, which are typical of the "Stunt" disease

Control.—Control measures have not been well worked out for this disease. The indications are, however, that planting seed from healthy plants in new or sterilized soil will eliminate it.

Massey, L. M. and Paul E. Tilford. 1932. Cyclamen stunt. Phytopath. 22: 19.

Soft Rot (*Bacillus carotovorus* Jones)

The crown of the plant is usually the point of attack. Leaf petioles and flower stems become affected with a soft, slimy rot and soon wilt and droop. The plants soon become stunted and unsightly from the loss of leaves.

Leaf Spots (*Glomerella cingulata* Spauld. and Schrank; *Phoma cyclamenae* Hals.; *Phyllosticta cyclaminicola* Trel.; *Ramularia cyclaminicola* Trel.)

All of these fungi under conditions of excessive humidity may produce leaf spots on cyclamen.

Control of soft rot and leaf spots.—If the plants are not overshaded or kept too wet and if the greenhouse is properly ventilated, these diseases will seldom become serious. All leaves which become infected with the leaf spots should be removed and destroyed. It is advisable to spray the young plants with bordeaux mixture at 2- to 3-week intervals (See Page 9).

Root Knot or Nematodes (*Caconema radicicola* [Greef] Cobb)

See Pages 6 and 16.

DAHLIA

(*Dahlia* spp.)

Stunt *(Virus)*

Dahlia "stunt", as the name implies, dwarfs the plants. Often there is a tendency for an excessive number of shoots to develop, making a bushy plant, Figure 9. The leaves are usually curled, often yellowish-green in color rather than the normal green, and are more susceptible to hopperburn than the leaves of a healthy dahlia plant. Sometimes numerous small cracks appear in the stem and also in the skin of the tubers, Figure 10. Stunted plants seldom flower, and tuber development is much repressed.

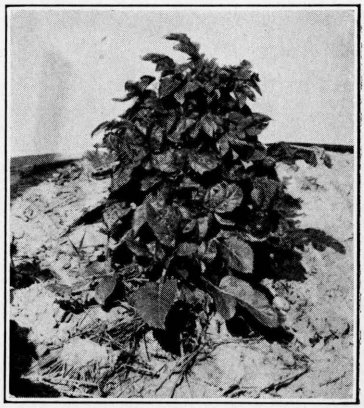

Fig. 9.—Dahlia "Stunt"

Control.—All plants which show symptoms of stunt should be removed from the planting and burned. Tubers should not be saved from stunted plants unless the variety is an expensive one, in which case they may be saved and planted in an isolated place the following year to make sure that they are affected with "stunt" before being discarded.

Tilford, Paul E. 1930. Dahlia stunt disease. Ohio Agr. Exp. Sta. Bull. 446, 64-65.

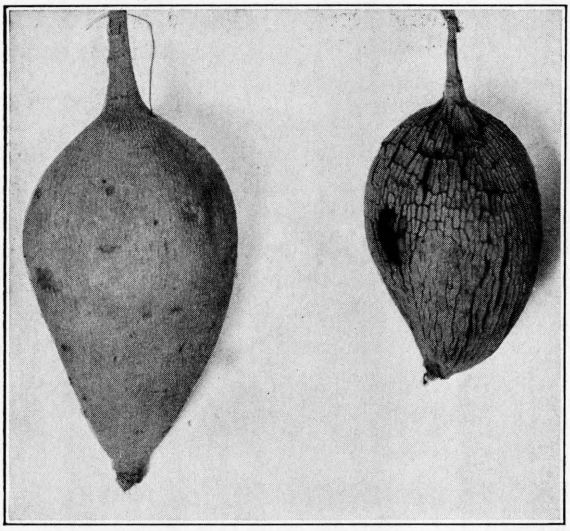

Fig. 10.—Small, cracked tuber produced by dahlia plant affected with "Stunt". Tuber on the left produced by a healthy plant

Root Rot (*Botrytis* sp.)

This disease causes the tubers to rot while in storage. The affected tubers have a water-soaked appearance. The interior is soft and wet, becoming yellow, brownish, and finally black. Infection always occurs through wounds in the surface of the tubers.

Control.—Handle the tubers carefully at digging time to prevent injuries. Store them in a cool (45° F. or lower) place and cover them with sand, which should be kept slightly damp.

Cook, Mel. T. and C. A. Schwarze. 1913. A botrytis disease of dahlias. Phytopath. 3: 171-174.

Wilts (*Fusarium* sp.; *Verticillium dahliae* Kleb.)

Affected plants wilt and gradually die. Brown or black streaks appear in the fibro-vascular system of the stems and tubers. Tubers from affected plants often rot in storage.

Control.—The diseased individuals should be removed from the planting and destroyed by burning. Planting healthy tubers in soil free from wilt organisms eliminates the disease.

Mildew (*Erysiphe polygoni* D. C.)

Mildew occurs on dahlias, usually late in the season, as a white, powdery covering on the leaves.

Control.—When necessary, dusting with sulfur dust or spraying with one of the sulfur fungicides will control mildew (See Page 8).

Hopperburn (*Empoasca fabae* Harris)

The leaves turn yellow and then brown along the edges, and the central green area becomes puckered, due to its continued growth after the edge of the leaf is dead. The plants are stunted and, in some respects, resemble those affected with the "stunt" disease. They start to grow, however, after the leafhoppers have been eliminated; whereas plants affected with "stunt" never grow properly.

Control.—Spraying the plants regularly every 2 weeks during the summer with bordeaux mixture will prevent serious losses from hopperburn (See Page 9).

DELPHINIUM OR LARKSPUR

(*Delphinium* spp.)

Root Rot or Crown Rot (*Sclerotium delphinii* Welch)

The first noticeable symptom is a discoloration of the lower leaves, followed in a few days by the death and drying of the entire plant. An examination of the crown shows that the stems are rotted and black at and below the soil line. The rot may involve most of the roots. Strands of white fungous growth can usually be found on some of the rotted parts. The fungus is especially active during wet periods, and, under such conditions, small, tan, egg-shaped bodies can be found in and on the rotted tissue. These are the sclerotia or resting bodies of the fungus.

Control.—This is a difficult disease to control once the fungus gets in the soil. The soil in the beds should be sterilized and then disease-free plants set (See Page 11).

When the disease first appears in a planting it can often be checked by watering the soil around the plants with a solution of corrosive sublimate, 1-2000 (See Page 11). Repeat this treatment three times at one-week intervals.

Takamichi, T. 1927. A sclerotium disease of larkspur. Phytopath. 17: 239-245.

Bacterial Blight (*Bacterium delphinii* [E. F. S.] Bryan)

The most conspicuous symptom is the appearance of tarry, black spots, which are irregular in shape and size, on the upper leaf surfaces. Blighted areas also appear on the lower leaf surfaces, but they are brown in color.

The blossoms may also be attacked, becoming black spotted and distorted. (This should not be confused with mite injury). Leaf petioles and stems become involved and show the typical black lesions.

The disease becomes severe during cool, wet periods, such as occur in the spring, and, at this time, the young shoots are often entirely killed.

Both annual and perennial varieties of larkspur are affected.

Control.—In the late summer or early fall, the tops should be removed from all perennial larkspurs and burned. The soil around diseased plants and the crowns should be drenched with a solution of corrosive sublimate, 1-2000 (See Page 11).

In the spring just as growth starts, drench the soil around the crowns with bordeaux mixture. Then, after the young shoots get through the ground, spray them and the surrounding soil thoroughly with bordeaux mixture (See Page 9).

Colloidal sulfur has proved an excellent bactericide in laboratory tests, and it should be an effective spray for bacterial blight (See Page 9).

Bryan, Mary K. 1924. Bacterial leafspot of delphinium. Jour. Agr. Res. 28: 261-270.

Diaporthe Blight (*Diaporthe arctii* [Lasch] Nit.)

The lower leaves of diseased plants which have reached the flowering stage become brown and dry but remain attached. Brown lesions occur near the base of the plants, finally girdle the stems, and then the foliage withers and dies. Eventually, the lesions extend upward several inches from the soil and downward into the root system. The crown and uppermost roots are enveloped in a cottony weft of mycelium during rainy periods. Small, black fruiting bodies of the fungus develop on the leaves, stems, and seed capsules.

The disease has only been reported thus far on the annual larkspur, *Delphinium ajacis*.

Control.—Little is known, as yet, concerning the control of this disease. Since the fungus is seed borne, seed should only be purchased from reliable seedsmen who are not likely to supply seed from diseased plants.

Diseased plants should be removed from the planting and destroyed.

Wolf, F. A. 1931. Diaporthe blight of larkspur. Phytopath. 21: 77-81.

Mildew (*Erysiphe polygoni* D. C.)

Mildew, which appears as white or grayish patches on the leaves, commonly occurs on delphiniums late in the summer.

Control.—Mildew can be prevented by keeping the plants lightly covered with sulfur dust or by spraying with one of the sulfur fungicides (See Page 8).

FERN

(Nephrolepis exaltata)

Anthracnose (*Glomerella nephrolepis* Faris)

Anthracnose is only known to affect the Boston fern. The disease appears on soft and growing leaf tissues; the tips of the fronds are usually affected first. Infected tissue becomes brown in color and shrivels. Plants are seldom killed but are made very unsightly.

Control.—Remove the diseased fronds and give the plants plenty of space in the greenhouse. Keep the tops dry and ventilate to regulate the humidity and temperature.

Faris, James A. 1923. Anthracnose of the Boston fern. Mycologia **15**: 89-95.

FERN

(Asparagus plumosus)

Blight (*Ascochyta asparagina* Petrak.)

The small branchlets are caused to dry and are shed prematurely. Sometimes, the smaller branches are attacked at the crown and the entire branch is killed.

Control.—The disease has been controlled in the South where it is said to be serious by spraying frequently with a 1-1-50 bordeaux mixture (See Page 9).

Wolf, F. A. 1927. Blight of asparagus fern. Jour. Elisha Mitchell Sci. Soc. 43: 91-96.

GERANIUM

(Pelargonium spp.)

There are three diseases of geraniums—bacterial leaf spot, Botrytis blight, and Cercospora leaf spot—which are prevented by the same control measures, and these are given following the descriptions of the diseases.

Bacterial Leaf Spot (*Bacterium pelargoni* Brown)

The affected region shows first as a water-soaked dot which can be seen only by transmitted light. As the spots become older, they are definitely outlined, usually irregular but occasionally

circular in shape, and brown in color. The disease is found on both old and young leaves. Several spots may appear on the same leaf and finally the tissue between the original lesions yellows, turns brown, and dries. The original spots, however, show plainly in the dead area.

Botrytis Blight (*Botrytis cinerea* Auct.)

Both flowers and leaves may be attacked, but usually the blossoms are attacked first. The flowers fade and dry prematurely, and, if the humidity is high, a gray mold soon develops on the affected blooms. The leaves become infected after the diseased petals fall on them, and brown, dry, wrinkled areas soon develop. The leaves also become covered with the gray fungous growth if the humidity is high.

Cercospora Leaf Spot (*Cercospora brunkii* Ell. and Gall.)

The spots are small, light brown or pale brick-red in color, more or less circular in shape, and have a narrow, slightly raised, and darker border. Several spots may unite to affect most of the leaf.

Control of bacterial leaf spot, Botrytis blight, and Cercospora blight.—Planting geraniums in a location out-of-doors where they will get plenty of light and air, giving them plenty of space, and hand-picking diseased flowers and leaves will control these diseases. In the greenhouse, the plants should be spaced well apart, watered carefully so that the tops are not splashed, and properly ventilated to keep the humidity down.

Stock plants and cuttings may be sprayed with bordeaux mixture or colloidal sulfur (See Page 9).

Brown, Nellie A. 1923. Bacterial leafspot of geranium in the eastern United States. Jour. Agr. Res. 23: 361-372.

Garman, Philip. 1920. The relation of certain greenhouse pests to a geranium leafspot. Maryland Agr. Exp. Sta. Bull. 239.

Melchers, L. E. 1926. Botrytis blossom blight and leafspot of geranium, and its relation to the gray mold of head lettuce. Jour. Agr. Res. 32: 883-894.

Blackleg (*Pythium* spp.)

Blackleg is primarily a disease of cuttings and young plants. It is characterized by a blackening, shrivelling, and rotting, usually, of the entire stem and petioles. The rot starts at the base of the stem, and the affected cutting or plant soon wilts and dies.

Control.—The sand in the cutting bench should either be replaced with fresh sand or sterilized each season (See Page 11).

The bench must be properly cared for with regard to watering, shading, and maintaining the correct temperature.

Dropsy (*Physiological*)

Water-soaked spots develop on the leaves, which later become brown and corky. The leaves yellow first around the spots, and later the whole leaf yellows and drops off. Corky ridges develop on the petioles and stems, Figure 11. The affected plants soon become unsightly and stop growing.

Fig. 11.—Geranium dropsy. Note corky ridges on stem

Dropsy is thought to be caused by a warm and moist soil which stimulates root action, and a moist, cool air which inhibits leaf transpiration. The disease is usually more severe in late winter after a period of poor light.

Control.—Spacing the plants properly to allow for air circulation and to admit the light, ventilating to keep the air dry and the temperature even, and never overwatering will usually prevent dropsy.

Diseased plants usually recover when given good growing conditions or when set out-of-doors.

Halsted, B. D. 1893. Geranium dropsy. New Jersey Agr. Exp. Sta. 14th An. Rept., 432.

GLADIOLUS

(*Gladiolus* spp.)

Scab (*Bacterium marginatum* McCulloch)

Scab is probably more common than any of the other gladiolus diseases. Some scab can be found in almost every planting. The most characteristic symptom of this disease is the occurrence of circular, shallow, brown to black depressions on the corms, Figure 12. Several scab lesions may coalesce to form an irregular lesion. The depressions are surrounded by a distinct, raised margin which appears more or less water-soaked. The center of the lesion may appear shiny as if it were varnished. This varnished appearance is due to the drying of bacterial exudate. On the husks, scab appears as brown streaks or spots. Often the center of the husk lesions disintegrates, leaving a hole in the husk with a brown, burned-appearing margin exposing the lesion on the corm below. The brown-black lesions

may become so numerous and extensive on the lower part of the leaves, due to the activity of the bacteria in severe cases, that the leaves are rotted off at the soil. This stage is sometimes called neck rot.

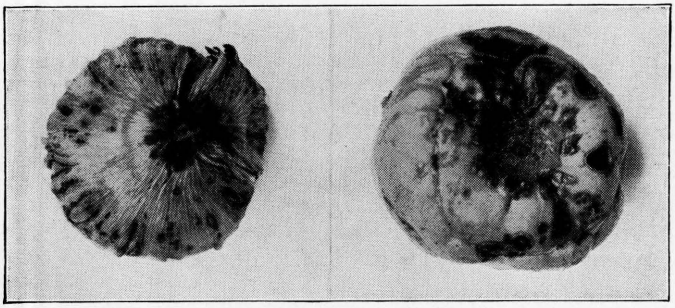

Fig. 12.—Gladiolus scab. Corm at left shows lesions on husks; corm at right shows sunken lesions

Control.—Gladiolus scab can be effectively controlled by sterilizing the corms and then planting them in soil which is free from the scab organism. Gladioli should not be planted in the same soil year after year. It is best if a rotation can be followed in which they are not planted in the same soil more than once in 4 years. The cheapest and most satisfactory treatment for large quantities of corms is to soak them for 2 hours in a corrosive sublimate solution, 1-1000 (See Page 11). Complete details on the procedure for treating corms in large lots are given in Ohio Agricultural Experiment Station Bimonthly Bulletin No. 149. Soaking the corms for 5 minutes in a suspension of Calogreen (extra fine grade of calomel), made by mixing 1 pound of Calogreen with 2½ gallons of water, practically eliminates scab. Treating in a Calogreen suspension diluted at the rate of 1 pound to 16 gallons of water usually gives good control of scab. Also Semesan, an organic mercury compound, is an effective treatment when the corms are soaked in a 1 per cent solution for 7 hours.

Many of the scab lesions are only on the husks and do not penetrate to the corm. For this reason, removing the husks in the spring just before treating the corms is advisable. The husks should not be removed in the fall because the husked corms dry out rapidly in storage.

McCulloch, Lucia. 1924. A leaf and corm disease of gladiolus caused by *Bacterium marginatum*. Jour. Agr. Res. 29: 159-177.

ROTS

There are several corm rots of gladiolus. The control measures are much the same for all of these diseases and are given following the descriptions of the various rots.

Hard Rot (*Septoria gladioli* Pass.)

The symptoms of hard rot are not clear cut as they are in the case of scab, and it is often impossible to distinguish hard rot from dry rot without making a laboratory diagnosis. This is especially true in the early stages of the disease. Somewhat circular to irregular, sunken lesions form on the corms, Figure 13. These are dark brown in color and, at first, can not be seen until the husks are removed. The rot progresses until the whole corm is mummified. Hard rot does not spread in storage but does progress in individual corms.

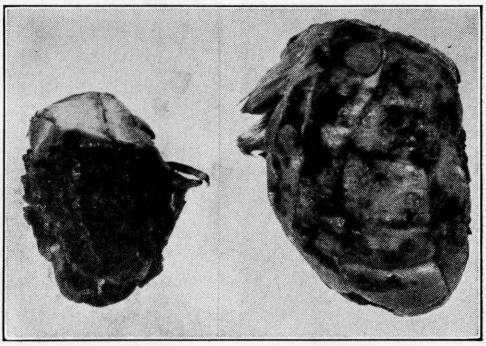

Fig. 13.—Hard rot

Hard rot also affects the leaves. The leaves of small plants grown from seed or from cormels are more often affected than leaves of larger plants grown from corms. Small, circular spots are formed on the leaves, in the center of which are numerous, minute, black bodies. These are the fruiting structures of the fungus and contain the spores.

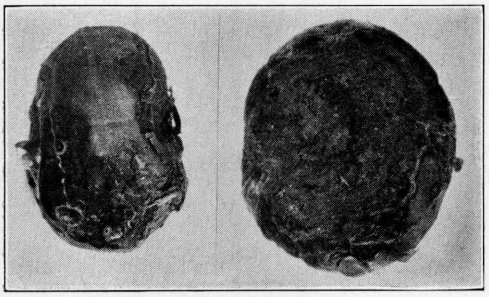

Fig. 14.—Dry rot

If corms are planted which are only partly rotted, the plants may appear normal for a while; then, perhaps, when they are half grown the leaves will begin to die at the tips and later the whole plant will die.

Dry Rot (*Sclerotium gladioli* Massey)

It has already been pointed out that it is difficult to distinguish dry rot from hard rot on the corms, especially in the early stages, without making a laboratory diagnosis. The lesions of dry rot do

not have as distinct a margin as those of hard rot, and they enlarge more rapidly, Figure 14. Finally, the whole corm is turned to a black mummy, much the same as with hard rot. Sometimes, small, pin-head sized, black bodies can be seen on the rotted corms. These are produced by the dry rot fungus and are called sclerotia; they are never present with hard rot.

When corms slightly affected with dry rot are planted, the young plants appear normal, but later the leaves die from the tip until the whole plant succumbs.

Dry rot does not spread in storage but does progress in the corms already infected.

Fusarium Rot (*Fusarium oxysporum* [Schl.] var. *gladioli* Massey)

Fusarium rot symptoms are first noticed as small, reddish-brown spots with water-soaked margins on the corms. In storage, if the temperature and humidity are high, the rot progresses rapidly and soon reduces the corm to a black mummy, Figure 15. The husks may show discolored and brittle areas where the fungus has attacked them.

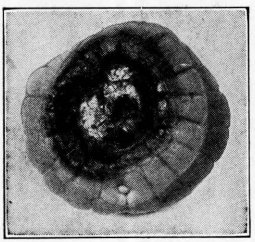

Fig. 15.—Fusarium rot

If diseased corms are planted, weak plants which die prematurely will be produced, or the corms may rot after they are planted, in which case no plants will be produced at all.

Penicillium Rot (*Penicillium gladioli* Machacek)

This rot seems to be largely a storage trouble gaining entrance through injuries to the surface of the corm. Uninjured corms are not attacked. Penicillium rot causes large, sunken areas in the corm, which are usually covered with a yellow fungous growth, Figure 16. Close examination reveals numerous, egg-shaped, tan bodies in the rotted tissue. These are the sclerotia of the fungus. In some cases, the whole corm is rotted, but usually only a part of the corm is affected.

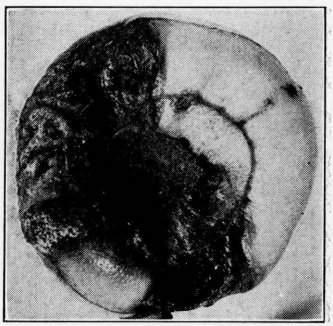

Fig. 16.—Penicillium rot. Note small sclerotia in rotted portion

Control measures for the rot diseases.—Surface sterilization of the corms is ineffective for the rots, since the organisms are inside the corms. Carefully sorting the corms and discarding all that show any evidence of rot is fairly effective. If only a small number of corms is

to be planted, they should all be husked and inspected closely for rot. Where large quantities are handled, the inspection should be as critical as is feasible.

Since the rot fungi live in the soil for a long time, rotation is essential in controlling these diseases.

Spraying small plants from seed or cormels with bordeaux mixture is advisable at about 10-day intervals, since hard rot sometimes affects the leaves of small plants (See Page 9). Potash-fish-oil soap should be added to the spray for a spreader at the rate of 1 ounce to 1 gallon of spray (See Page 10).

When the corms are dug, they should be handled carefully and not injured any more than is necessary. They should be dried rapidly and kept through the winter in a dry and cool storage. The storage temperature should not go above 45° F.

Drayton, F. L. 1926. The dry rot disease of gladioli. Scientific Agr. 6: 199-209.

Machacek, J. E. 1926-1927. A Penicillium rot of gladiolus. Quebec Soc. Protect. Plants An. Rept. 19: 77-86.

Massey, L. M. 1916. The hard rot disease of gladiolus. Cornell Univ. Agr. Exp. Sta. Bull. 380, 151-181.

————. 1926. A Fusarium rot of gladiolus corms. Phytopath. 16: 509-523.

————. 1928. Dry rot on gladiolus corms. Phytopath. 18: 519-529.

McCulloch, Lucia and Charles Thom. 1928. A rot of gladiolus corms caused by *Penicillium gladioli*. Jour. Agr. Res. 36: 217-224.

Bacterial Leaf Blight (*Bacterium gummisudans* McCulloch)

This disease is a leaf blight and does not affect the corm, except that smaller corms are formed when many of the leaves are injured or killed. Early symptoms appear as water-soaked spots on the leaves. These spots enlarge the long way of the leaf, thus forming more or less square or rectangular lesions. Several lesions may unite and involve the entire leaf. When the blighted areas become old and dry, they turn brown, and the leaves may be killed entirely. Considerable quantities of bacterial slime exude from the blighted leaves, and under moist conditions a sticky film is formed over the leaf, to which soil and dust particles adhere. The disease is usually more prevalent in young stock than in mature plants and is more severe during wet years and in low, wet spots in a field.

Control.—Spraying young stock with bordeaux mixture at about 10-day intervals should control leaf blight (See Page 9).

McCulloch, Lucia. 1924. A bacterial blight of gladioli. Jour. Agr. Res. 27: 225-230.

Mosaic *(Virus)*

The mosaic disease of gladioli was not observed until recently. Leaves of diseased plants show a distinct mottling—dark green and light green areas. They are dwarfed and produce smaller flowers. The flower petals show the effects of the disease by failing to develop normal color. The corms have a distinct rough and warty appearance.

Control.—Since this is a fairly new disease, not much is known regarding its control. In sorting the corms, however, all that show the warty condition typical of corms affected with mosaic should be discarded.

Dosdall, Louise. 1928. A mosaic disease of gladiolus. Phytopath. **18**: 215-218.

General references on gladiolus diseases

Deitz, Harry F. 1929, March. Gladiolus bulb diseases. The Gladiolus Review **6**: 95-106.

Tilford, Paul E. 1930, March. Gladiolus disease control. The Gladiolus Review **7**: 95-97.

————. 1931. Gladiolus diseases. Ohio Agr. Exp. Sta. Bimo. Bull. **149**: 67-73.

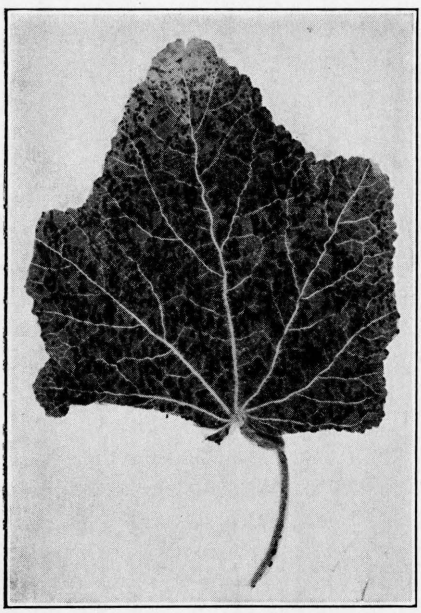

Fig. 17.—Rust on hollyhock leaf

HOLLYHOCK

(Althaea rosea)

Rust (*Puccinia malvacearum* Bert.)

Rust is without doubt the most common and serious disease of the hollyhock. It is usually found wherever the plant is grown.

Light brown pustules appear on the leaves and stems of the plants, Figure 17. The under sides of the leaves may be almost entirely covered with the rust pustules. The older, lower leaves are usually killed, and the plants are made very unsightly.

Control.—The tops of all hollyhocks and all fallen leaves should be cleaned up in the fall and burned.

Keeping the plants lightly covered with a sulfur dust or spraying with one of the sulfur fungicides during the growing season

will protect them (See Page 8). It may be necessary to make an application of the fungicide once a week during periods of frequent rainfall.

HYACINTH

(Hyacinthus orientalis)

Soft Rot (*Bacillus carotovorus* Jones)

The most common symptom of this disease is the failure of the bulb to produce flowers. Growers commonly say that such bulbs are blind. If a flower stalk does develop, the buds open irregularly, and eventually the flowers rot. The stalk commonly rots off at its base and falls over. The rot involves the top of the bulb, and, after a few days, the leaves and flower stalks, if there are any, can be lifted from the rotted bulb.

Control.—The planting of good, vigorous bulbs and growing them properly overcomes the disease. Too much water, too much heat while forcing, heating of the bulbs while in storage or shipment prior to planting, and repeated freezing and thawing, all encourage soft rot.

Coons, G. H. 1918. The soft rot of hyacinth. Mich. Acad. of Sci. Rept. 20: 353-354.

Yellow Rot (*Bacterium hyacinthi* Wakker)

The yellow rot of hyacinth occurs in this country but not as commonly as in Europe. Yellow stripes appear on the leaves; these stripes later die and leave a brown streak down the leaf. The vascular bundles in the bulbs are filled with yellow, bacterial slime. Pockets or rotted areas later develop in the bulbs, and finally the entire bulb rots.

Control.—Plant only disease-free bulbs and destroy all plants which become affected with the disease. Use either sterilized soil or soil that has not been used before in growing hyacinths (See Page 11).

Smith, Erwin F. 1901. Wakker's hyacinth germ. U. S. D. A., Div. of Veg. Phy. and Path. Bull. 26.

HYDRANGEA

(Hydrangea opuloides)

Mildew (*Erysiphe polygoni* D. C.)

The dwarf hydrangea grown in the greenhouse is very susceptible to mildew. A white, powdery growth develops on the leaves, and, if it is not checked, the plants are often badly stunted.

Control.—Spraying with one of the sulfur fungicides or dusting with sulfur dust will control mildew (See Page 8).

Foex, E. 1917. Un Oidium de l'Hortensis. Rev. Path. Veg. et Ent. Agr. 14: 217-223.

Chlorosis (Physiological)

The forcing type of hydrangea does not do well in an alkaline soil. The leaves become yellow and the plants are stunted.

Control.—This type of chlorosis is overcome by using a soil which is slightly acid. It is often necessary to use such materials as aluminum sulfate to acidify the soil before good hydrangeas can be grown.

Wiggin, W. W. and J. H. Gourley. 1931. Studies on the reaction of greenhouse soils to the growth of plants. Ohio Agr. Exp. Sta. Bull. 484.

IRIS

(*Iris* spp.)

Soft Rot (*Bacillus carotovorus* Jones)

The first visible symptom of the disease is a slight wilting of the leaves. Later, the leaves become limp and completely collapse. A soft, slimy rot which later becomes dry and granular develops in the rhizome. All of the internal structure of the rhizome is finally disintegrated except the tough, outer skin, which remains intact. Usually, the infection is rather local in plants and seems to spread slowly through the soil from one shoot to another. The soft rot organism gains entrance to the plants through wounds of various sorts, those made by the iris borer (*Macronoctua onusta*) being the most important.

Control.—Badly diseased plants should be destroyed by burning. If the disease is detected in the first stages, the plants may be taken up and the rotted portions of the rhizomes cut away. The rhizomes should then be washed in a solution of corrosive sublimate, 1-1000 (See Page 11) and set in new soil.

All rubbish should be cleaned from the iris beds in the fall, since the iris borer passes the winter in the egg stage on old leaves and rubbish.

Applications of lime and superphosphate seem to make the plants more resistant to soft rot.

Hoare, A. D. 1925. Iris diseases. Jour. Min. Agr. (Gr. Brit.) 32: 454-458.

Richardson, J. K. 1922-1923. A study of soft rot of iris. Quebec Soc. Protect. Plants An. Rept. 15: 105-120.

Leaf Spot (*Didymellina iridis* [Desm.] Hoehn.)

The first evidence of this disease is the appearance of minute, brown spots surrounded by a water-soaked margin, on either surface of the leaves. At first, the spots enlarge slowly, but, after blooming time, they enlarge more rapidly and may kill all the leaves. The centers of the older spots take on a grayish color and are dotted with the black, spore-bearing structures of the fungus. The rhizomes are gradually weakened as a result of the premature death of the leaves, and, after a few years of serious attacks, the plants may die.

Control.—The fungus passes the winter on the old iris leaves, and it has been found that cutting them off at the ground in the fall and destroying them by burning is all that is necessary to control the disease.

Tisdale, W. B. 1920. Iris leaf spot caused by *Didymellina iridis*. Phytopath. **10**: 148-163.

Crown Rot (*Sclerotium delphinii* Welch)

This disease ordinarily attacks the base of the leaves; these leaves finally rot off, fall over, and die. Usually the trouble is first noticed when the leaves begin to turn brown and die at the tips. An abundance of light-colored fungous mycelium and numerous, light brown, sclerotial bodies usually appear on the rotted leaf bases.

This same fungus attacks delphiniums and many other ornamental plants.

Control.—The disease is seldom serious in plantings until they become badly crowded. When it appears, the rhizomes should be taken up, washed in corrosive sublimate solution (1-1000), divided, and replanted in new or sterilized soil, allowing plenty of space (See Page 11).

Mians, E. B. 1929. Observations concerning diseases of iris and tulips. Proc. Ind. Acad. Sci. 38: 93-102.

LILAC

(Syringa vulgaris)

BLIGHTS

Two blights occur on lilac. The control measures are about the same for each and are given after the descriptions of the diseases.

Bacterial Blight (*Bacterium syringae* [Van Hall] E. F. S.)

The young shoots and leaves are attacked early in the spring. Brown to black spots which enlarge rapidly during rainy periods appear on the leaves and young internodes. The entire shoot may be blackened, or the blight may extend down one side, in which case the shoot soon bends because of the restricted growth on the blighted side. The young stems may become infected directly, or the bacteria may work down into the stem by way of the leaf petioles.

Phytophthora Blight (*Phytophthora cactorum* [Leb. and Cohn] Schröt.)

The symptoms of this disease are much like those of bacterial blight. The young leaves and shoots, soon after they develop in the spring, are blighted and become a dark brown color, rather than the typical blackening caused by bacterial blight. Young shoots and suckers may be killed back for long distances, many times to the point of origin. Blossoms are also attacked and caused to turn brown.

The disease is much more severe during extremely wet springs.

Control.—All blighted shoots should be pruned out as soon as they are detected. The shrubs should be kept thinned out to allow free circulation of air. Spraying the young growth with bordeaux mixture as soon as it starts to open, and again after fully opened, is said to aid in preventing infection. Colloidal sulfur has proved to be an excellent bactericide in the laboratory and should be of value in preventing bacterial blight (See Page 9).

The same fungus which causes the Phytophthora blight also attacks rhododendrons, and, for this reason, it is not advisable to plant lilacs and rhododendrons in close proximity.

Bryan, Mary K. 1928. Lilac blight in the United States. Jour. Agr. Res. 36: 225-235.

Mildew (*Microsphaera alni* [Wallr.] Wint.)

Mildew on lilacs usually does not appear until the latter part of the season. The grayish-white fungous growth develops extensively on the leaves but seems to do very little harm.

Control.—Keeping the leaves lightly covered with sulfur dust or spraying with one of the sulfur fungicides will prevent the disease (See Page 8).

LILY

(*Lilium* spp.)

There are two virus diseases which occur on lilies, and, since the control measures are the same for both, they are given following the descriptions of the diseases.

Mosaic *(Virus)*

Mosaic attacks practically all varieties of cultivated lilies. The symptoms vary somewhat depending on the variety affected. The usual mosaic symptom, a mottling of the leaves with definite light and dark green areas, is always present, but the exact type of mottling varies. On *L. longiflorum,* the Easter lily, regular or irregular light green areas, which dry out and die leaving small, linear, necrotic lesions, form on the leaves. The affected leaves are usually twisted, distorted, and curled. On *L. auratum, L. canadense, L. superbum, L. speciosum,* and others, the chlorotic areas occur as elongated streaks of varying width on the leaves. These areas may extend the entire length of the leaf, but they do not die out or cause distortion of the leaves. The affected leaves, however, are much reduced in size. The third and most common type of mottling occurs as rounded or irregular chlorotic areas scattered in a definite pattern over the leaf surface. Affected leaves are not distorted and are not much reduced in size.

Yellow Flat *(Virus)*

The Easter lily, *Lilium longiflorum,* is most commonly affected, although *L. formosum* and *L. giganteum* are susceptible.

The leaves in the top of the plants affected with this disease curl downward and are paler in color than leaves on a healthy plant. The curled leaves are flat and do not form the typical, shallow trough formed by leaves on a healthy plant. Diseased plants have a flat rosette or cylindrical appearance rather than the pyramidal shape of healthy plants.

Bulbs from diseased plants are small, flat, and compact and are inclined to split.

Control of mosaic and yellow flat.—The bulbs should be obtained from a reliable source, since both of these diseases are transmitted by the bulbs. Affected plants should be rogued from outdoor or greenhouse plantings as soon as they appear. The diseases do not spread in the greenhouse if insects are adequately controlled by frequent fumigation.

Neither mosaic nor yellow flat is transmitted by the seed.

Guterman, C. E. F. 1930, January. Summary of the work on diseases of lilies. Hort. Soc. of New York Yearbook, 51-102.

Ogilvie, L. and C. E. F. Guterman. 1929. A mosaic disease of the Easter lily. Phytopath. 19: 311-315.

Botrytis Blight (*Botrytis elliptica* [Berk.] Cooke)

Small, orange-colored spots develop on the leaves, stems, and buds. These spots enlarge, and, under damp conditions, soon become covered with a grayish mold. If the weather continues damp, the leaves and the entire stem may be destroyed, and the rot may even extend to the bulb.

The disease becomes severe only during cool and extremely humid periods.

Control.—The tops of the old plants should be thoroughly cleaned up in the fall and burned. Dusting the plants with copper-lime dust or spraying with bordeaux mixture will usually prevent infection (See Pages 9 and 10).

Bulbs of diseased plants may be taken up, dusted with sulfur after the stalks have been cut off, and then set in new soil.

Ward, Marshall. 1889. A lily disease. Ann. Bot. 2: 319-382.

Foot Rot (*Phytophthora cactorum* [Leb. and Cohn] Schröt)

This disease has been reported only on *Lilium pyrenaicum* and *L. candidum*. The plants rot off just below the ground and fall over.

Control.—Plant only good, vigorous bulbs from a reliable source in new or sterilized soil (See Page 11).

Drechsler, C. 1926. Foot rot of *Lilium candidum* and *Lilium pyrenaicum* caused by *Phytophthora cactorum*. Phytopath. 16: 51-53.

LOBELIA

(*Lobelia* spp.)

Rhizoctonia Disease (*Rhizoctonia solani* Kühn = *Corticium vagum* B. and C.)

This disease has been reported on lobelia growing in the greenhouse in pots. The lower leaves are yellowed and rotted, and necrotic lesions form at the base of the stems, and, finally, the plants wilt and die. A cob-web-like growth, which consists of the mycelium of the fungus, can be seen on the rotting leaves. Sometimes, plants form abundant aerial roots coming from just above the stem lesions. After the top has been killed, new shoots may develop from the crowns.

Control.—Planting lobelias in sterilized soil will prevent the trouble (See Page 11). Giving the plants plenty of space and ventilating properly are important.

Teng, S. C. 1929. Rhizoctonosis of Lobelia. Phytopath. **19**: 585-588.

MONKSHOOD

(*Aconitum* spp.)

Wilt (*Verticillium albo-atrum* Reinke and Berth.)

The stems of diseased plants rot at and below the ground line, and the rot may extend into the roots. Brown to black streaks occur in the vascular region of the stem and extend into the fleshy roots, or "planters".

The diseased plants wilt and finally die.

Control.—Remove diseased plants, with the soil around them, and destroy by burning. Start the plants either from seed or from healthy roots in new or sterilized soil (See Page 11).

NARCISSUS, DAFFODIL, JONQUIL

(*Narcissus* spp.)

Root Rot (*Fusarium* sp.)

Root rot causes dwarfing of the plants, and the blossoms do not develop normally. The roots and the basal plate of the bulb rots, and, finally, the entire bulb may be rotted.

Control.—Good control has been obtained by soaking the bulbs in a disinfecting solution and then planting in soil which has not grown narcissi before or in sterilized soil (See Page 11). Treating the bulbs in a solution of corrosive sublimate, 1-1000 (1 ounce to 7½ gallons of water), for one hour is fairly effective (See Page 11). Treating for 6 hours in a 0.25 per cent solution of liquid Semesan is also effective.

When the bulbs are treated for nematodes, a fungicide should be added to the hot water since soaking in the water alone spreads the basal rot spores from diseased to healthy bulbs.

Wedgworth, H. H. 1928. Experiments on the control of a narcissus root-rot. Miss. Agr. Exp. Sta. Circ. 79.

Weiss, Freeman. 1929. The relation of the hot-water treatment of narcissus bulbs to basal rot. Phytopath. **19**: 100.

Nematode Disease (*Tylenchus dipsaci* [Kühn] Bast.)

Bulbs infested with nematodes are characterized by an internal brown ring which can be seen when the bulbs are cut across. Mites may cause a similar symptom, but the two can be

readily distinguished by examining the diseased tissue with a magnifying glass. The young leaves soon become infected and are yellowed, twisted, more or less prostrate on the ground, and covered with thickened specks.

Control.—An effective control measure consists of treating the bulbs with hot water held at a temperature of 110° F. for 2½ to 3 hours. Immediately after treatment, the bulbs should be immersed in cold water. One should not attempt to treat bulbs with hot water without special equipment to maintain a constant temperature and without very accurate thermometers.

A disinfectant should be added to the water to prevent the spread of the root rot spores. See root rot control, Page 51.

Soil in which nematode-infested narcissi have been growing should be sterilized with steam before being used again (See Page 12).

NASTURTIUM

(*Tropaeolum* spp.)

Wilt (*Bacterium solanacearum* E. F. S.)

The leaves of diseased plants wilt, turn yellow, and die. The stems appear translucent or water-soaked, the vascular bundles are darkened, and the roots are usually blackened and decayed.

Control.—The diseased plants should be destroyed and nasturtiums should not be planted in the same soil again until it is sterilized (See Page 11).

Bryan, Mary K. 1915. A nasturtium wilt caused by *Bacterium solanacearum*. Jour. Agr. Res. 4: 451-458.

PALMS

Anthracnose (*Colletotrichum kentiae* Hals.)

This disease causes water-soaked spots, which later dry and become brown, on the leaves. Within these dead areas, salmon-colored bodies develop which are the fruiting structures of the fungus. In time, the diseased areas fall out, leaving holes in which remain the hard, woody vessels of the leaf.

Control.—Collect all infected leaves and burn them. Do not splash the tops in watering, since the spores may be spread in this way. If necessary, spray with ammoniacal copper carbonate (See Page 10).

Halstead, B. D. 1893. Palm diseases. N. J. Agr. Exp. Sta. 14th An. Rept., 407-414.

PANSY, VIOLET

(*Viola* spp.)

Wilt (*Fusarium violae* Wolf)

Apparently healthy plants suddenly wilt and die in a few days, and, when the diseased plants are pulled up, a dark, slightly sunken area on the stem just at the surface of the ground is found. The smaller roots are destroyed and only the stubs of the larger roots remain.

Root Rot (*Thielavia basicola* [Berk. and Br.] Zopf.)

Plants affected with this disease are dwarfed, the leaves are yellow, and the roots are decayed with a brown to black rot.

Control of wilt and root rot.—The diseased plants should be destroyed, and the soil should be sterilized before other plants are set (See Page 11).

There is some evidence which indicates that undecomposed manure in the soil encourages wilt.

Wolf, F. A. 1910. A Fusarium disease of the pansy. Mycologia 2: 19-22.

Anthracnose (*Colletotrichum violae-tricoloris* Smith)

Brown, dead areas, which at first are surrounded by a distinct black margin, appear on the leaves. Lesions may also appear on the petals, especially along the margin, and cause the flowers to be deformed. Occasionally, plants are killed outright.

LEAF SPOTS

In addition to pansy anthracnose, violets are subject to leaf spots caused by *Alternaria violae* Gall. and Dorsett and by *Cercospora violae* Sacc. Mildew and rust may also attack violets.

Control of anthracnose and leaf spots.—When these diseases become severe in large plantings, it is necessary to spray with bordeaux mixture (See Page 9). In small plantings, gather the spotted leaves and destroy them by burning. Clean up all old leaves in the fall and burn them.

Smith, R. E. 1899. A new Colletotrichum disease of the pansy. Bot. Gaz. 27: 203-204.

PEONY

(*Paeonia* spp.)

BLIGHTS

There are two common blights of the peony, and, since the control measures are the same for both, they are given following the discussions of the diseases.

Botrytis Blight (*Botrytis paeoniae* Oud.)

This is undoubtedly the most common and destructive disease of the peony and is found wherever the plant is grown.

Stems, buds, and leaves are all affected. The young stalks become infected early in the spring and suddenly wilt and fall over when they are only 4 to 8 inches tall. Soon after the young buds form, they may turn black and dry up. This stage of the disease is commonly called bud blast. Larger buds, which are infected later, turn brown and fail to open; the stalk for several inches below the bud is usually killed. Sometimes, the open flowers will develop a rot. The leaves are usually attacked later than the other parts of the plants. Large, irregular spots appear on them, the tissue is killed and becomes brown and dry. The crowns of the plants may even become infected with the Botrytis rot.

In wet weather the diseased parts soon become covered with a felty, brown coat of fungous spores.

Phytophthora Blight (*Phytophthora paeoniae* Cooper and Porter)

This disease affects the stems, leaves, and buds. Infection may start on the young stems which soon become dark brown or black and collapse. Black, blighted areas with concentric markings appear on the leaves. In wet weather, the disease spreads very rapidly and the rot may extend to the crowns of the plants.

Control of Botrytis blight and Phytophthora blight.—The diseased parts should be removed and destroyed as soon as they are detected to prevent the formation of spores. All peony tops should be cut off near the crowns in the fall and burned.

In the spring, when the young shoots come through the ground, they should be sprayed with bordeaux (See Page 9). It is well to soak the soil around the plants with the spray, and, about a week later, a second application should be made. It is not desirable to spray later in the season because of staining the foliage and because bordeaux will not prevent bud infection. The exudate from the buds seems to counteract the effect of the bordeaux.

Peony varieties seem to vary in their susceptibility to the Botrytis blight, and, if control measures are not practiced, it is advisable to plant the more resistant sorts.

Cooper, D. C. and C. L. Porter. 1928. Phytophthora blight of the peony. Phytopath. 18: 881-899.

Winters, R. 1930. Varietal susceptibility of the peony to *Botrytis paeoniae*. Phytopath. 20: 523-525.

Root Knot or Nematodes (*Caconema radicicola* [Greef.] Cobb)

Plants affected with nematodes produce weak, spindly shoots which remain short and yield no blossoms. When the roots are examined, numerous knots or galls are found on the smaller roots and the larger roots are stubby, irregular, and swollen, Figure 18.

Control.—The safest practice for the small gardener is to destroy affected roots and plant nematode-free stock in new soil.

Fig. 18.—Nematode galls on peony root

The problem is more difficult, however, for the commercial peony grower who has a large stock which is affected. Experimental work to date indicates that a hot water treatment when the roots are dormant will kill most of the nematodes and not injure the roots. Presoaking the roots for 15 to 20 minutes in water at 100° F. and then treating them for 30 minutes at a temperature of 120° F. seems to be the most effective treatment. The hot water treatment should not be attempted until the grower has obtained special apparatus to keep the water at the exact temperature required and has accurate thermometers.

The treated roots, of course, must be planted in nematode-free soil.

Nelson, Ray. 1931. Method to control root-knot of peony. Mich. Agr. Exp. Sta. Quart. Bull. 14: 10-16.

Le Moines Disease

The symptoms of this disease are practically the same as those caused by nematodes, except that nematodes are not found in the root galls. This point, of course, can only be determined by a laboratory examination. The cause of Le Moines disease is not known.

Control.—Destroy all affected roots, so that they will not be used for dividing.

Stem Rot (*Sclerotinia sclerotiorum* [Lib.] Massee)

Young or even nearly mature stalks rot off at the base near the ground and suddenly wilt. Black sclerotia, resting bodies of the fungus, are later formed in the pith of the diseased stems.

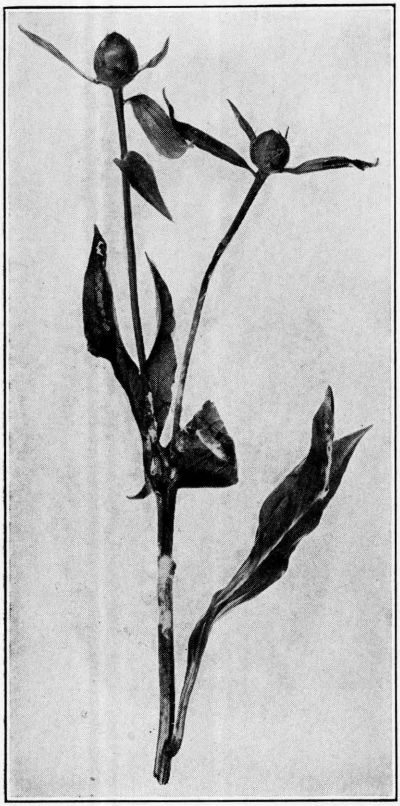

Fig. 19.—Sclerotinia stem rot of peony

Control.—Promptly remove the wilted stalks and destroy them. Keep manure away from the crowns of the plants and follow out the control measures suggested for Botrytis and Phytophthora blights.

Leaf Blotch (*Cladosporium paeoniae* Pass.)

This disease causes large, purple spots to develop on the upper surfaces of the leaves. The spots on the under side are a dull brown color and, in rainy weather, become covered with an olive green mass of spores.

The disease is very common and widespread but not very serious. It usually does not appear until fairly late in the season.

Control.—Removing the tops in the fall is sufficient to keep the disease in check, since the fungus lives over winter on the old leaves.

Wilt (*Verticillium albo-atrum* Reinke and Berth.)

Diseased plants wilt and die slowly with no external indications of the cause of the trouble. When the stems of wilted plants are split, a discoloration can be seen in the sap tubes which may extend down into the roots.

Control.—Remove and destroy diseased plants and replace the soil with fresh soil before setting disease-free plants. Never use diseased plants for dividing.

Mosaic

The so-called mosaic disease of peony causes the development of concentric bands of alternating dark and light green on the leaves. These spots may be either large or small. Affected plants are not dwarfed and apparently are uninjured.

Control.—No control for the disease is known except to destroy the plants, and this is not advisable since the plants are uninjured.

Crown Elongation Disease

No cause is known for this peculiar condition sometimes occurring in peonies. The crowns are decidedly elongated, more numerous than usual, may be branched, and produce weak, spindly shoots which never flower. Affected plants are said to resemble witches' brooms, Figure 20.

Control.—The only known control is to remove and discard all the affected plants.

Fig. 20.—Crown elongation disease of peony. Apparently normal shoot in the center

Whetzel, H. H. 1928. The crown elongation disease of the peony. Phytopath. 18: 243-244.

General Reference on Peony Diseases

Whetzel, H. H. 1915. Diseases of the peony. Trans. Mass. Hort. Soc. 103-112.

PETUNIA

(*Petunia hybrida*)

Mosaic (*Virus*)

The leaves of plants affected with mosaic are typically mottled with yellowish-green and dark green areas and are usually crinkled

and deformed, Figure 21. The blossoms usually show mottling and are also deformed. Diseased plants are stunted.

Control.—Destroy all plants which develop mosaic symptoms. The plants must be kept free from aphids, since they commonly transmit the mosaic virus. All weeds in the region of petunia beds should be destroyed, because some weeds are affected with mosaic and may serve as a source of infection.

Allard, H. A. 1916. The mosaic disease of tomatoes and petunias. Phytopath. **6**: 328-335.

Fig. 21.—Petunia affected with mosaic

PHLOX

(*Phlox* spp.)

Leaf Spot (*Septoria divaricata* Ell. and Ev.)

Brown spots develop on the leaves and may cause them to wither and die. The lower leaves are usually more seriously affected.

Control.—Removing the tops and raking up and burning all fallen leaves in the fall usually keep the disease under control. Spraying with bordeaux mixture or ammoniacal copper carbonate or dusting with copper-lime dust will help control the disease where sanitation alone does not affect control (See Page 8).

Mildew (*Erysiphe cichoracearum* D. C.)

A powdery mildew commonly occurs on phlox as a grayish-white growth on the leaves.

Control.—Remove the tops and rake up and burn the fallen leaves in the fall. Divide crowded clumps and give the plants plenty of space. If necessary, keep the plants lightly covered with sulfur dust or one of the sulfur sprays (See Page 8).

Nematodes (*Caconema radicicola* [Greef] Cobb; *Tylenchus dipsaci* [Kühn] Bast.)

Plants affected with the root knot nematode, *Caconema radicicola,* are stunted and have the typical galls or knots on the roots (See Pages 6 and 16).

The nematode *Tylenchus dipsaci* attacks the tops of the plants, causing swollen and cracked areas in the stem and distortion of the leaves.

Control.—All affected plants should be removed from the garden and burned. The soil surrounding the diseased plants should either be removed or sterilized (See Page 16).

POPPY

(*Papaver* spp.)

Bacterial Blight (*Bacterium papavericola* Bryan & McW.)

Intensely black lesions are formed on the leaves, stems, flower parts, and seed pods of the Shirley and Oriental poppies. Young lesions appear as small water-soaked areas but soon darken into definite spots with a water-soaked margin which disappears with age. Many spots may coalesce and involve most of the leaf, or, if the spots are isolated, finally the areas between the lesions become yellow and the leaf falls. Lesions on the stem may become so numerous that the plant is girdled and finally killed.

Control.—The only known control is to destroy infected beds of poppies and either sterilize the soil or use a different location for growing the plants (See Page 11).

Bryan, Mary K. and Frank P. McWhorter. 1930. Bacterial blight of poppy caused by *Bacterium papavericola* sp. nov. Jour. Agr. Res. **40**: 1-9.

PRIVET

(*Ligustrum* spp.)

Anthracnose (*Glomerella cingulata* [Ston.] Spauld. and Schrenk)

This is a very common disease of the European privet. Cankers may be found on the twigs and cause a blighted condition. More often, however, one or more cankers form near the base of

the plant and finally girdle it, thus causing the death of the entire plant. The diseased bark is brown and often shows the fruiting bodies of the fungus.

Control.—The European privet, *Ligustrum vulgare,* and the privet known as "Lodense" are both very susceptible and should not be used for planting.

Amur privet, *Ligustrum amurense,* Ibota privet, *L. ibota,* Regal privet, *L. ibota regelianum,* and California privet, *L. ovalifolium,* are all resistant and should be used for planting. The California privet winter-kills badly in northern climates, but all the others are hardy.

Spraying with bordeaux or dusting with copper-lime dust are of questionable value as control measures. Sometimes such treatments appear beneficial but not always.

Mix, A. J. 1925. Anthracnose of European privet. Phytopath. 15: 261-272.
————. 1929. Further studies of privet Anthracnose. Phytopath. 19: 102.

RHODODENDRON

(*Rhododendron* spp.)

Leaf Spots (Physiological, and various fungi)

Winter injury is very common on rhododendron. The green leaves which remain on the plants through the winter give off a small amount of water all winter long. If the ground is frozen hard for a great depth, the roots cannot absorb enough water to replace that transpired by the leaves, and, under these conditions, the leaves dry out and die. The injury starts with a drying and browning at the tips and along the margins. Entire leaves may die and roll downward.

Control.—Rhododendrons should never be planted in a southern exposure where they will warm up during sunshiny days in the winter. They should be heavily mulched in the fall so that the soil does not freeze to a great depth. Soil that is loose and well drained, so that the roots will go down deep, is essential. A very acid, cool soil that is loose, well drained, and contains an abundance of humus is necessary for good vigorous plants that will be resistant to winter injury. A light mulch of peat moss during the summer is beneficial in keeping the soil cool and moist.

Sunscald is common on rhododendron leaves. When the sun shines brightly following a rain, the drops of water lying on the leaves condense the sun's rays to such an extent that the underlying leaf tissue is burned, Figure 22. Rhododendrons grow naturally in locations where they are partly shaded by trees. They should be planted around the home only in places where they are protected to some extent.

Pestalotia macrotricha Kleb. is found more often associated with leaf spots of rhododendrons than any other fungus. It is a weak parasite and enters the leaf only through wounds, such as winter injury, sunscald, and insect or mechanical injuries. Once it has gained entrance to the leaf, it enlarges the original injured area. The spots are silvery white with a brown zonate margin, and numerous, small, black dots (the fruiting structures of the fungus) appear in the silvery white region.

Several other fungi are commonly found on rhododendron leaves. Most of them, however, are saprophytes or very weak parasites which do not affect the leaves except through some point of injury.

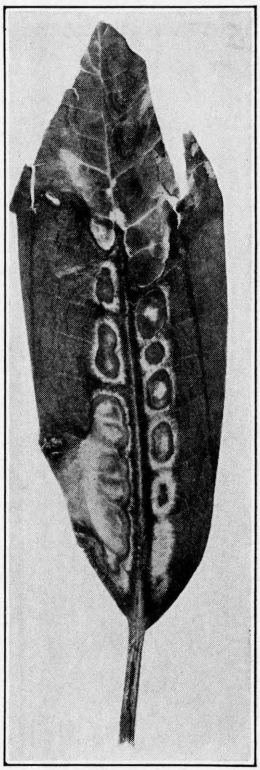

Fig. 22.—Sunscald on rhododendron leaf

Schmitz, Henry. 1920. Observations on some common and important diseases of the Rhododendron. Phytopath. **10**: 273-278.

White, R. P. 1930. Pathogenicity of *Pestalotia* spp. on Rhododendron. Phytopath. **20**: 85-91.

Phytophthora Die-back (*Phytophthora cactorum* [Leb. and Cohn] Schröt.)

Infection from the die-back fungus on rhododendrons occurs through terminal buds, through lateral bud scales, or through injuries. A shrivelled canker, chocolate brown in color, is formed on the twigs as the infection advances in the bark. The petioles and leaves are also attacked, and the leaves turn brown, roll downward along the midrib, and droop. If the cankers on the twigs extend all the way around, the above parts wilt and soon die.

Control.—All diseased tips should be pruned out, well back of the canker, as soon as they appear. The same fungus which causes this disease also attacks lilacs, and, for this reason, it is not advisable to plant lilacs and rhododendrons near each other.

White, R. P. 1930. Two Phytophthora diseases of rhododendron. Phytopath. **20**: 131.

————. 1931. Diseases of ornamentals. N. J. Agr. Exp. Sta. Circ. 226, 64.

Bud Rot (*Sporocybe azaleae* [P. K.] Sacc.)

The buds rot or "blast", become a dark brown color, and fail to open. The external bracts become more or less silvery and are covered with the fine, black, bristly fruiting structures of the fungus. The fungus may also work down the stem killing the cambium.

Control.—Picking and burning the infected buds and destroying the seed pods after blooming is completed are the only effective control measures.

Schmitz, Henry. 1920. Observations on some common and important diseases of the rhododendron. Phytopath. **10**: 273-278.

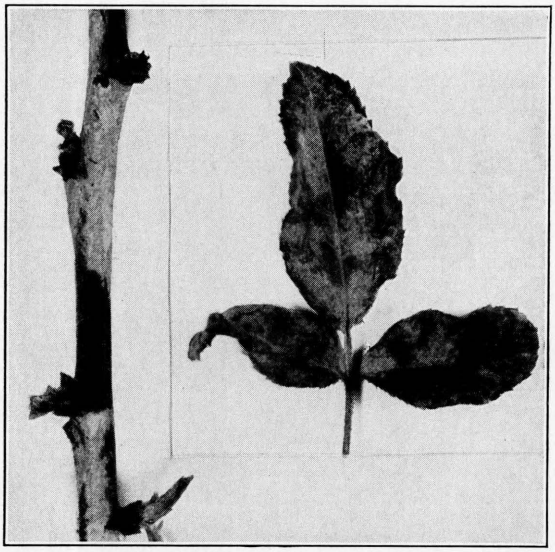

Fig. 23.—Mildew on rose cane and leaf

ROSE

(*Rosa* spp.)

Rose mildew, black spot, and the leaf spots may all be prevented by the same practices which are given following the descriptions of the diseases.

Mildew (*Sphaerotheca pannosa* [Wallr.] Lev.)

Mildew is one of the most common diseases of roses, both in the rose garden and in the greenhouse. Almost all varieties are susceptible, but certain of the hybrid teas and the climbers are affected more severely than others. Crimson rambler and Dorothy Perkins are among those most susceptible to mildew.

The most noticeable symptom of mildew is the white, powdery coating which develops on the leaves and young buds, Figure 23. Young growth is usually affected first. In severe cases, the leaves are dwarfed and distorted and the buds do not open properly.

Out-of-doors, mildew may appear in late spring or early summer, but it usually is most serious in late summer. In the greenhouse, it is usually worse in late summer and early fall before the fires are started and again in the spring.

Black Spot (*Diplocarpon rosae* Wolf)

Black spot is almost as common as mildew, occurring on both outside and greenhouse roses. Varieties vary greatly in their susceptibility to black spot, some being almost immune while others are extremely susceptible.

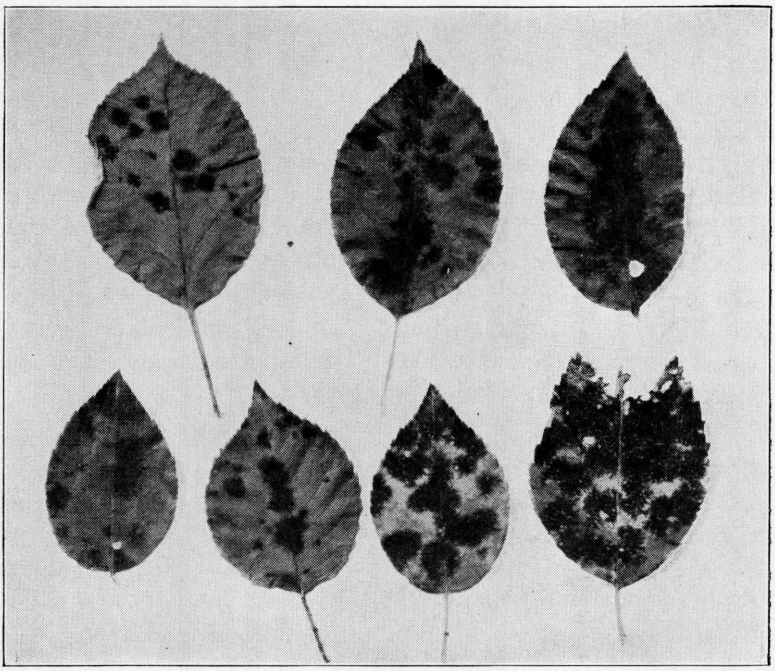

Fig. 24.—Black spot of roses

Circular, black spots with irregular borders appear on the upper leaf surfaces, Figure 24. These spots enlarge and several may appear on the same leaflet, finally uniting and involving most of the surface. The areas between the spots soon turn yellow and the leaf falls. Plants may be completely defoliated; and when this occurs the buds, which ordinarily would not grow until the following year, push out leaves. This late growth often does not mature properly in the fall and the plants winter injure badly. The following year the plants are weakened so that they do not flower well.

Leaf Spots (*Cercospora rosicola* Pass.; *Phyllosticta rosae* Desm.)

Leaf spots are common and, in some cases, cause injury due to defoliation. Ordinarily, however, they are not serious. The spots usually appear as yellowish-green dots, which enlarge, become brown, and often have a purple border.

Control of mildew, black spot, and leaf spots.—All fallen leaves should be raked up in the fall and burned, since the organisms which cause these diseases live over winter on the old diseased leaves. A sulfur fungicide should be applied at weekly intervals during the summer, beginning as soon as growth starts in the spring (See Page 8). Sulfur dusts have been found to be effective and are usually more convenient to apply than sprays. During periods of frequent rains, the dust should be applied twice a week.

Ventilating properly, starting the fires early in the fall, and keeping them going late in the spring are important in preventing mildew and black spot in the greenhouse. Painting the heating pipes with sulfur and lime is also advisable (See Page 9). If mildew or black spot appears, the plants should be dusted with a sulfur dust or sprayed with a sulfur spray (See Page 8).

Good cultural practices which insure unchecked, vigorous growth of the plants are important, since these diseases are usually more serious in houses where roses are not properly grown.

Massey, L. M. 1918. Experiments for the control of black spot and powdery mildew of roses. Phytopath. 8: 20-23.

———— and Bruce Parsons. 1931. Rose disease investigations. Second Progress Rept. Am. Rose Annual, 65-80.

Parsons, Bruce and L. M. Massey. 1932. Rose disease investigations. Third Progress Rept. Am. Rose Annual, 47-58.

Wolf, F. A. 1912. The perfect stage of *Actinonema rosae*. Bot. Gaz. 54: 218-234.

Rust (*Phragmidium* spp.)

Rust of roses occurs only on out-of-door plants and is not nearly as prevalent as black spot or mildew; however, it is very destructive when it occurs. Orange-brown spore masses appear on the under sides of the leaves and later in the season become black, due to the formation of winter spores. The young, green canes may be infected and badly distorted.

Control.—All fallen leaves should be raked and burned in the fall of the year, since the disease lives over winter on the old infected leaves. Also, infected canes should be pruned out and destroyed. A dormant spray of lime-sulfur or bordeaux mixture, followed by weekly applications of sulfur dust during the growing season, will control the disease (See Pages 8 and 9).

Mosaic (*Virus*)

In the greenhouse, infected plants are dwarfed and flower poorly. The leaflets show distinct chlorotic areas, especially along the midrib, and may be distorted. The symptoms vary, of course, with different varieties of roses and under different conditions. Out-of-door roses may be affected but are not injured seriously.

Control.—Plants which show mosaic should be taken from the benches and destroyed. Sometimes the disease can be detected on the young plants while they are still in the pots. Such plants should not be set.

White, R. P. 1932. Chloroses of the rose. Phytopath. 22: 53-69.

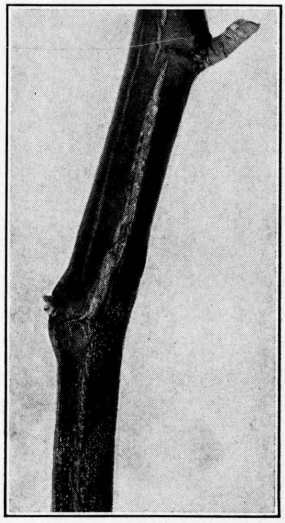

Fig. 25.—Brown canker on rose cane. Note pimple-like fruiting bodies of the fungus.

CANKER DISEASES

There are four fairly common canker diseases of the rose. They have been given names which are descriptive of their location on the plant or their appearance. Brown canker and Brand canker are both controlled by the same practices and these are given following the descriptions of the two diseases.

Brown Canker (*Diaporthe umbrina* Jenk.)

This disease attacks practically all types of roses and is very destructive.

Cankers, which are raw-umber in color, occur on any part of the canes. The cankered surface is covered with the protruding, pimple-like fruiting bodies of the fungus, Figure 25. The stems may be completely girdled, in which case the distal portion of the stem dies.

When infection occurs on the young stems during the growing season, small, reddish, circular spots appear which later become white. These enlarge rapidly the following spring to form the cankers described above.

Small, brown to purple spots appear on the foliage, and the blossoms may also be involved. The outer petals become brown and bear the fruiting bodies of the fungus. When the blossoms are infected in the bud stage, they do not open further. The stems back of diseased blossoms may become infected and gradually die back.

Brand Canker (*Coniothyrium wernsdorffiae* Laubert)

Brand canker is not widely distributed and its attack is usually confined to the rambler type of rose. Brown cankers with reddish-brown or purple margins occur on the canes, starting usually where a prickle has broken off. The diseased bark cracks longitudinally, and the whole canker is slightly sunken below the adjoining healthy tissue. When the cane is girdled, it wilts and soon dies. The fruiting bodies of the fungus are visible as small, black dots in the center of the cankers.

Control of brown canker and brand canker.—Heavy spring pruning is necessary to control these diseases. All canes which bear cankers should be pruned well back of the affected areas. If cankers appear at any time during the growing season, they should be pruned out and burned.

The plants should be given a dormant spray of lime-sulfur solution in the spring before growth starts (See Page 8). Either sulfur dust or a sulfur spray should be applied during the summer, as recommended for the control of black spot and mildew (See Page 64).

Jenkins, Anna E. 1918. Brown canker of roses, caused by *Diaporthe umbrina*. Jour. Agr. Res. 15: 593-599.

Laubert, R. 1905. Eine neue Rosenkrankheit, Verursacht durch den Pilz *Coniothyrium wernsdorffiae*. Arb. K. Biol. Anst. Land. u. Forstw. 4: 458-460.

Waterman, Alma M. 1930. Diseases of the rose caused by species of Coniothyrium in the United States. Jour. Agr. Res. 40: 805-827.

Stem Canker and Graft Canker (*Coniothyrium fuckelii* Sacc.)

Small, pale yellow or reddish spots which gradually enlarge and become brown appear on the bark. Several of these lesions may grow together and girdle the stem, thus causing the death of the distal portion. The wood in the cankered areas becomes dried, and usually the bark is cracked. Small, black fruiting bodies of the fungus can usually be seen on the affected bark.

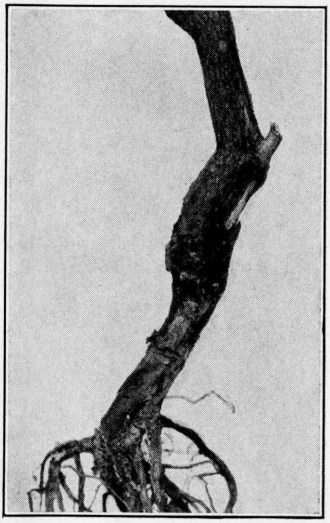

Fig. 26.—Graft canker of rose

Infection may occur through any injury, such as cut surfaces left in pruning or removing flowers, or even through the wound caused by the breaking off of a prickle.

Newly made grafts are often attacked at the point of union of the stock and scion. A dark brown lesion occurs at the base of the scion and soon involves the whole scion, causing its death, Figure 26. *Rosa manetti* under-stock is immune, but *Rosa odorata* is susceptible, and when it is used the lesion starting at the union may extend to the stock as well as the scion.

Vogel, Irvin H. 1919. A rose graft disease. Phytopath. 9: 403-412.

Waterman, Alma M. 1930. Diseases of the rose caused by species of Coniothyrium in the United States. Jour. Agr. Res. 40: 805-827.

Crown Canker (*Cylindrocladium scoparium* Morg.)

This disease attacks only greenhouse roses. Cankers, at first blue-black or purplish and smooth but later reddish-brown, hard, and cracked longitudinally, form in the bark, usually at the crown. The union of stock and scion and the area immediately above are common points of attack. The canker may extend up the stem several inches and may completely girdle the stem or only one side may be affected. Diseased tissue is dry and "punky".

Infected plants are not ordinarily killed outright but linger on continuing to become poorer and poorer. Infection may occur in stubs left from cutting flowers or in any wound on the canes.

Control.—Diseased plants should be removed, since they are never profitable and they act as a source of infection to the healthy

plants. If the disease has occurred previously in a greenhouse, the soil should either be changed or sterilized before replanting (See Page 11). If the soil is changed, the benches should be washed out with a disinfectant (2 per cent formaldehyde solution) before new soil is put in. If the disease has occurred in the house before, all potting soil and pots used for roses should be sterilized. Special care should be taken not to spread the disease on tools from one house to another.

Anderson, P. J. 1918. Rose canker and its control. Mass. Agr. Exp. Sta. Bull. 183.

Massey, L. M. 1917. The crown canker disease of the rose. Phytopath. 7: 408-417.

————. 1921. Experimental data on losses due to crown-canker of roses. Phytopath. 11: 125-134.

Crown Gall (*Bacterium tumefaciens* E. F. S. and Townsend)

The galls which are characteristic of this disease usually form at the crowns of the plants, although they may occur on the aerial parts of the stems or on the roots. Plants growing out-of-doors seldom have aerial galls. In greenhouses, however, the aerial galls are fairly common. These galls occur at points where the canes have been injured, Figure 27.

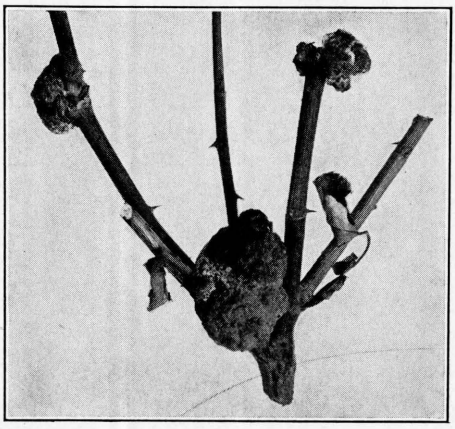

Fig. 27.—Crown gall on rose

Plants badly infected with crown gall are dwarfed and do not flower well.

Control.—Remove and destroy all diseased plants. The surrounding soil should be sterilized before another plant is set in (See Page 11). In the greenhouse, the disease does not usually cause much loss.

Waterman, Alma M. 1928. Rose diseases. Their causes and control. U. S. D. A. Farmers' Bull. 1547.

SNAPDRAGON

(Antirrhinum majus)

There are three common diseases of snapdragon—rust, blight, and anthracnose. The control measures necessary for rust will prevent the other two, and, for this reason, the control measures are given together for the three diseases following the descriptions.

Rust (*Puccinia antirrhini* Diet. and Holw.)

The reddish-brown rust pustules appear most abundantly on the lower surfaces of the leaves, although the upper leaf surfaces, stems, petioles, and seed pods are susceptible, Figure 28. Under favorable conditions the pustules increase rapidly in number, and the plants are severely injured or killed outright.

Fig. 28.—Snapdragon rust

Blight (*Phyllosticta antirrhini* Sydow.)

Blight attacks both leaves and stems and sometimes causes damping-off of the seedlings. The leaf spots at first are small, circular, dark colored areas which later enlarge and become a cream to pale brown color, Figure 29. A zonate or target-board type of marking is usually evident in the old spots; and numerous, dark, pimple-like structures, which are the fruiting bodies of the

fungus, can be seen in the centers of the spots. Dark, sunken cankers or spots appear on the stems, which later become light colored in the centers and bear the fruiting structures. On young seedlings the stem lesions may completely girdle the plant and cause rapid wilting and death.

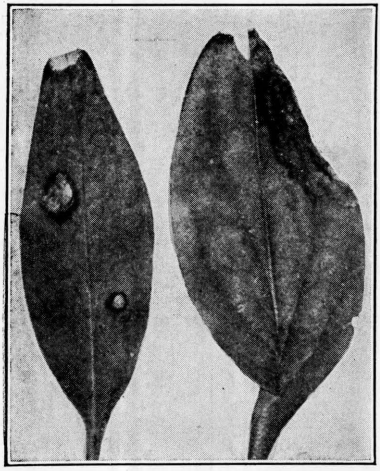

Fig. 29.—Blight on snapdragon leaves

Anthracnose (*Colletotrichum antirrhini* Stew.)

Anthracnose is most serious in the greenhouse during the fall and again in the spring; whereas, out-of-doors, it is most likely to occur during August and September. Leaves and stems of plants of all ages are attacked. On the older stems the spots are sunken, elliptical in shape, and at first are dirty white in color with a narrow brown border. Later, minute, black pimples (stroma) appear in the spots. Several spots may coalesce or a single spot may enlarge and girdle a stem or branch, causing the distal portion to die. The leaf spots are circular, slightly sunken, at first a yellowish-green, later changing to a dirty white in color.

Control of rust, blight, and anthracnose.—The rust fungus is not transmitted by the seed, and, for this reason, plants should always be started from seed rather than from cuttings. The young seedlings should be grown in a part of the greenhouse where there are no older snapdragons affected with rust.

If the plants are set in beds out-of-doors, they should be spaced far enough apart so that air can circulate freely between them. If the beds are watered, it should always be done in the morning rather than in the evening. It is better to surface water than to sprinkle, since wetting the tops makes conditions favorable for infection. Sulfur dust or one of the sulfur sprays applied at weekly intervals until the plants start blooming will prevent infection (See Page 8).

In the greenhouse these diseases are prevented by setting disease-free plants, by surface watering, and by ventilating to avoid excessive humidity. If rust appears, sulfur dust or a sulfur spray should be applied thoroughly. The treatment is more

effective if the night temperature is raised to about 72° F. for three successive nights. If a new crop of rust spores develops, the treatment should be repeated.

The damping-off of seedlings caused by blight can be prevented by planting the seed in soil freshly treated with formaldehyde dust (See Page 14).

Butler, O. 1923. Experiments on the field control of snapdragon rust together with a description of a method for the control of the disease in greenhouses. N. H. Col. Agr. Exp. Sta. Bull. 22.

Doran, Wm. L. 1921. Rust of Antirrhinum. Mass. Agr. Exp. Sta. Bull. 202.

Guba, E. F. and P. J. Anderson. 1919. Phyllosticta leafspot and damping-off of snapdragon. Phytopath. **9**: 315-325.

Peltier, Geo. L. 1919. Snapdragon rust. Univ. of Ill. Agr. Exp. Sta. Bull. 221.

Smiley, Edwina M. 1920. The Phyllosticta blight of snapdragon. Phytopath. **10**: 232-248.

Stewart, F. C. 1900. An Anthracnose and stem rot of the cultivated snapdragon. N. Y. (Geneva) Agr. Exp. Sta. Bull. 179.

SNOWBERRY

(Symphoricarpus racemosus)

Anthracnose (*Glomerella cingulata* [Ston.] Spauld. and Schrenk)

The most conspicuous symptom is the reddish to black discoloration of the fruits. Infected berries shrivel with a dry rot and finally fall to the ground. Twigs become infected and are killed for considerable distances back of the diseased fruits. The leaves are also attacked, discolored, and caused to drop.

During wet, humid periods flesh-colored spore masses appear on the diseased berries and twigs.

Alternariose (*Alternaria solani* [Ellis and Mart.] Jones and Grout)

The infected berries become yellow to brown in color and decay with a soft, watery rot. The bark of young twigs may also be killed for some distance back of the diseased fruits.

Control of anthracnose and alternariose.—During the dormant season all diseased canes should be pruned out and burned. A dormant spray of lime-sulfur should be applied in the spring before growth starts (See Page 8). In the late summer, after the berries are formed, the shrubs should be dusted thoroughly with copper-lime dust at about 10-day intervals until freezing weather arrives (See Page 10). Thorough sanitary measures,

such as cleaning up all fallen fruits and leaves in the fall and burning are important since the fungus may live over winter on these diseased, fallen parts.

Barrus, M. F. and J. G. Horsfall. 1928. Preliminary note on snowberry anthracnose. Phytopath. 18: 797-801.

Davis, W. H. 1931. Anthracnose, Alternariose, and Botrytis rot of the snowberry. Mycologia 23: 159-190.

SWEET ALYSSUM

(Alyssum odoratum)

Rhizoctonia Disease (*Rhizoctonia solani* Kühn = *Corticium vagum* B. and C.)

The lower leaves of affected plants become water-soaked, rot, and shrivel up. Lesions appear on the stems, and usually that part above the lesion wilts and dies, Figure 30. During wet periods or early in the morning a cob-webby mycelium can be seen on the infected plants. The disease usually gets started and progresses during wet periods.

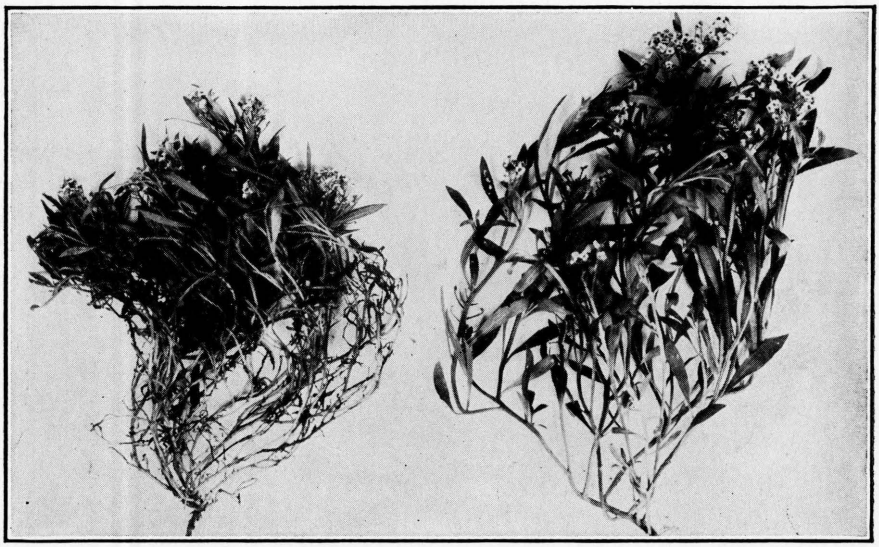

Fig. 30.—Rhizoctonia disease of sweet alyssum. Diseased plant on the left. Healthy plant on the right

Control.—Spraying the plants thoroughly with bordeaux will check the disease. New growth comes on rapidly, and soon the bordeaux stain will not be noticeable.

Tilford, Paul E. 1930. A Rhizoctonia disease of sweet alyssum. Phytopath. 20: 587-590.

SWEET PEA

(Lathyrus odoratus)

Sweet pea anthracnose, root rots, and streak are all three prevented by the same control measures which are given following the descriptions of the diseases.

Anthracnose (*Glomerella cingulata* [Ston.] Spauld. and Schrenk)

Stem, leaves, flowers, and seed pods are affected by anthracnose, which is the most troublesome disease of sweet peas grown out-of-doors. White areas appear on the leaves; these may involve the entire leaf and cause it to wither and fall. The stems are usually attacked near the tips, and the young shoots wilt and dry up. Infected seed pods lose their green color, shrivel, and may show salmon-colored areas due to spore formation.

The disease is likely to be serious on sweet peas growing near apple trees infected with bitter rot, since the same fungus is the cause of both diseases. The fungus over-winters in cankered limbs and mummied fruits of the apple, on sweet pea refuse, and on seed from infected seed pods.

Root Rots (*Thielavia basicola* [B. and Br.] Zopf.; *Rhizoctonia solani* Kühn; *Fusarium lathyri* Taub.)

Plants affected with Thielavia root rot are dwarfed, yellow, and can be easily lifted from the soil because of the decayed root system. Severely diseased plants have only stubs of roots left, and these are blackened due to the invasion of the fungus Thielavia. The plants seldom die quickly but linger on and produce no blossoms. It is a serious disease of greenhouse-grown peas.

Young seedlings may be completely destroyed by the Rhizoctonia root rot. It is a frequent cause of damping-off and seed rotting. Older plants which are infected are dwarfed, yellow, and finally wilt because of the decayed roots. The diseased roots are brown and never black, as in Thielavia root rot. The infection may extend up the stem causing a brown, sunken canker at or above the soil line.

Fusarium root rot generally kills the young seedlings when they are 8 to 10 inches high. The stem below and for a short distance above the ground and the roots are attacked. Infected seedlings soon collapse and fall over.

Streak (*Bacillus lathyri* Manns and Taub.)

Reddish-brown to dark-brown spots and streaks, originating near the base and extending up the stem, appear on mature plants as they near the blooming stage. The disease spreads from the

stems to the leaf petioles, flowers, and seed pods. Small, roundish spots develop on the leaves and the leaves gradually die, until finally the entire plants are killed prematurely. Streak affects both indoor- and outdoor-grown sweet peas. The bacteria which cause the disease are seed borne.

Control of anthracnose, root rots, and streak.—The organisms which cause anthracnose and streak are transmitted by the seed; whereas the root rot organisms are in the soil. Seed treatment and soil sterilization are necessary to effect control. This can be most conveniently done out-of-doors, by planting the peas in soil freshly treated with formaldehyde dust (See Page 13 and Figure 31). The dust should be worked in a strip of soil 6 inches deep and 12 inches wide, at the rate of 3 ounces per foot of row. The seed should be planted immediately after the soil is treated.

Fig. 31.—Two rows on the left were planted in soil treated with formaldehyde dust. Soil on the right was left untreated. Rhizoctonia rotted the seed and caused damping-off of the plants in the untreated soil.

The most effective treatment in the greenhouse is to treat the seed in a 5 per cent formaldehyde solution (5 parts of commercial 40 per cent formaldehyde in 95 parts of water) for 5 minutes and plant them in steam sterilized soil (See Page 12). If equipment for steaming is not available, the formaldehyde dust treatment is also of value in the greenhouse.

Manns, T. F. 1913. A bactrial disease of sweet peas and clover. Gardener's Chronicle 53: 215-216.

Taubenhaus, J. J. 1914. The diseases of the sweet pea. Del. Col. Agr. Exp. Sta. Bull. 106.

Mildew (*Microsphaera alni* [Wallr.] Wint.)

Serious mildew infection usually occurs on greenhouse-grown sweet peas in the spring when it is difficult to control the temperature and humidity. Outdoor-grown peas are seldom seriously affected. A white, powdery growth develops on the upper leaf surfaces and causes malformation of the leaves. If the disease is severe, the leaves may fall.

Control.—Proper temperature control and ventilation are essential in controlling mildew in the greenhouse. Painting the heating pipes with sulfur is usually effective (See Page 9). After the heat is turned off in the spring, this is of no value; then spraying with one of the sulfur fungicides or dusting with sulfur dust must be resorted to (See Page 8).

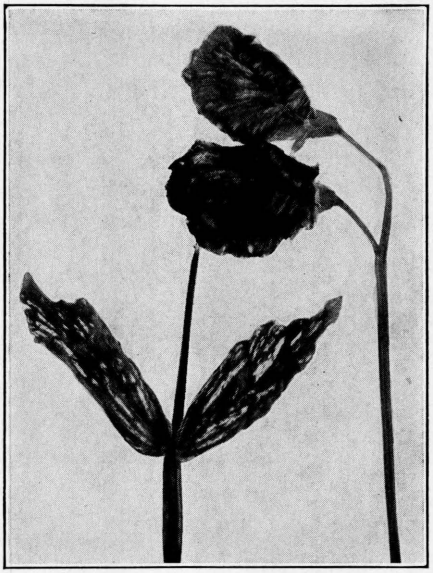

Fig. 32.—Mosaic of sweet peas showing on leaves and flowers

Mosaic *(Virus)*

The leaves of plants affected with mosaic exhibit a distinct yellowish mottling and are curled, Figure 32. Diseased plants are usually dwarfed, the flower stalks are short, and the color of the blooms is broken.

Fig. 33.—Fasciation at the base of sweet pea stem

Mosaic affects both indoor- and outdoor-grown sweet peas. It is spread from diseased to healthy plants by aphids.

Control.—In the greenhouse thorough and frequent fumigation should be practiced to control aphids. Outdoors it is necessary to spray with a contact insecticide, such as nicotine sulfate. Infected plants should be removed from the planting as soon as they are detected.

Fasciation

Fasciation at the base of greenhouse-grown sweet peas is common. A bunch of short, fleshy, thick stems with aborted and misshapen leaves develops on the stem near the soil line, Figure 33. The abnormality usually appears

when the plants are young and continues to enlarge as the plants grow. Apparently, the condition causes no injury, and affected plants continue to grow and blossom about as well as normal ones.

There is some evidence that fasciation may be caused by the crown gall organism (*Bacterium tumefaciens* E. F. S. and Townsend); however, unfavorable growing conditions seem to be the cause in most cases.

Control.—If the crown gall organism is known to be the cause, the soil should be sterilized or changed (See Page 11). Giving the peas good cultural care should help to prevent fasciation.

Brown, Nellie A. 1927. Sweet pea fasciation, a form of crown gall. Phytopath. 17: 29-30.

Muncie, J. H. and M. K. Patel. 1930. Fasciation of sweet peas. Am. Jour. Bot. 17: 218-230.

TULIP

(*Tulipa* spp.)

Botrytis Blight or Fire (*Botrytis tulipae* [Lib.] Hopk.)

Fire is the most common disease of tulips grown in the greenhouse or outside. Small, black bodies of pin-head size, called sclerotia (resting bodies of the fungus), appear on the outer brown husks of affected bulbs, Figure 34. Yellow to brown rot lesions, which sometimes can not be detected until the outer husks are removed, also develop on the bulbs.

Minute, yellowish spots surrounded by a water-soaked area appear on the leaves and flower stalks. A gray fungous growth can be seen in the center of these areas during very humid periods. The lesions enlarge and may involve the entire leaf or, if on the flower stalk, cause it to collapse and fall over. Infection often begins at the edge of the leaf, in which case the leaf becomes curled. After the whole leaf is blighted, a gray fungous growth develops over it, and spores are formed in great abundance.

White to light brown spots develop on the blossoms; this is a very striking symptom on red varieties, Figure 34. The whole flower may finally be blighted and die. Buds are often attacked so severely that they never open.

Control.—The bulbs should be sorted carefully before planting and the outer husks removed. All bulbs with sclerotia or rot lesions should be discarded. Careful handling of the bulbs is important, since infection occurs more easily on injured bulbs than on sound ones. Soil which is known to be free of the organism or sterilized soil should be used (See Page 11). The tulip plants should be watched carefully after they come up, and any which show symptoms should be removed and destroyed immediately.

This is equally important in the greenhouse and out-of-doors, since spores soon form on the diseased plants and spread the infection to other plants.

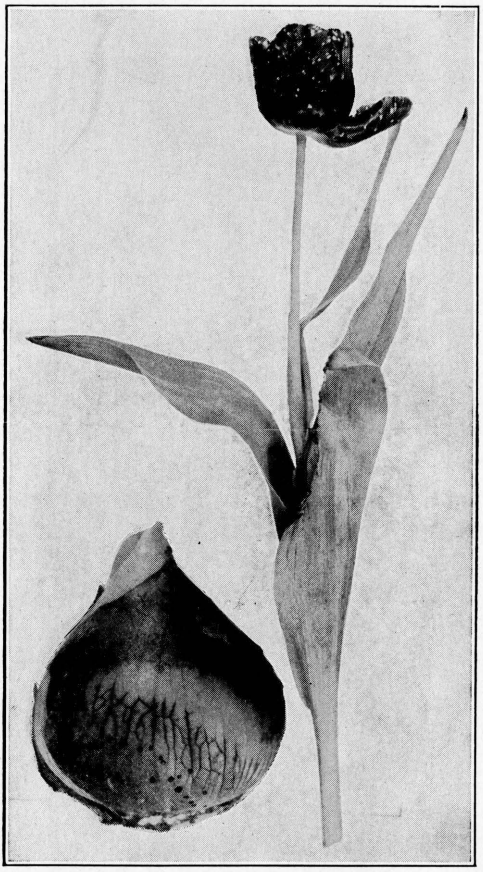

Fig. 34.—Fire disease of tulip. Note spots on blossom and blighted leaves. Tulip bulb showing sclerotia of the Botrytis fungus which causes the fire disease.

In beds out-of-doors all plant debris should be cleaned up and destroyed as soon as blooming is finished. If the bulbs are not to be taken up, the entire tops should be cut below the ground, removed, and burned as soon as the plants become yellow and mature. It is best, if possible, to take up the bulbs each summer and store until fall.

Hopkins, Edwin F. 1921. The Botrytis blight of tulips. Cornell Univ. Agr. Exp. Sta. Memoir 45.

Gray Bulb Rot (*Rhizoctonia tuliparum* [Kleb.] Whetzel and Arthur)

This disease is never serious except in large outdoor plantings. Bare places in the beds where the tulips fail to come up are the most striking symptom. The bulbs are rotted and are covered with an abundance of gray fungous growth.

Control.—The causal fungus lives over from one year to the next either on the bulbs or in the soil. It is controlled by planting only healthy, sound bulbs in soil free of the pathogen. The soil in affected areas should be sterilized before tulips are planted again (See Page 11).

Whetzel, H. H. and John M. Arthur. 1925. The gray bulb rot of tulips caused by *Rhizoctonia tuliparum*. Cornell Univ. Exp. Sta. Memoir 89.

Breaking (*Virus*)

Tulips which have a variegated flower color are said to be "broken". In normal tulips the flower color is uniform over the perianth, except at the base; whereas, in "broken" strains the original color is restricted to lines or stripes, somewhat irregularly distributed on a white or yellow background. Mottling of the leaves and stems, reduced size and vigor, and a reduction in the production of off-sets are also symptoms.

"Breaking" has been proven recently to be caused by a virus, transmitted by aphids.

Control.—Diseased plants should be removed and destroyed as soon as they appear in the planting. "Broken" strains should never be propagated, since the plants are usually grown at a loss and the disease is likely to spread to the normal strains at any time.

Greenhouses in which tulips are grown should be kept free from aphids by frequent fumigation, since they transmit the disease.

Cayley, Dorothy M. 1928. Breaking in tulips. The Annals of Applied Biology 15: 529-539.

Hughes, A. W. McKenny. 1931. Aphids as vectors of "Breaking" in tulips. The Annals of Applied Biology 18: 16-28.

Blossom Blight (*Phytophthora cactorum* [Leb. and Cohn] Schröt.)

This blight attacks the flower stalks immediately below the flower, causing it to droop. Double varieties planted in wet, shaded locations are most seriously affected.

Control.—Do not plant tulips in wet or shaded locations.

ZINNIA

(Zinnia elegans)

Mildew (*Erysiphe cichoracearum* D. C.)

Powdery mildew occurs on zinnias as a white flour-like growth on the leaves. It usually does not appear until fairly late in the summer and is more likely to occur in locations where the plants are partly shaded.

Control.—Dusting the plants with sulfur dust or spraying with one of the sulfur sprays will prevent mildew (See Page 8).

INDEX