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FUNGOUS DISEASES OF COLORADO CROP PLANTS

By

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FUNGOUS DISEASES OF COLORADO CROP PLANTS

By WILFRED W. ROBBINS and OTTO A. REINKING

INTRODUCTION.

Colorado crops, of orchard, garden and field, are not troubled with as many fungous diseases as are those of the states to the east and west which have a moister climate. Colorado's comparative freedom from fungous troubles causes frequent comment from those who are familiar with conditions as they exist in the east. Such destructive diseases as bitter rot of apple, brown rot of stone fruits, peach leaf curl and late blight of potato do no injury to crops in Colorado.

The direction of migration of economic plant diseases follows rather closely the direction of migration of man himself. Man is the chief agent in the spread of disease from one locality to another far distant. Prior to 1888, one finds little recorded mention of plant diseases within Colorado's borders. And we have reason to believe that up to that year and even up to several years later, fungous diseases of cultivated plants in Colorado were largely unknown or not serious enough to attract much attention. Today many diseases have permanently invaded the state. This has been due to more intensive cultivation in the state, to an introduction of a greater variety of host crops, and (until a few years ago) to a lack of proper inspection laws.

Crandall writes in 1891: "In all localities east of the mountains there is yet entire freedom from fungous diseases, with the exception of the occasional appearance of plum pockets on native wild varieties. The bacterial disease, variously known as 'pear blight,' 'apple tree blight,' 'twig blight,' is prevalent, and in some sections has done great damage. In the western districts diseases and insect troubles are at present unknown, but it can hardly be hoped that the immunity now enjoyed will continue. Growers in that district should prepare themselves to profit by the experience gained elsewhere and meet the first attacks with determined efforts at extermination." This was in 1891. Some years later, in 1898, Crandall (Crandall, C. S., 11th Annual Report Colo. Exp. Sta. for 1898) reports as follows: "Colorado orchards have in past years been free from fungous diseases, but the diseases which have given the eastern growers trouble are gradually coming in and

there is a rapidly growing interest in them among the fruit growers."

The first disease to attract attention in Colorado was the twig blight of pear and apple. In 1888, Cassidy (Cassidy, James, "Apple Twig Blight," 1st Annual Report Colo. Agr. Exp. Station, pp. 64-70, 1888) reported this disease near Fort Collins, as appearing in the latter part of June and continuing until late in August. He considered this trouble on the apple to be identical with fire blight of pear and a similar trouble on Lombardy and other species of cottonwood. Blight of pear and apple has become increasingly serious throughout Colorado. In 1891, Crandall (Crandall, Chas., "A Preliminary Report on the Fruit Interests of the State." Bull. No. 17, Colo. Agri. Exp. Sta., 1891) comments that the "bacterial disease variously known as 'pear blight,' 'apple tree blight' and 'twig blight' is prevalent and in some sections has done great damage." In 1898, (Crandall, C. S., "Blight and Other Plant Diseases," Bull. 41, Colo. Exp. Station, 1898) Crandall indicates that the disease had brought numerous inquiries to him. We judge from this that it had become more widespread. Paddock (Paddock, W., 22nd Annual Report State Board of Agriculture, 1900) reports a body blight of apple and pear known in some localities as "crater blight." This is now considered to be due to the organism causing fire blight. In 1903, Paddock (Paddock, W., Bull. 84, Colo. Exp. Sta., 1903) showed that apricot blight was the same as pear blight. It seems well established now that the bacterial organism, *Bacillus amylovorus,* may cause a blight on pear, apple, quince, apricot and plum, known by such common names as pear blight, fire blight, twig blight, apple blight, blossom blight and body blight. From the foregoing brief historical sketch of pear blight in Colorado, we see that since its appearance in 1888, it has become more widely spread in the state and its attacks have increased in severity.

The history of potato diseases in Colorado is as instructive as that of pear blight. The first mention of potato troubles in Colorado is found in a publication by Paddock and Rolfs, (Paddock, W., and Rolfs, F. M., "Potato Failures," Bull. 64, Press Bull. No. 8, Colo. Exp. Sta., 1901) in 1901, in which they call attention to potato failures in various sections, due probably to *Rhizoctonia.* They indicate that this disease has "undoubtedly been present in our potato fields for a long time." They say that little blight (*Fusarium*) is in evidence. In 1902, Rolfs (Rolfs, F. M., "Potato Failures," Bull. 70, Colo. Exp. Sta., 1902) published a preliminary report on *Rhizoctonia,* describing the occurrence and effects of the disease on the potato, the nature of the fungus, and giving the results of inoculation and preventive experiments. This is our first valuable

account of *Rhizoctonia* in Colorado. In 1904 (Rolfs, F. M., "Potato Failures," Bull. 91, Colo. Exp. Sta., 1904) Rolfs published further notes on *Rhizoctonia*, in which he gives additional information relative to the life history of the fungus, its injuries, spread, and remedial measures.

The first mention of potato blight (*Fusarium*) is found in a press bulletin by Paddock in 1906 (Paddock, W., "Potato Problems," Press Bulletin No. 26, 1906). Within the last few years, and particularly during 1911 and 1912, *Fusarium* has seriously crippled the potato industry in many parts of the state. It is doubtful, however, if the organism, *Fusarium oxysporum*, is responsible for all the potato troubles in districts suffering.

Other potato diseases such as early blight, internal brown spot, and potato scab have not developed in severity as have *Fusarium* and *Rhizoctonia*. Both of the latter diseases have made remarkably rapid progress in the state. This is largely due to the general practice of growing potatoes continuously year after year on the same soil. Colorado potato failures, although lamentable, have been a blessing in disguise. They have brought forcibly to our attention the necessity of a proper system of crop rotation and the more general adoption of diversified farming. Crop rotation is a highly reliable practice in the control of a great majority of diseases of field and garden crops.

It is well that we keep on the watch for the first appearance of fungous diseases in the state. In many instances, the immediate suppression of a disease that has just been introduced may mean the saving of thousands of dollars to an entire community. Fungous diseases fluctuate in prevalence from year to year, largely depending upon climatic and weather conditions. If a disease is very bad one year, the chances are that there will be an abundance of infection material near at hand the following season. However, it sometimes happens that a serious outbreak is followed by a year of comparative freedom from disease. On the other hand, a serious outbreak may follow a year during which little disease was present.

The Department of Botany of the Experiment Station will be ready at all times to identify promptly plant diseases that are sent in, and suggest remedies.

DISCUSSION OF CHIEF FUNGOUS DISEASES

ALFALFA.

BACTERIAL BLIGHT.—Diseased plants are stunted and lighter green in color than normal. Stems chiefly infected. Infected portions at first are water-soaked in appearance, and olive green in

color. Small drops of a sticky amber liquid, which soon dries with a glistening finish, later turning brown and then black, may collect over diseased portion. In advanced stages, the stems shrivel, become brittle, turn black, and die. Diseased leaves show a water-soaked appearance and an orange yellow coloration along the leaf-stalk and midrib. Later, they dry up and become brittle. On one-year-old plants, the whole crown may become infected, turn black, and die. The disease is caused by a bacterium which attacks the first crop only and then lives over until next season in the soil and on old stems. In years when late frosts are prevalent, the disease is most severe.

Control—As soon as danger from late frosts is past, clip the frosted alfalfa. By so doing, the stems split by freezing and hence subject to attack by the causal bacterial organism will be removed and new sprouts given a chance to grow.

Plate I. Alfalfa leaf spot.

DOWNY MILDEW.—This disease has become increasingly abundant in Colorado, since it was first noticed in 1906. However, it has not become serious, except in a few localities. The leaves at tips of branches are usually attacked, turning yellow-green or yellow-gray to purple. A fuzzy growth develops on the under side of the leaf, which is grayish at first, and later violet.

Control.—Do not irrigate excessively. Do not crowd plants, as it makes them more liable to attack.

LEAF SPOT.—The disease first attacks lower leaves. Diseased spots are local, brown to black or yellow, circular, and with irregular edges (Plate I). Affected leaves usually turn yellow and drop prematurely. The trouble occurs in both old and new fields, and under very different soil conditions.

Control.—Since alfalfa leaf spot is widespread and easily disseminated, control-measures are not entirely satisfactory. If disease is serious, mowing of infested field when leaves begin to turn yellow will hold the disease in check.

APPLE.

FIRE BLIGHT.—See Pear, page 34.

APPLE ROT—BLACK MOLD.—The fruit is attacked usually at the blossom end. Spots are formed which at first are small, dark purple-brown, and slightly sunken (Plate II). Affected tissue is

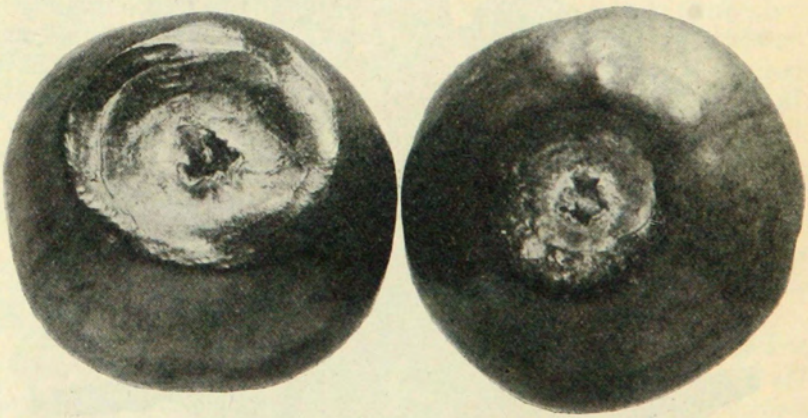

Plate II. Apple rot or black mold.

not greatly softened. In severe cases the apple becomes a shriveled, dark-brown mass. When the apple is placed in storage, the spot increases in size, and sometimes involves the entire fruit. The disease often gains entrance to the fruit by means of wounds. Frequently, no external evidence of the trouble is noticeable, but when

the apple is cut through, the core cavity and seeds are found to be blackened, and in severe cases the surrounding flesh may be discolored.

Control.—(1) Sanitation. Diseased fruit should be either collected from the ground in the fall, or plowed under. Trees should be kept in good health.

(2) Spray with Bordeaux 4-5-50, or lime-sulfur, just before the buds open in the spring.

(3) Avoid injuring fruit before placing in storage.

CROWN GALL.—Galls may appear on root, stem, or leaf. In orchard fruits, they are most common at the crown, forming there large warty swellings (Plate III). There are two types of galls,

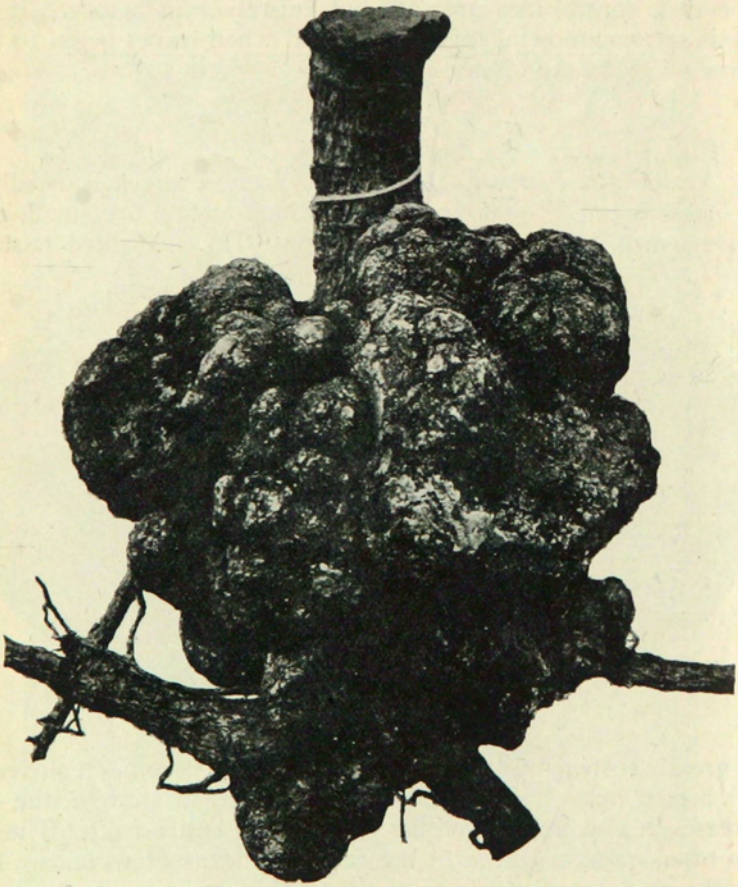

Plate III. Crown gall on a six-year-old plum tree. The warty growth is hard and woody.

soft and hard. Soft galls usually decay at the end of the season; the harder types may persist for years. Hairy root, a form of crown gall, is characterized by excessive production of fibrous roots.

Control.—(1) Plant only disease-free stock. Burn all infested nursery trees.

(2) Avoid unnecessary injury to plants.

BITTER PIT.—A non-parasitic disease, also known as "Baldwin-spot" and "brown-spot." Spots on the surface are more abundant near the blossom end. They are small, sunken, and various shades of brown. Affected areas may be scattered throughout the apple tissue nearly to the core. The disease may appear before maturity, but develops more often in storage.

Control.—(1) Spotting of susceptible varieties cannot be entirely prevented.

(2) Fruit should be stored in dry air at a low temperature.

JONATHAN SPOT.—The spots, which are distributed over the apple surface, are usually only skin deep, irregularly circular, brown to almost black, and usually somewhat sunken. The disease is not confined entirely to the Jonathan, but develops on other varieties. It is produced only on matured fruit and is most severe in storage and after taken out of storage.

Control.—Cold storage greatly retards development.

POWDERY MILDEW.—This occurs on leaves and twigs. On the leaf, light powdery patches are produced. These are more common on the under surface, but sometimes on both. The patches are small at first, but later increase in size until the entire leaf is covered. In severe cases, affected leaves are crinkled, dwarfed, and drop off. Twigs are stunted or even killed in the worst cases. Powdery mildew does the most injury to nursery stock.

Control.—(1) Cut out and burn infected twigs if the disease is severe.

(2) Spray with Bordeaux mixture or lime-sulfur, immediately after petals fall and later at intervals of two to four weeks, depending upon severity of disease.

RUST.—One stage of this disease is found upon the cedar and another upon the apple. The leaf, fruit, and young twigs of the apple may be affected. The spots on the leaves and fruit are at first about the size of a pin-head, and pale-yellow in color. Later, long cylindrical-shaped organs project from the surface (Plate IV). Fruit may be dwarfed or deformed as a result of the infection.

On the cedar, the diseased condition is known as a "cedar apple." The cedar apple is an enlargement of the leaves and twigs of the ordinary red cedar. These enlargements may be one-half to two inches in diameter. In the winter the gall-like structure is hard

Plate IV. Pear affected with rust. The appearance of the disease on the apple fruit is similar. Note the long cylindrical-shaped bodies projecting from the surface.

and woody, but in the spring may become swollen and gelatinous. Numerous finger-like gelatinous outgrowths are formed following a rain. Spores from the cedar apple infect the apple, causing the well-known rust upon it.

Control.—(1) Where practicable, remove all cedars in the vicinity of orchard.

(2) Some varieties of apples are comparatively rust resistant, for example: Winesap, Grimes Golden, Yellow Transparent, Ben Davis, Red Astrachan, Duchess, and Maiden Blush. The following are most susceptible: Wealthy, Jonathan, Missouri Pippin, Whitney, and Red June.

APRICOT.

BLACK KNOT.—See Plum, page 37.

CROWN GALL.—See Apple, page 12.

ASPARAGUS.

RUST.—Asparagus rust attacks the tall, branching plants that come up after the cutting season. The plant is hindered in its food-making process, and consequently the underground stems do not receive the normal amount of stored material. As a result, they lack the strength to send up a good crop of "spears" the following spring. The rust appears as small lengthened spots on stems and leaves. The spots look like blisters at first, then they break open

and appear powdery. The spots that make their appearance in July and August are rusty in color, while those that come in September and October are black.

Control.—(1) Dry sulfur:

a. Use a finely pulverized sulfur, preferably "*flowers* of sulfur," rather than "*flour* of sulfur." ("Flowers of sulfur" is a fine grade that has been sublimed. It sometimes goes by the name of "atomic sulfur." "Flour of sulfur" is a cheaper grade of ground roll sulfur.)

b. Make first application to plants at rate of 150 lbs. per acre, about three weeks after the last cutting of sprouts. Follow with another application at rate of 100 lbs. per acre in about one month.

c. Apply sulfur only in early morning when plants are covered with dew. The sulfur must stick to the plant.

d. On small patches of asparagus, the sulfur may be sprinkled on with ordinary large pepper box. On large patches use some form of bellows-blower.

(2) Spores are carried over winter on diseased stalks and on ground surface. Late in fall, cut and burn the diseased stalks in the field where they have fallen. Further, in order to insure the killing of spores on the ground, put a light covering of straw on the asparagus bed, and burn.

(3) Select disease-resistant varieties. Palmetto is very resistant to asparagus rust.

(4) Plants that have a good supply of water and are well cultivated, and as a result, are making a strong, vigorous growth, are less liable to attacks of rust than plants poorly cared for and deprived of water.

(5) Asparagus escapes from cultivation and frequently becomes common along fences. Unless such stray plants are destroyed, they may be a source of rust infection.

BEAN.

BACTERIAL BLIGHT.—This occurs upon the pod, leaf, and stem of common and Lima beans. The leaves are usually the first to be attacked. At first there appear large, watery patches that are brown in color. Later these patches dry up, becoming papery and brittle. Hence the leaves curl and become ragged in appearance. Pods are most severely attacked. On these, the spots are small at first, but spread rapidly into large, watery areas with indefinite pink or reddish-brown borders. In time, the pods rot. Infected areas on the stem are similar to those on the leaf. The disease is carried over on infected seed. It is spread in the field by insects.

Control.—(1) Select seed from healthy pods only, grown in fields that are not infected.

(2) New lands should be used when available, and crop rotation should be practiced.

(3) In severe cases spray with Bordeaux mixture, 4-5-50 formula.

a. First spray, when plants are 2 to 3 inches high.

b. Second spray, ten days later.

c. Third spray, after blossoming.

(4) Any measure that will check ravages of insects is advised.

ANTHRACNOSE.—The disease is found on all parts of the bean plant above ground. One is usually attracted by the spots on the pods (Plate V, Fig. 1). These are, at first, small and dark-col-

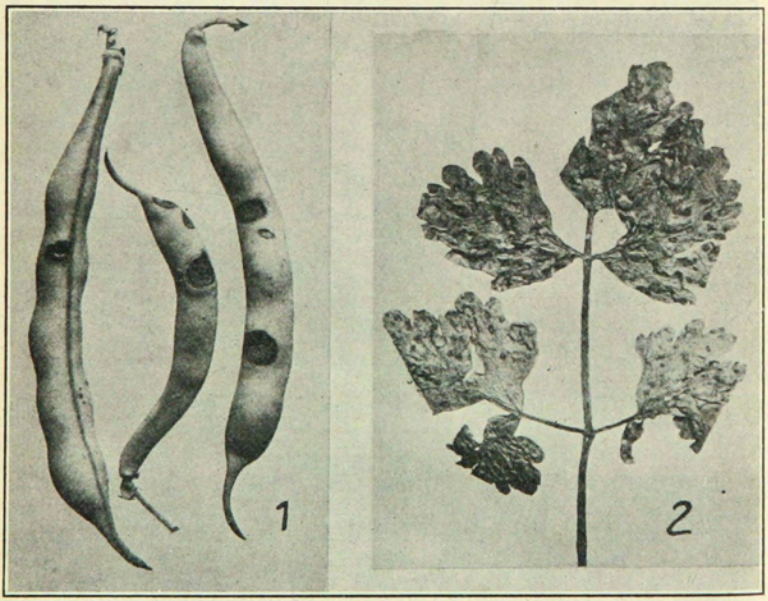

Plate V. Fig. 1. Anthracnose of bean. Fig. 2. Late blight of celery.

ored. They increase rapidly in size up to a quarter-inch or more. Spots may run together and cover the greater part of the pod. They are round or oval, sunken, nearly black, or at times pinkish, and usually surrounded by a reddish zone. On the leaves the spots are found mostly on veins and stem. The spots of the seed are located directly under pod spots.

Control.—(1) Use seed from healthy pods only, preferably those grown on fields known to be free of the disease.

(2) Burn infected material.

(3) Rotation of crops is important.

(4) Spray with 4-5-50 Bordeaux first, as soon as the plants are up, then about ten to fourteen days later, and again when the pods are forming.

BEET.

ROOT ROT (*Rhizoctonia*).—The outer leaves are first attacked at the base, turn black and droop. The disease spreads into the crown of the beet, which turns brown, cracks, and in time may rot away. The trouble spreads rapidly from plant to plant. Young plants are also frequently attacked by the root rot fungus.

Control.—(1) Keep soil well aired by good cultivation.

(2) Rotate crops.

SOFT ROT.—This is a bacterial disease. The lower end of the root decays, the rotted portion being honeycombed. The cavities of this portion are filled with a rather sticky, colorless, sour-smelling liquid. The upper part of the root, the crown, and leaves, are not affected, and hence the plant maintains a normal color and form above ground. Young plants are not attacked seriously.

Control.—(1) It is useless to spray.

(2) A wet, poorly drained soil favors the development of disease. Improve soil conditions.

LEAF SPOT.—This disease attacks the outer, older leaves first. The youngest leaves in the center rarely show the spots, and the beet plant is seldom killed. At first the spots are tiny white points scattered over the leaf surface. They gradually increase in size, become round, show a distinct line between diseased and healthy portion, and assume a brown color frequently tinged with a red-brown or purple. Still older spots assume an ash-gray center. They are usually distinct, but may become numerous enough to cover the entire leaf. Such a leaf blackens and dies. As the older leaves die, new leaves are formed at the center of the crown. Hence, there is formed an elongated crown with tufts of small green leaves at the top.

Control.—(1) Deep fall plowing and crop rotation is the most satisfactory method of control.

2. Spraying with Bordeaux mixture, 4-5-50 formula, will almost perfectly control the disease, but it is seldom practical. The time for spraying is indicated by the first appearance of the disease. The leaves must be covered thoroughly on both sides.

(3) A proper and uniform supply of moisture in the soil is beneficial.

(4) If cattle or sheep are used in pasturing the tops, care should be taken that no diseased leaves are scattered to fields intended for beets the following year. Do not allow livestock to enter fields to be used for beets the following year until several days after they have been taken off from the beet-top pasture. The spores of the leaf spot fungus pass through the alimentary canal of cattle uninjured.

(5) Beet tops should be plowed under in the fall, to a depth of ten inches or more.

(6) Manure from stock fed with diseased beet tops should be applied to the land one or two years in advance of the beet crop.

ROOT KNOT.—This trouble is caused by minute worm-like animals (nematodes) which are invisible to the naked eye. It is often mistaken for a fungus trouble. No deformities are produced on the beet above ground. Badly infested plants are dwarfed, wilt easily, and are usually a pale green. In severe cases, the plant may be killed. Galls may form on fine feeding roots, or on larger roots. These enlargements are scattered, or close together and produce abnormal thickening of the root system. In severe cases the roots are a swollen mass.

Control.—(1) Rotation of crops. Cultivate immune crops for two or three years. Kill all weeds and other plants in which the worm-like animals live. Plants not attacked are barley, corn, broom corn, millet, red top, rye, sorghum, timothy, wheat, and winter oats.

(2) Prevent running water, implements, animals, etc., from bringing the nematodes from near-by infested fields.

(3) Starving the parasite by keeping the land free from all vegetation for two years is an effective control method, though often impracticable.

CROWN GALL.—The crown gall of beet is caused by the same organism which produces galls of the apple. The characteristic swellings or galls may be produced upon any portion of the beet root. See crown gall on apple.

Control.—Rotation is the only effective remedy if the bacteria once gets into the soil. Plants which are not attacked, like the grains or grasses, should be used in the rotation.

BLACKBERRY.

LEAF SPOT.—Diseased spots are small and numerous. They have a white or ashy-gray center, bordered with a brown or reddish ring. In later stages, minute black specks may cover the center of

each spot. This disease is not very common and epidemics are rarely developed.

Control.—See anthracnose of currant.

ORANGE RUST.—See Raspberry, page 45.

ANTHRACNOSE.—See Currant, page 29.

CABBAGE.

CLUB ROOT.—This is an uncommon disease in Colorado. It occurs on cabbage, radish, turnip and other members of the mustard family. The roots of the infected plants become greatly swollen and contorted, usually forming a cluster of finger-like or spindle-shaped swellings. Wilting of the plant results, particularly on hot days, although in the early stages of the disease such wilted plants may recover at night. Later, the plant succumbs or forms only a small head. The organism causing the trouble is in the soil and first attacks the young roots.

Control.—(1) The disease may be carried from field to field in the soil on the feet of horses, or on cultivators. Diseased plants thrown on the manure pile or compost heap may subsequently reach the field. Precautions should be taken to burn all affected plants.

(2) Rotation of crops.

(3) Destruction of weeds of the mustard group that may harbor the fungus.

BLACK ROT.—This is a bacterial disease. Infected plants are dwarfed, and often one-sided. In severe cases the entire head fails to develop or the plant dies. A black ring, corresponding to the woody part of the stem, is found in cross-sections of affected stems. This blackened tissue often can be traced up into the head. Infection takes place at the leaf margin or about insect wounds. The leaf veins become blackened as the disease progresses. The tissue between the leaf veins turns yellow and then brown. Affected leaves dry up and drop prematurely, thereby producing an elongated stem covered with leaf scars. Diseased leaves pulled from the stem show blackened bundles in the leaf stalk.

Control.—(1) Disinfect the seed, before sowing, in corrosive sublimate, 1-1000, for fifteen minutes, or in formalin, 1-200, for twenty minutes.

(2) Prepare seed-bed with manure and soil that is free from diseased refuse.

(3) Crop rotation is very important. No cultivated crucifers or cruciferous weeds should be allowed to grow in the ground for four or five years after a bad attack.

(4) Keep down insects, slugs, snails, etc., for they spread the disease from plant to plant.

(5) Do not allow livestock to roam over infested fields, for they carry the organisms to non-infected fields.

(6) Diseased plants should be pulled up and destroyed.

CANTALOUPE.

LEAF BLIGHT OR "RUST."—This disease is more properly termed "blight." The name "rust" is suggested by the rusty appearance of the leaves due to the numerous brown spots with which they are covered. These spots are circular; they first appear on leaves in the center of the hill. They may enlarge as the disease progresses, and several may run together, causing a curling and death of the leaf. Frequently the disease occurs on stems. Moist weather favors the spread of blight. Affected plants ripen their fruit prematurely, thus destroying the flavor.

Control.—(1) Use resistant varieties.

(2) Rotation of crops. This is highly advisable.

(3) Spray with 4-5-40 Bordeaux, first when the vines begin to run, followed by 1 or 2 more at intervals of 10 to 14 days.

CARROT.

SOFT ROT.—This is a bacterial disease which causes a soft rot of many vegetables. Decomposition usually begins either at the crown or root tip, and progresses rapidly through the core. Bacteria enter the fleshy tissue through wounds. Lengthwise sections of diseased roots show a softened, watery, decayed portion which is usually brown. There is a sharp line of division between the decayed and sound tissue.

Control.—(1) Treatment must aim entirely toward prevention.

(2) Rotation of crops is advised, with such crops as the grasses, cereals, etc.

(3) Use manure that is free from refuse of diseased plants.

(4) Dry the root surface before storage. The roots should be left on the surface of the ground, exposed to the sun, a few days before storage. Store in a dry and well ventilated place. The organism cannot endure drying nor can it invade dry tissue.

(5) Cold storage is advised at a temperature between 39 and 50 degrees F. This temperature, coupled with the disinfection of the root surfaces by drying and sunlight, should prevent serious injury from the rot.

CELERY.

BLIGHT.—There are two distinct blights of celery, *early blight* and *late blight.* Both diseases are due to fungi which feed upon the leaves, and in some cases the stems. The organisms causing the two diseases are entirely different. The effects of, and the remedial measures for the two are similar, however.

Early blight may make its appearance in the early stages of the plant's growth, either in the seed-bed or in the field. The outer leaves are first attacked; grayish-green spots, roughly circular in outline and with slightly raised borders, appear. Later the spots become darker in color, an ashen-gray, and larger. In some cases several adjacent spots may run together. Finally the entire leaf withers and dies. When the spots become brownish, it is an indication that they are producing reproductive bodies, the spores. These are readily blown from plant to plant, and in this way the trouble is spread throughout the field.

Late blight, in general appearance, resembles early blight (Plate V., Fig. 2). It may follow early blight in the same field and its effect upon the marketable value of the celery plant is similar. As compared with the early blight, the spots on the leaves are more irregular, and yellowish in color rather than ashen-gray. The spots later become covered with small, black fruiting bodies. These are readily seen with the hand lens. Late blight is found in the field until the plants are lifted and commonly continues its destructive work in storage. In fact, often the worst damage to the celery crop from late blight comes while the plants are in storage.

Control.—(1) Do not set plants from the seed-bed that are the least spotted.

(2) Dip leaves of all transplants in a weak solution of ammoniacal copper carbonate.

(3) Keep the plants in as vigorous condition as possible from start to finish. This is important.

(4) Remove and burn all diseased leaves, if practicable, as fast as they appear, so as to prevent further spread of the disease.

(5) Remove and burn all celery debris from the celery plot in the fall; this debris may harbor the spores which will live over the winter to infect young plants the following spring.

(6) Spray with ammoniacal copper carbonate, or 5-6-50 Bordeaux mixture, first when the plants are in the seed-bed, following with treatments at two or three week intervals throughout the growing season.

(7) In the case of late blight, dip only the leaves of lifted plants into ammoniacal copper carbonate before placing in storage.

(8) Do not store plants that show any spotting.

(9) The celery leaf spot disease may be spread by the use of affected seed. To render the seed safe, soak them three hours in formalin solution (1 pint 40 per cent formalin in 70 gallons of water). Thoroughly dry seed before planting.

CEREALS.

RUSTS.—The cereal rusts are too well known to need description. They occur on both stems and leaves, and in many instances cause serious injury to the crop.

Control.—There are no satisfactory, practical methods of control. Some varieties are more rust-resistant than others. It appears that plants growing on soil that is well-drained are more resistant to rust than plants on poorly-drained soil.

BARLEY.

COVERED SMUT.—Smut masses enclosed by thin covering, which breaks open soon after heads appear. Smutted grains ("smut-balls") often occur in threshed grain. Chaff as well as grain is smutted. Spores are blown from infected heads to healthy grain. These spores remain over winter on the outside of the healthy grain.

Control.—Use the formalin sprinkle as given under bunt of wheat.

LOOSE SMUT.—Smut masses not enclosed for any length of time by thin covering. As soon as smutted heads appear, the spores are scattered by the wind, and nothing but the bare stalk of the head remains. "Smut-balls" not formed. Smut mass olive-green in color. Appears earlier in season than covered smut. It is the more common sort of barley smut with us. Infection of sound seed always takes place before harvest time. The smut is carried over within the seed, not on the outside, as in the case of covered smut of barley.

Control.—Use *hot water* method as described under loose smut of wheat. *Note*: In the case of barley, the water in Tub No. 2 is kept exactly at 125 degrees F., and the grain is left in it 15 minutes.

WHEAT.

STINKING SMUT, OR BUNT.—Bunt is the most destructive smut of wheat. It is more common than loose smut of wheat. Bunt is exclusively a kernel smut. The contents of the grain of wheat are entirely replaced by a powdery mass of black spores. The spore mass or "smut-ball" is rather hard. Bunt usually is not noticed until the heads are mature. As a rule, all grains of a head, and all heads of an infected plant are smutted. Smutted grains, as compared with healthy ones, are darker in color, lighter in weight, plumper, and more easily crushed. When the smutted grain is crushed, numerous black spores are liberated, and the grain gives off a characteristic decayed fish odor. The spores get on healthy grain usually at threshing time; the smut-balls are

crushed in the thresher. A few broken smutted seeds can contaminate a large amount of healthy grain. Spores are carried from farm to farm by threshing machinery, and by wind. Bunt affects both spring and winter varieties of wheat. The spores of bunt will not cause smut in oats, barley, corn, or sorghum. The smuts of these cereals are distinct.

Control.—The object of seed treatment is to kill all bunt spores clinging to the outside of healthy grains. Bunt spores are carried into the ground with the grain of wheat, the young seedling is infected and at maturity the heads of the plant are smutted. Before treating seeds with formalin, place them in a tub or barrel of cold water, and stir. The lighter smutted grains will come to the top and may be skimmed off. Smutted seeds may also be fanned out with a good fanning mill. The easiest and most efficient seed treatment is the *formalin sprinkle.* This is done as follows:

(1) Formalin is a solution of formaldehyde gas in water. It usually has a concentration of about 40 per cent. Ask for this strength. Formalin may be obtained of any druggist. Put 1 pint (1 lb.) of formalin in 45 to 50 gallons of water. Stir thoroughly. Use this material when fresh; it deteriorates with standing.

(2) Put seed wheat to be treated on clean, hard barn floor, or in wagon box, or on canvas. The floor, wagon box, or canvas should be cleaned with a strong formalin solution, or with boiling water. Spread grain out a few inches deep.

(3) Sprinkle solution over grain with ordinary garden sprinkling can. Use about 1 gallon of solution to each bushel of grain.

(4) Shovel grain over and over. One person can handle the sprinkler while another thoroughly mixes the grain.

(5) Shovel treated grain into a pile and cover with canvas or gunny sacking that has previously been dipped in formalin solution or boiled in water. Leave covered for 2 or 3 hours.

(6) Spread grain out not more than 2 inches deep and allow to dry.

(7) Treated grain, if not planted directly, should be kept in smut-free sacks or bins. Disinfect sacks or bins with strong formalin solution or boiling water. Drills may be disinfected by washing out with strong formalin solution.

LOOSE SMUT.—The entire head of wheat is affected and turned into a powdery mass. It is earlier than bunt, and the smut-masses break open immediately after the head appears. At harvest time only bare stalks of diseased heads remain. The smut-mass has no odor. Smut-balls are not formed. Sometimes only a part of the grain-head is affected; in such cases it is always the lower part. Infection of sound seed always takes place before harvest time. Seed

that is apparently sound may carry the smut fungus within. Loose smut is carried over within the seed, not on the outside, as in the case of bunt.

Control.—The object of seed treatment is to kill the smut fungus that may be within apparently healthy grain, and at the same time not injure the germ. The formalin treatment is worthless. It is also needless to try and remove affected seed by placing seed wheat in cold water, or by fanning it. If you do not treat your own grain, be careful to get seed from a field that is smut-free. With considerable care, seed with loose smut of wheat may be treated successfully, by use of *hot water method.* This method is as follows:

(1) Soak grain for 5 or 6 hours in cold water. Use small quantities of grain (about 10 lbs.), placed in coarse sacks.

(2) Remove grain, in sacks, to tub or barrel No. 1, in which the temperature of the water is about 110 to 120 degrees F. Keep the grain in this 1 or 2 minutes. *Use good thermometer.*

(3) Remove grain to tub or barrel No. 2, in which the temperature of the water is kept *exactly* at 129 degrees F. Leave grain in this 10 minutes.

(4) Spread seed out to dry.

(5) In the above process some seed is killed. Hence it is necessary to increase the amount of seed used per acre. The extra amount of seed can be determined by comparing treated and untreated seeds when tested for germination.

OATS.

BLADE BLIGHT.—This is a bacterial disease which at first causes yellowing of the leaf. Diseased portions on the leaf are either round, or long and streak-like. The trouble usually begins at the tip of the leaf and works down into the plant. It may, however, start on the lower portion of the plant. In advanced cases the leaves collapse and take on a mottled reddish color. The leaves often crack and there appear droplets of a sticky fluid on their surface. At first this fluid is yellowish, but later it turns brown.

Control.—No control has been found.

LOOSE SMUT.—The common smut of oats is the loose smut. It appears as soon as the plant begins to head. As a rule, all heads on smutted plants and all grains on smutted heads are affected. Chaff as well as grain is smutted. Smut spores are early blown away by the wind, leaving the oat stem bare. Spores are carried over winter, clinging to the outside of healthy grains.

Control.—The formalin sprinkle as described under bunt of wheat is entirely satisfactory. It is unsafe to use bluestone (copper sulfate) in treating oats for smut.

CORN.

SMUT.—The appearance of corn smut is well-known. Black smut masses usually appear on the ears, but also frequently on tassels, leaves, and stems. Black spores are produced in tremendous numbers and scattered broadcast by the wind. Spores may live in the soil or in the manure pile. The spores that rest over the winter, in the spring produce spores of another type, and it is these new spring or early summer spores that infect the corn plant. Any part of the corn plant may be infected. Hence seed treatment is useless.

Control.—(1) The formalin sprinkle and hot water treatments are useless. Corn smut cannot be controlled by any form of seed treatment.

(2) Corn smut spores may pass through the digestive tract of animals without destroying their germinating power. Furthermore, the spores may actually grow and reproduce in fresh manure. Use well rotted manure, as it contains few or no living spores.

(3) Remove and burn all smut masses from field before they discharge the spores.

(4) Since spores may remain alive in the soil several years, crop rotation is of value. Any other crop than corn may be used in the rotation, for corn smut spores cannot cause smut, or be carried over, in any other plant.

SORGHUMS.

SMUTS.—Under the name sorghum are included milo, kafir, feterita, durra, kaoliang, broom corn, Sudan grass, and shallu. There are two smuts of the sorghum, kernel smut and head smut. In kernel smut of sorghum, each kernel becomes a smut mass, and the head retains its usual shape. The disease appears early in the season. The formalin sprinkle is an entirely efficient treatment for sorghum kernel smut. It is the more common sorghum smut.

In head smut of sorghum, the entire head becomes a large deformed smut mass. It is a loose smut. The life history of this smut is not well understood. Seed treatment is probably of no use. Cut out and burn infected plants. Rotation of crops may be of advantage. Milo is not attacked.

SUMMARY OF TREATMENTS OF CEREAL SMUTS.

1. Use the formalin sprinkle for:
   - (a) Bunt or stinking smut of wheat.
   - (b) Covered smut of barley.
   - (c) All smuts of oats.
   - (d) Kernel smut of sorghums.
   - (e) Smuts of millets.

2. Use the hot water treatment for:
   (a) Loose smut of wheat.
   (b) Loose smut of barley.
3. Seed treatment is useless for:
   (a) Corn smut.
   (b) Head smut of sorghums.

CHERRY.

SHOT HOLE.—This disease is evidenced by leaf spots, which are brown, circular, and with margins that may or may not be sharp (Plate VI). Shot-holing may be caused by the diseased portion falling out. In severe cases large numbers of spots appear in a cluster causing the whole leaf to assume a yellow color and fall.

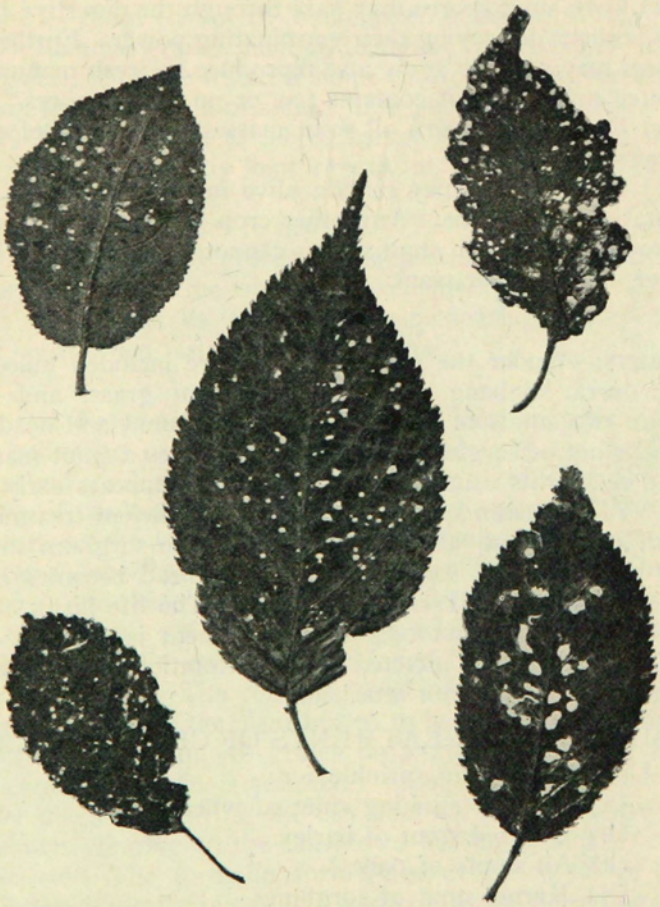

Plate VI. Shot-hole of plum.

This disease must not be confused with spray injury. Fruit and fruit stems are rarely attacked.

Control.—(1) Spray with self-boiled lime-sulfur, 8-8-50; atomic sulfur 5-50; commercial lime-sulfur 1¼-50; or Bordeaux mixture, 4-5-50 formula.

(a) First when petals fall, beginning when they are three-fourths off.

(b) Ten days to two weeks later.

(c) Three to four weeks before fruit is harvested.

(d) In sections, subject to severe attacks, an application should be made just after the fruit is picked.

(2) If possible, dispose of fallen leaves by fall or spring plowing.

BLACK KNOT.—See Plum, page 37.

CROWN GALL.—See Apple, page 12.

CUCUMBER.

BACTERIAL WILT.—This is evidenced by a wilting of the leaves and runners. There is no indication of injury to the roots, such as blackening, or to the leaves and stems, such as spotting. The leaves even retain their green color for quite a time. The water tubes are plugged, thus causing a wilting. By squeezing an infected runner, there oozes a sticky, milky, stringy liquid. This wilt also occurs on the Hubbard squash and cantaloupes.

Control.—Practice crop rotation.

(2) Insects are important agents in the spread of the disease. Spray for squash bug and cucumber beetle.

(3) Remove and burn affected parts promptly.

DOWNY MILDEW.—This disease is found on almost all cultivated species of the gourd family, such as cucumbers, muskmelons, watermelons, squash, and pumpkins. Affected leaves have irregular yellow spots, which run together in serious attacks causing the entire leaf to yellow, shrivel, and die. A whitish downy mass tinged with purple can often be seen on the under side of the large older spots. In weather unfavorable to the disease, the spots remain small. The disease starts with older leaves, and spreads toward the ends of the vines. Hence the center of the hill is first killed. Very few cucumbers are produced on diseased vines.

Control.—(1) Spray with Bordeaux mixture, 4-5-50 formula.

(a) First application, when the vines begin to run.

(b) Later sprayings, at intervals of about ten days, if the weather is dry, and oftener if the disease spreads rapidly.

POWDERY MILDEW.—A common disease attacking all parts of the cucumber. This trouble has the general characteristics of all powdery mildews. At first the diseased stems are covered with whitish, powdery, circular spots. Later, these spots spread and may cover the entire leaf, which becomes distorted and retarded in its growth. Infection is found mostly on the upper surfaces, and on older leaves. Stems are similarly attacked. Blossoms attacked fail to set their fruit. Diseased fruits develop the same symptoms as leaves. Such fruits become distorted and bitter.

Control.—(1) Apply flowers of sulfur with a good dust sprayer. The sulfur must be distributed to every part of the plant. Vines should be sulfured 1 to 7 times.

(a) First application, when the shoots are a foot long.
(b) Second application, at the first sign of the mildew.
(c) Later applications, as need indicates and according to the weather. Less sulfuring is necessary during hot, dry weather.

CURRANT.

CANKER OF CANES.—This disease has become prevalent in certain sections of the state. Apparently healthy canes may bear the fungus, which causes the trouble, for several years. The first indication of the disease is yellowing of the leaves and early coloring of the fruit. Positive evidence of the presence of the canker in a patch of currants is the appearance of pinkish, cushion-like masses on dead canes (Plate VII).

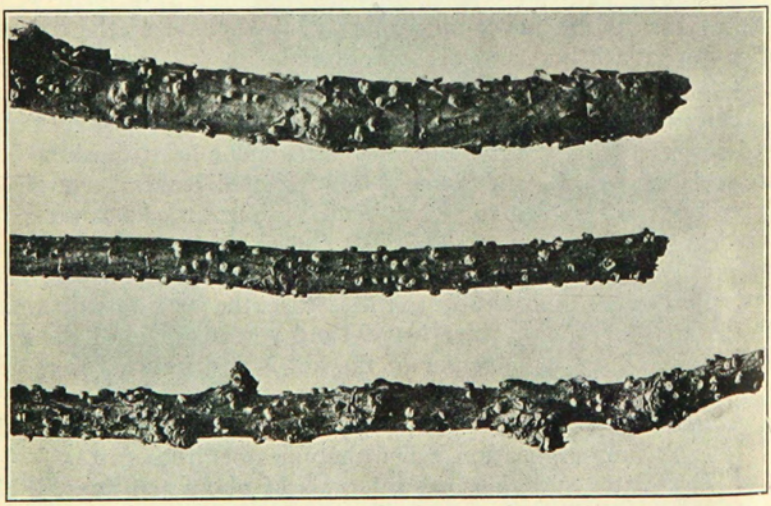

Plate VII. Canker of currant canes. The cushion-like bodies seen scattered over the canes are pinkish in color.

Control.—(1) Cut out and burn all diseased plants as soon as the trouble appears in the spring.

(2) All cuttings for planting should be made from stock that is known to be healthy. Do not even take cuttings from plants that appear healthy when such plants stand in a plantation known to have diseased plants.

(3) Spraying is not recommended.

CURRANT LEAF SPOT.—Diseased spots are about one-eighth of an inch in diameter and more or less angular. They have grayish centers with brown borders. Minute black specks may be seen on older diseased areas within the grayish center. Spots may be few or numerous. In the latter case, the leaf turns yellow and falls. Serious defoliation may result. This spot is easily distinguished from the anthracnose leaf spot by its larger size, its well-defined area, and its gray center, usually with black specks. Anthracnose leaf spots are black and small.

Control.—See anthracnose of currant.

ANTHRACNOSE.—This disease attacks fruit, fruit-stems, new canes, leaves and leaf stalks. Newly developed spots on the berries are rather noticeable. As the berries ripen, spotted fruits are less conspicuous. This is probably because the worst affected fruit has dropped. The spots on fruit are black, circular, and resemble fly specks. Affected berries do not rot or wither. Spots on the fruit-stems are black, and slightly sunken. They are from one-fourth to one-half of an inch in length and extend half way or more around the stem. Spots on new canes are rather inconspicuous. They are pale yellow or light brown, therefore almost the color of the cane. A slight discoloration of the bark is produced. The lower leaves are attacked first. They become thickly covered with small, dark brown spots. Affected leaves turn yellow and fall. Spots on the leaf-stalk are conspicuous. They are black and slightly sunken. Diseased plantations are easily recognized by the yellow color of the foliage. At ripening time the diseased leaves fall, leaving the vines bare, and exposing the red fruit.

Control.—(1) Spray with Bordeaux mixture, 4-5-50 formula, or lime-sulfur, 1 to 50.

(a) First application, made on bare canes before the leaves appear.

(b) Second application, made while the leaves are unfolding.

(c) Later applications, at intervals of from two to three weeks, until the fruit is two-thirds grown.

FLAX.

WILT.—The cause of flax wilt is a fungus which grows on the inside of the flax plant. It is found that the roots of diseased plants

are chiefly affected. Flax wilt may live over in the soil from year to year. Plants of all ages may be attacked. They wilt and die as from lack of water. The disease may spread very rapidly.

Control.—(1) Flax is being grown for the first time in many sections of the state. Since the spores of the fungus causing wilt may be carried by the seed, it is particularly important that clean seed be used, to prevent the introduction of the disease to the soil. Disinfect seed with formalin. This treatment is as follows:

(a) Make solution of formalin at the rate of 1 pound to 40 gallons of water.

(b) Spread seed upon a clean canvas or good tight floor.

(c) Sprinkle a small quantity of solution upon the seed. At the same time, rake the seed about. Take pains that all seeds are moistened, but do not use so much of solution as to cause the seeds to stick together. There is danger from using too much moisture. Use about ½ gallon of solution to each bushel of seed.

(d) Allow the seed to stand for several hours, covered by a canvas, then rake and stir until thoroughly dry.

(2) Fanning seed before treatment will remove many light weight infected seed.

(3) Store flax seed in dry place. The fungus grows on moist seed.

(4) The wilt fungus is held over in old flax straw and stubble. Hence remove and burn infected flax straw and refuse.

(5) Do not use manure made from infected flax straw. Well composted manure will contain no spores capable of germination.

(6) If wilt becomes bad, plant infected land to some other crop.

(7) Use disease-resistant varieties.

GOOSEBERRY.

MILDEW.—English varieties of gooseberries suffer more from the attacks of this fungus than American sorts. The frost-like coating of the parasite appears on stems, leaves, and fruit. The whitish, cobwebby growth becomes darker in color later in the season, and careful examination with a hand lens will show the presence of numerous black specks over the entire diseased surface. The black bodies carry the spores.

Control.—(1) Spray with potassium sulphide, 1 oz. in 2 gallons of water. Apply first spray just when the buds begin to open. Follow this with sprayings at intervals of about 14 days until the fruit is ready to pick.

(2) Establish good circulation of air about the plants by cutting out the lower drooping branches.

LETTUCE.

LETTUCE DROP.—The first indication of the disease is a sickly plant. Later the outer leaves wilt, one after the other, and fall flat upon the ground. Finally, water-soaked areas are produced over the stem, and the whole plant falls over and rots away. Such plants show a cottony growth on the under side of affected leaves. In the last stages of the disease, many small black bodies may be formed upon the affected portions.

Control.—(1) Remove and burn all diseased plants as soon as they appear.

(2) Spray the place where the infected plants stood, either with Bordeaux mixture, 4-5-50 formula, or with bluestone dissolved in water at the rate of one pound to seven gallons of water, or with weak formalin.

(3) Guard against introduction of the trouble in refuse or compost which may contain diseased lettuce plants.

(4) Rotation. Do not follow lettuce with celery, or celery with lettuce, as both crops are subject to the disease.

(5) Set out healthy plants only.

(6) Soil steaming or sterilization is practicable for lettuce grown under glass.

ONION.

BLIGHT OR MILDEW.—In a few of the truck growing regions of the state, this disease has been rather serious. It makes its appearance the latter part of June or first part of July. Damp weather or excessive irrigation favors its development. It is possible to recognize the disease in its very young stages. Early in the morning, when there is moisture on the leaves, infected leaves have a peculiar, furry, violet tinge. Later on, they become covered with a white mildew-like growth, and finally collapse. As a result of the leaf infection, the onion bulbs do not reach their proper size.

Control.—(1) In case of serious outbreak of disease, spray with 4-5-50 Bordeaux mixture. Apply this from time to time until disease is checked.

(2) The disease is carried over the winter on dead onion leaves. Care should be taken to rake and burn all the tops.

(3) In case the disease has been serious for several successive years, it may be well to practice crop rotation, not going back to onions until three or more years.

PEA.

POWDERY MILDEW.—This disease is prevalent in the state on both garden and field peas. It is readily recognized by the white cobwebby growth on both surfaces of the leaves. Moist weather,

over-irrigation, and crowded condition of plants favor its development.

Control.—(1) Bordeaux mixture readily controls it. It is seldom a practical remedy, however, as the disease is not often severe enough to warrant the expense.

(2) Keep soil well-drained.

(3) Do not overcrowd the plants.

(4) Early crops are not as liable to attacks of fungus as late crops.

PEACH.

SCAB.—The disease is found on fruit, leaves, and twigs. It is also known as "black spot" and "freckles." Spots on the fruit are about ⅛ of an inch or less in diameter, dark brown to blackish, and nearly circular. Diseased areas are found only on the surface and may be slightly depressed when many spots come together. Frequently, individual spots crack. If a mass of spots come together, producing a "smutty" or blackish appearance, the peach cracks open and shrivels. Infection is most abundant about the stem attachment and weather side of fruit. On the leaf the spots are nearly circular and are formed only on the surface. They are pale green in early stages and a yellow-brown or purple in later stages. Wood of the current season may be attacked.

Control.—(1) The disease is very easily controlled by spraying. Spray with 8-8-50, self-boiled lime-sulfur, about one month after the petals drop and again three or four weeks later.

BLIGHT.—This disease occurs on fruit, leaves, and stem. The spots on fruit are irregularly oval to circular. At first, they are pink, but later become typically brown with a pink outer ring. These spots are slightly raised and found only on the surface Gumming is not abundant on diseased fruit. Badly infected fruit is shed early. On leaves the spots are irregularly circular and reddish to brown in color. Spots may fall out, causing shot-holing. In severe attacks, defoliation may take place. On twigs the spots are irregularly oval in shape. At first they are reddish, but later become brown to black, and often sunken. Gumming is generally conspicuous on diseased twigs. Buds on the fruiting wood are killed.

Control.—Spray in the fall with Bordeaux mixture, 4-5-50 formula.

POWDERY MILDEW.—The leaves, twigs, and fruit are attacked. White irregular blotches are produced on the leaves, mostly along the midrib. In the shade, both leaf surfaces are affected. The leaves crinkle, curl, and in severe cases the younger ones near the tip fall. White blotches are formed on diseased twigs (Plate IX).

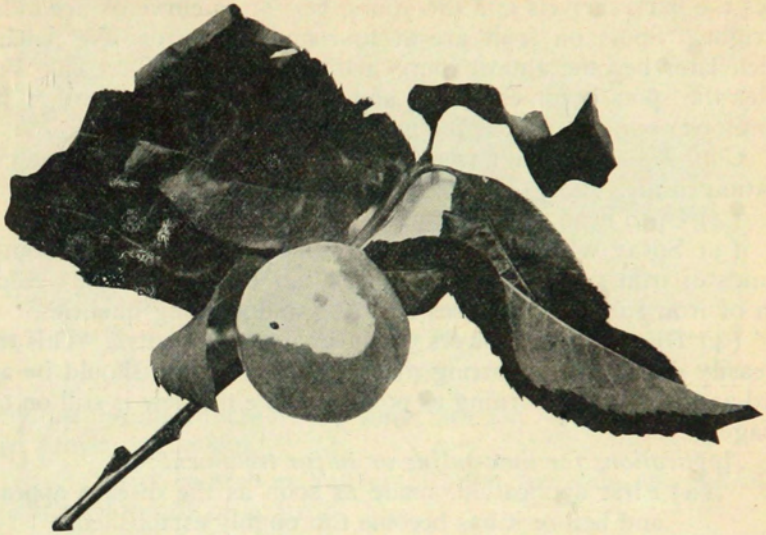

Plate VIII. Peach fruit attacked by powdery mildew.

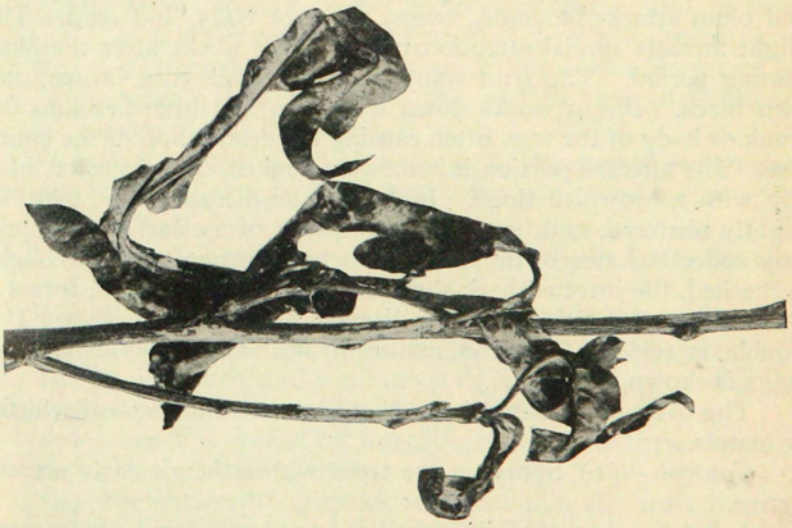

Plate IX. Peach twigs attacked by powdery mildew.

The bark under these blotches becomes dry and brown. In severe cases the bark shrivels and the young tips often curve or are killed outright. Spots on fruit are at first musty or frost-like patches which later become almost pure white (Plate VIII). The skin under the spots becomes brown and the flesh becomes hard. The entire crop is often ruined for market.

Control.—(1) Plant trees far enough apart to allow free circulation of air. This tends to prevent development of mildew.

(2) Open head system of pruning is to be preferred.

(3) Spray with lime-sulfur solution, 1-50, with or without 3 pounds of iron sulfate added to 50 gallons of the mixture. Addition of iron sulphate increases covering and sticking qualities.

(4) Dusting with flowers of sulfur is also effective. This can be easily done with a dusting machine. The sulfur should be applied as early in the morning as possible while the dew is still on the foliage.

Applications for lime-sulfur or sulfur treatment:

(a) First application, made as soon as the disease appears and before it has become thoroughly established.

(b) Later applications, made at intervals of 9 days or oftener, according to the severity of the disease. One or two applications may be sufficient while in some seasons five or six applications are necessary.

PEAR.

FIRE BLIGHT.—Fire blight of the pear, apple, quince, apricot, and plum attacks blossoms, twigs, limbs or body, and fruit. The blight attracts special attention two or three weeks after the blossoming period. The fruit spurs at first shrivel, turn brown, and then black. Blight works down the twigs and branches into the trunk or body of the tree, often causing the destruction of the entire tree. The affected portion is somewhat sunken, dark in color, usually with a brownish tinge. In spring the diseased bark may be slightly blistered, and here and there drops of a clear, slimy liquid may collect. Later in the season, when the progress of the blight is checked, the infected bark shrinks, becomes smooth, and forms a definite line of division between diseased and healthy tissues. The trouble is seldom found on mature fruit. Hold-over canker on twigs is shown in Plate X.

The disease is caused by a bacterium which is spread chiefly by insects.

Control.—(1) Spraying the trees with a fungicide is not effective.

(2) A number of blight remedies have been placed on the market by manufacturers. They are supposed to make the trees im-

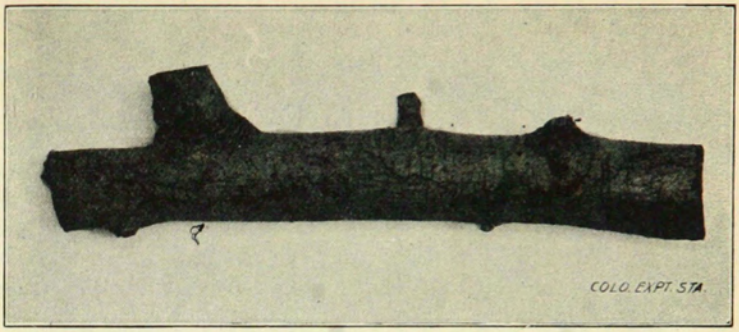

Plate X. Hold-over canker of pear twigs. Note the cracks from which the oozing takes place.

mune by the introduction of a fluid into the sap. These have not been proven successful.

(3) Strict sanitation and eradication methods are the most satisfactory means of control.

(a) All sources of infection should be destroyed. This can best be done by removing all diseased portions in the autumn after the leaves have fallen. Affected branches should be cut back from ten to fifteen inches below the discolored wood. Cankers in crotches should be scraped down to live wood, and disinfected.

(b) Trees should be inspected in early spring, and all cases of blight removed and burned. A weekly inspection of all trees during the growing season should be carried on as soon as the blossoms fall, and all cases of blight removed and burned.

(4) Tools as well as all cuts should be disinfected with corrosive sublimate, 1-1,000, so that bacteria are not spread.

(a) The corrosive sublimate may be carried in a bottle or wooden pail, and applied to the wounds and tools with a sponge.

(5) Collect diseased material in a sack; the sack may be strapped to the operator for convenience. Burn all affected material.

(6) A systematic and continuous fight in cutting and destroying diseased portions is essential for successful control.

(7) Disease is spread by insects. Hence keep these down by spraying with a good insecticide.

(8) The native thorn apples and mountain ash are a host for the organism causing fire-blight. Trees in the immediate neighborhood should be destroyed.

(9) Avoid heavy winter pruning, as it produces heavy succulent shoots subject to attacks of bacterium.

CROWN GALL.—See Apple, page 12.

RUST.—See Apple, page 13.

PLUM.

PLUM POCKETS.—The disease is present on fruit, twigs, and leaves. First evidence on the fruit is yellowing. The fruit then enlarges rapidly, attaining a size several times the normal. The surface becomes deeply wrinkled, and the pit fails to develop, having in its place a large air cavity (Plate XI., Fig. 2). The diseased

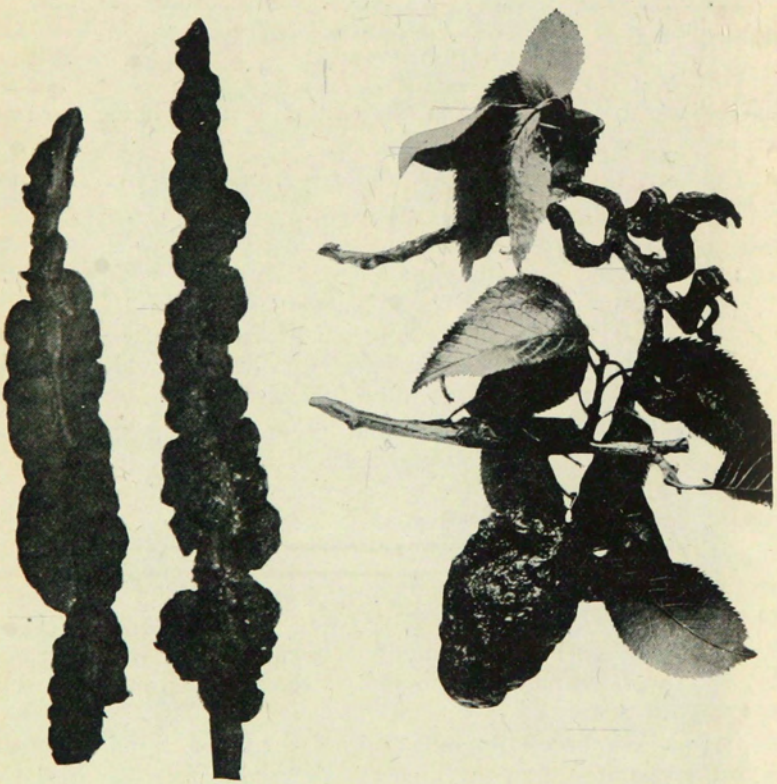

Plate XI. Fig. 1. Black knot on plum. Fig. 2. Plum pocket, showing the enlarged, darkened, diseased fruit.

fruit later turns brown, shrivels, and falls, or in some cases remains on the tree. Diseased twigs are enlarged, deformed, and usually somewhat curved. In later stages the twig turns brown. Infected leaves are abnormally thickened and deformed. Later they shrivel, become brown, usually remaining on the tree.

Control.—Affected branches and badly affected trees should be destroyed.

FIRE BLIGHT.—See Pear, page 34.

CROWN GALL.—See Apple, page 12.

SHOT HOLE.—See Cherry, page 26.

BLACK KNOT.—Early evidence of infection is indicated by a slight swelling of the branch. This is followed by a rapid increase in size. The knot attains its full size in 10 to 12 days. As growth increases, the bark ruptures and exposes a granular olive-green growth. Later this mass turns black (Plate XI, Fig. 1). Knots vary as to size and shape, some being only a quarter of an inch in length, while others attain a length of five or more inches. As a rule, they do not encircle the entire branch. Diseased twigs are often curved. The knots persist on old twigs and the next year they produce new knots. Old knots remain on trees for 5 or 6 years.

Control.—(1) All knots should be removed, by cutting at least 6 inches below the diseased portion, and destroyed.

(2) Spraying with Bordeaux mixture, 4-5-50 formula, just before the buds open, has been recommended.

POTATO.

EARLY BLIGHT.—This potato trouble is not prevalent in Colorado. The leaves become spotted in July or August, about the time the blossoms appear. The small brown spots are surrounded by concentric rings, which give them a very characteristic appearance. The spots may run together, causing withering and death of the entire leaf. As a result of the leaf affection, tubers do not develop normally. The tubers, however, are not diseased.

Control.—(1) Spray with Bordeaux mixture. This should be done at intervals of about two weeks. The first application is made before the appearance of the disease.

(2) Plant resistant strains.

(3) Maintain the vigor of the plant by proper methods of cultivation.

SCAB (OOSPORA).—This "Oospora scab," so prevalent in eastern states, has never been serious within the state. The most common scab on potatoes in Colorado is due to another fungus—*Rhizoctonia*. "Oospora scab" is a surface disease of the tubers. The fungus produces a roughened, pitted, scabby surface (Plate XII). It also occurs on beets, cabbage, and other plants.

Control.—(1) Use smooth, scab-free tubers for seed.

(2) Disinfect seed potatoes. Soak the tubers for two hours in formalin, 1 pound (pint) in 30 gallons of water.

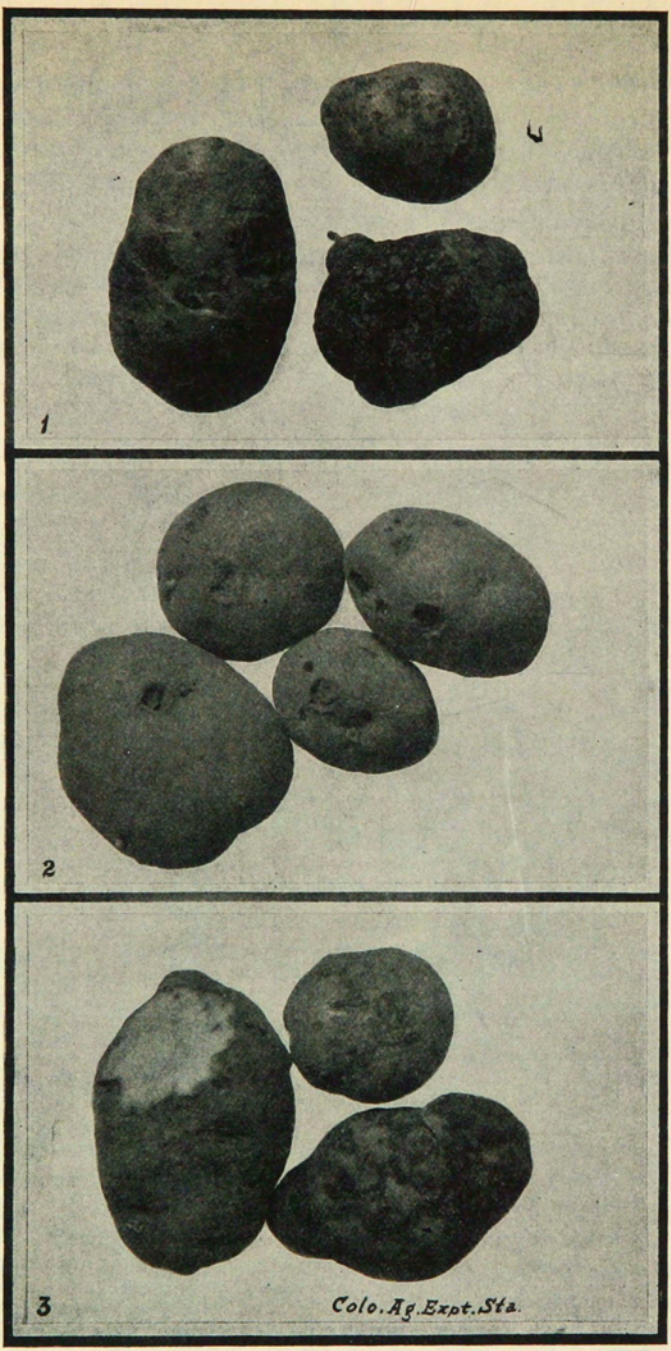

Plate XII. Scab of potatoes. Fig. 1. Surface scab. Fig. 2. Deep scab. Fig. 3. Scab produced by beetle.

(3) The spores of the fungus are uninjured in passing through the digestive tracts of livestock, and hence reach the field in the manure. Do not feed uncooked scabby potatoes to livestock.

(4) If the disease becomes prevalent in a soil, practice crop rotation, not returning to potatoes for 4 or 5 years.

FUSARIUM WILT OR BLIGHT.—The serious reverses that potato growing has undergone the last few years in Colorado have been ascribed to *Fusarium* wilt or blight. That it is the only cause of the epidemics is doubtful. However, it is quite certain that it is largely responsible.

In regard to the symptoms of *Fusarium* wilt, we quote from Professor B. O. Longyear, of this station:

"This trouble first manifests itself in the field by the wilting and yellowing of the lower leaves of plants that have reached the height of ten to twelve inches. In bad cases the entire foliage appears to suffer as though the plant were not getting sufficient moisture. Later on, the tips of the leaves turn brown and dry up, leading to the trouble commonly known as 'tip burn.' The edges of the leaves commonly roll inward during the heat of the day, although they may partially revive during the night.

"Badly affected plants will be found to have the root hairs and rootlets rotted away and often the larger roots appear sickly. Cross-sections of the main root often appear brownish in the region of the vascular bundles or woody part. Under the microscope thin sections of such roots and of the lower part of the stem will show the delicate filaments of the fungus which pass upward through the water-conducting tubes of the plant and eventually clog them to such an extent that the flow of sap is greatly obstructed. This is what causes the wilting and eventual drying of the foliage of the plant.

"The fungus also passes into the tuber-bearing stems under ground and frequently enters the stem end of the tuber for some distance. In bad cases the stem end of the tuber may be rotted away and the presence of the fungus deeper in is indicated by the browning of the vascular ring shown in a cross-section of the tuber. The fungus may also enter the tuber from the soil through any bruise, crack, or other break in the skin. Attacks of insect larvae upon the tubers are often followed by this disease through the wounds which the 'worms' produce.

"Under conditions of plenty of moisture and high temperature, this disease makes it most rapid progress and may reach its culmination at about the time when the tubers are ordinarily half to two-thirds grown. When a plant once shows the infection to any marked degree, all further growth ceases. The plants seem to stand still and eventually wilt down entirely or else struggle along in a dwarfed and sickly condition for some time.

"A common source of infection in newly planted fields is through the use of tubers for seed that already contain the fungus. Another

common source of the trouble is from planting the potato in fields that have previously shown the disease within two or three years. Such soils are said to be 'sick.'

"A second period of destruction due to this disease comes during storage. Tubers infected in the field when stored under conditions of

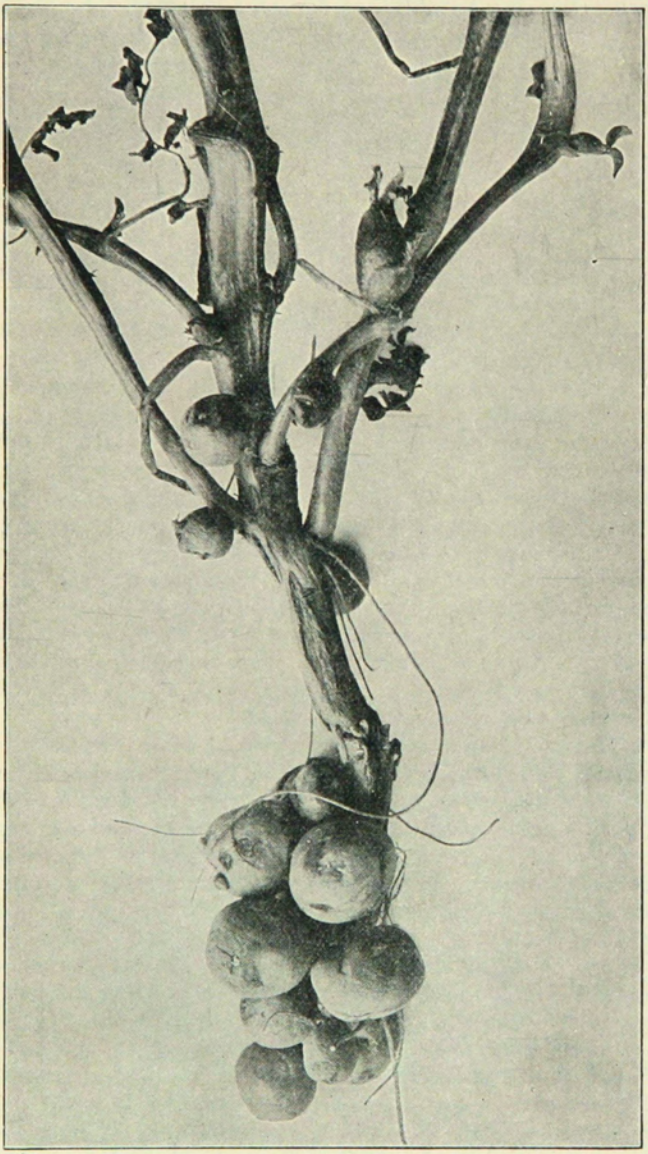

Plate XIII. "Little potatoes" and "aerial tubers," the former in a cluster beneath the soil surface, the latter on the stems above ground.

moderate temperature are apt to show a high percentage of dry rot. In such cases the fungus causes a blackening of the tuber, with a final outbreak of a whitish mold, and may serve to infect the wounds in other tubers."

Control.—(1) Spraying is entirely useless. The fungus is internal.

(2) Plant clean seed in a clean soil. The fungus is carried in the tubers and lives over in the soil.

(3) Practice crop rotation. This is the important lesson learned by Colorado potato growers. Fields in which *Fusarium* wilt has been bad, should not be planted to potatoes again until a lapse of 5 or 6 years.

RHIZOCTONIA.—This well-known potato disease in Colorado goes by a number of common names: Rosette, little potatoes, aerial potatoes, scurf, stem rot, collar rot, and black ring. The fungus causing the trouble lives in the soil. The symptoms produced by its attacks upon the plant vary. Apparently healthy plants may produce but a few tubers; the plant "goes to top." Again there may be an abundance of tubers, crowded just below the ground surface, but these are small, hence the name, "little potatoes" (Plate XIII). The fungus girdles the stem (Plate XIV), shutting off the movement of starch from leaves to tubers; as a result, small tubers may be formed on stems above ground (Plate XIII). In some instances there is a profuse branching of the plant, and a clustering of leaves at branch tips, which give the plant a bushy appearance. Again the leaves may be twisted and curled. Examination of diseased stems, taken just below the ground line, shows characteristic brown or black surface spots and patches of various shapes. Diseased tubers may be somewhat scabby. Close examination of such will often show the presence of very small black specks, resembling dirt. These black bodies represent a stage of the fungus which lives over winter (Plate XV).

Control.—(1) Use clean seed in a clean soil.

(2) Treat seed before planting with corrosive sublimate. Soak 1½ hours in solution, using 4 oz. of sublimate to 30 gallons of water. Keep solution in wooden barrel—it corrodes metal. Do not eat treated potatoes.

(3) Keep diseased plants and tubers out of stable manure.

(4) Practice crop rotation.

(5) The disease is less prevalent in light, well-drained soil, than in heavy, soggy soil.

INTERNAL BROWN SPOT.—In Colorado this disease affects the Early Ohio almost exclusively. It has not been found on potatoes grown in irrigated sections. It is recognized by the dry, brown

spots, irregularly scattered throughout the flesh. It is thought to be due neither to a fungus or bacterium. The cause is not known. It is not contagious. Control measures are not known.

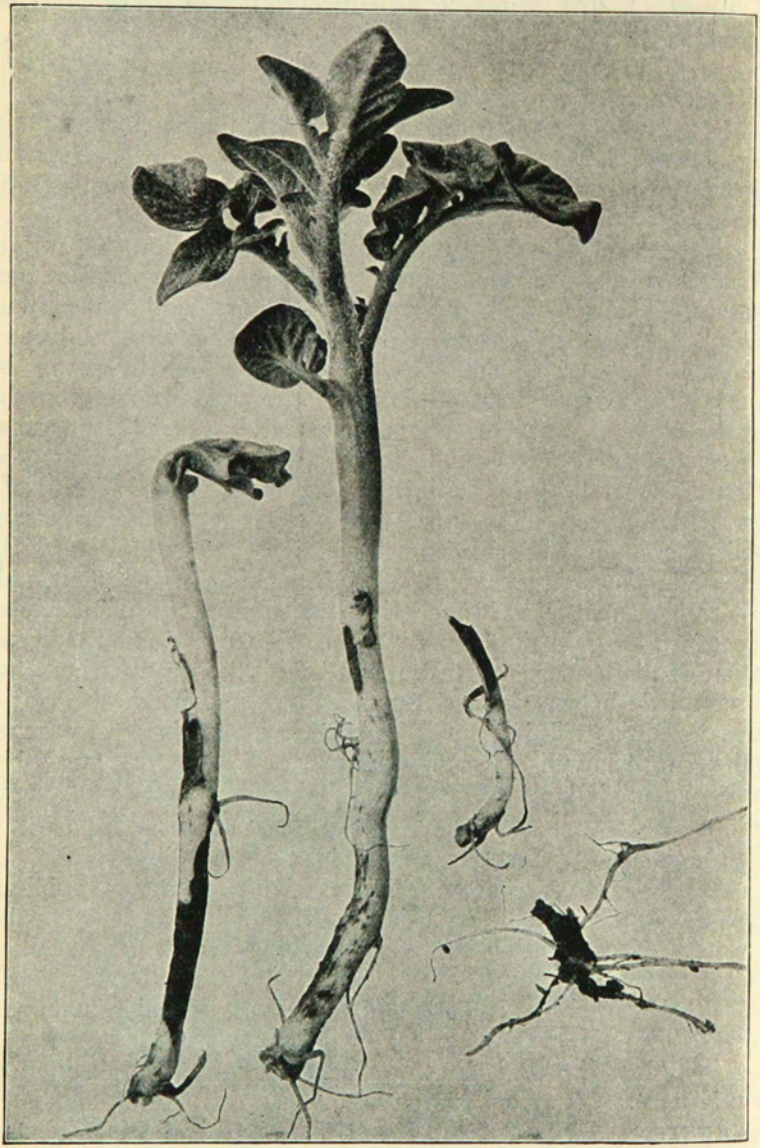

Plate XIV. Young potato stems attacked by *Rhizoctonia*. Note the darkened diseased patches near the ground line.

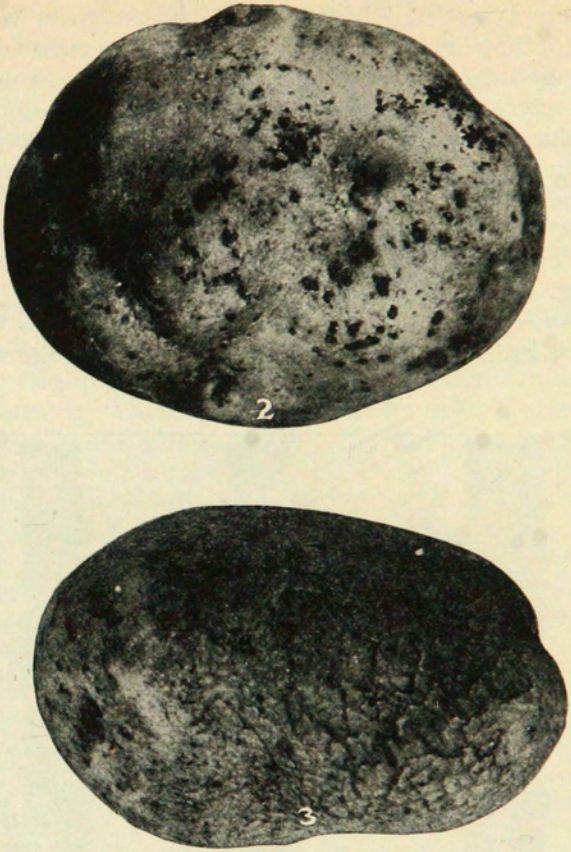

Plate XV. Fig. 2. Sclerotia of *Rhizoctonia* on seed potato. Fig. 3. The fine cracks seen on surface of potato are caused by the attacks of *Rhizoctonia*.

RADISH

WHITE RUST.—The white "rust" occurs not only on radish, but on other members of the mustard family, such as horseradish, turnip, and cabbage. It commonly affects leaves, but is also found on flower parts, distorting them to a marked degree. On the leaves the spore cushions are white and shining, and vary in size from mere specks to irregular patches an inch or more in diameter.

No serious injury has resulted from the attacks of this disease, as far as reports indicate.

RASPBERRY.

ANTHRACNOSE.—Young canes are chiefly attacked, although the disease may also appear on leaf and leaf-stalk. The spots on the canes are at first small and purplish, later they develop gray,

sunken centers bordered with purple. These spots enlarge, run together, forming irregular blotches which may encircle the canes. Badly diseased canes have roughened bark with a scabby appearance. In severe cases, the canes crack, wither, and die. Affected canes produce dwarfed leaves and premature, undersized fruit, which often dries. The first indication of the disease on the leaf-stalks is the production of minute spots. The fungus spreads from these spots into the leaf, where small affected areas are produced on the under surface. These diseased spots may drop out, causing shot-holing.

Control.—(1) Prune out and destroy all diseased canes.

(2) Rotation of crops. Avoid planting on site of diseased plantation.

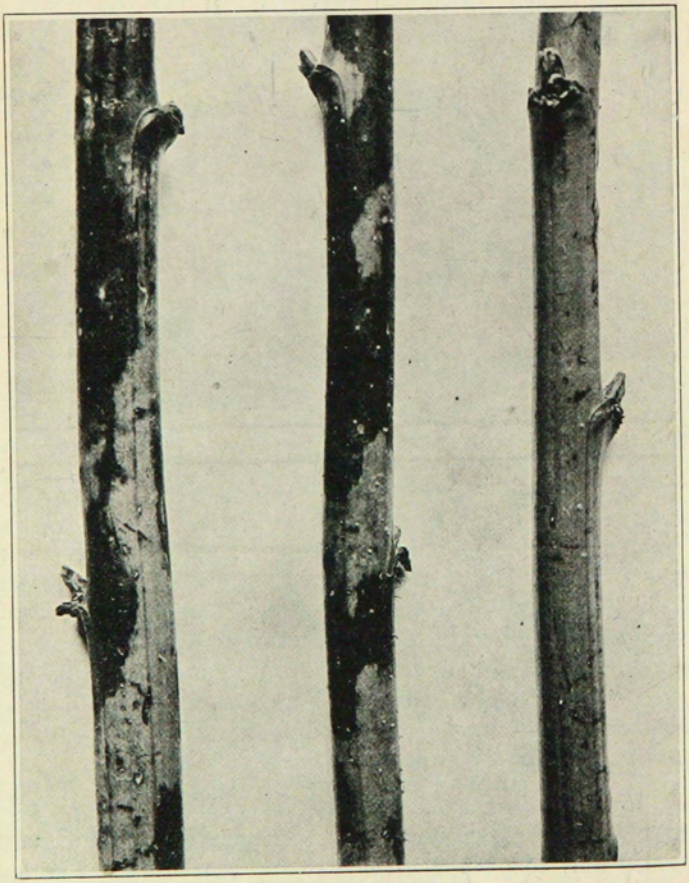

Plate XVI. Spur blight of red raspberries. The twig on the right was sprayed.

(3) Set out only healthy plants.

(4) In severe cases spray young canes with Bordeaux mixture, 4-5-50 formula, with 2 pounds of resin-fish-oil soap added to act as a sticker.

(a) First application, when canes are uncovered.

(b) Second application, when new canes are 8 to 10 inches high.

(c) Later applications, one or two more sprayings thereafter at intervals of 10 to 14 years.

SPUR BLIGHT.—This disease (Plate XVI) is found on the young canes and leaf-stalks. On the lower half of young green canes chocolate-brown discolorations are produced chiefly at the leaf attachments. Later this discoloration spreads, causing some buds to dry, shrivel and die. Other buds are so weakened that the newly developed spurs die soon after starting. No fruit is developed on the lower half of diseased canes. In later stages the disease spreads and discolors the whole lower third of the cane a purple-brown. In this stage the bark often cracks, causing drying of canes. Such stems are brittle and easily broken. Infection on leaf-stalk at first is in the form of a small chocolate-brown spot. The fungus spreads from this spot into the cane. Infected leaf-stalks are weakened and later collapse, causing the leaf to droop and dry up.

Control.—(1) Spray with Bordeaux mixture, 3-2-50 formula, with 2 pounds of resin-fish-oil soap added to act as a sticker. This mixture should only be applied to the young canes and not to the fruiting canes.

(a) First application, last part of May or early June when canes are 8 to 12 inches high.

(b) Second application, two weeks later. Regulate somewhat according to the ripening period of the fruit so as not to discolor fruit.

(c) Third application, two weeks after the second.

(2) Remove and burn old fruiting canes as soon as the berries have been gathered.

ORANGE RUST.—This is a common disease attacking the leaves and canes. The under surface of infected leaves becomes covered with a mass of orange-red spores. The growth of leaves is retarded, and they become curled and distorted. Affected canes are weakened and stunted. They are non-productive and finally die. The fungus lives in the plant from year to year.

Control.—Pull up and burn all diseased plants.

STRAWBERRY.

LEAF SPOT OR LEAF BLIGHT.—Although this disease is of frequent occurrence in strawberry beds, it rarely becomes serious. It attacks the leaves principally and may be recognized by the characteristic white spots bordered by red or purple. At first the spots are purplish. The degree of susceptibility of a variety toward the disease varies with the locality.

Control.—(1) Remove and destroy all diseased leaves when setting new plants.

(2) The fungus winters over on the leaves. Hence, after the picking season, mow the bed and burn it over.

(3) Although seldom necessary, it will pay to spray in bad cases. Use Bordeaux mixture. Spray 2 or 3 times early in the season, and, if necessary, once later.

(4) Resistant varieties for a locality may usually be found.

BLACK ROOT.—Many plants have been sent to the Station affected with a disease, which we have called "black root." There is a blackening and dying of the roots. As a rule, two-year-old plants are the worst affected, and the disease usually becomes evident in the spring. In a few cases, the trouble has appeared at the beginning of the winter season. No causal organism has as yet been associated with the disease. It seems to be most prevalent on soil that is poorly drained, or in bad physical condition, or on land that has been continuously cropped with strawberries without proper rotation with some legume. However, it has been noted in soil apparently in good condition.

TOMATO.

FUNGOUS (*Fusarium*) BLIGHT.—In this disease the first indication is a yellowing of the lower leaves, followed by their wilting and dying. The trouble may progress slowly, or within a week the entire plant may be dead, depending upon weather conditions and the severity of the attack. In a section of a diseased stem, the woody portion is blackened. Very often the fruit remains attached to the plant and ripens earlier than usual. This is probably the same fungus that is responsible for a part, at least, of wilt in potatoes.

Control.—(1) Spraying is useless.

(2) Remove and burn infected plants. A single diseased plant may be the source of infection of a large crop.

(3) The disease may live in the soil from year to year. Practice a crop rotation system in which tomatoes and potatoes do not come oftener than once in four years.

(4) Spores of the fungus may be carried from field to field and even from farm to farm by soil or mud sticking to cultivating implements, horses' feet, or workmen's shoes.

FRUIT ROT—BLOSSOM END ROT.—This disease usually appears on half-grown to full-grown tomatoes. It starts in at the blossom end as a slightly sunken, dry spot, which enlarges, darkens, and becomes rotted. The blossom end rot of tomato is considered to be a non-infectious disease.

Control.—(1) The application of fungicides is not effective.

(2) The appearance and progress of disease are favored by dry soil conditions. Keep an abundant and regular supply of moisture in the soil.

SOME INJURIES NOT DUE TO FUNGI

SUN SCALD.—Sun scalding may be developed on the fruit or body of the tree, usually the latter. Cankers are produced on the body. The southwest side of the tree is most frequently injured. Young trees may be killed outright or much weakened. The sun's rays may injure the trees either directly or by reflection from the hot dry soil, or water in irrigation ditches that are placed near the tree. Cankers produced in this manner may easily be mistaken for fungous troubles.

Control.—(1) Newly planted trees should be headed low.

(2) Protect trunks of newly planted trees.

(a) By wrapping the trunks with burlap, paper, straw, wood veneer or wire netting.

(b) By shading the trunk with a board placed on the southwest side.

FROST INJURY (Plate XVII).—Late spring frosts often injure the developing fruit and leaves. Frosted fruits become russeted either at the blossom or stem end, or very often in bands about the middle. Injured fruits may be deformed. "Frost blisters" may be produced on the leaves. Such leaves are crinkled, or have blisters produced by a separation of upper and lower surfaces. The lower surface of injured leaves usually has numerous cracks. Cankers may be produced on the southwest exposure of the tree, due to a freezing of sap and consequent killing of tissue. Such cankers may be mistaken for fungous troubles.

SPRAY INJURY.—Both foliage and fruit may be affected. Injured fruits may be russeted or spotted. Leaf injury may be in the form of irregular, scattered, light brown spots, or the margin of the leaf may be browned, or in severe cases the entire leaf may be

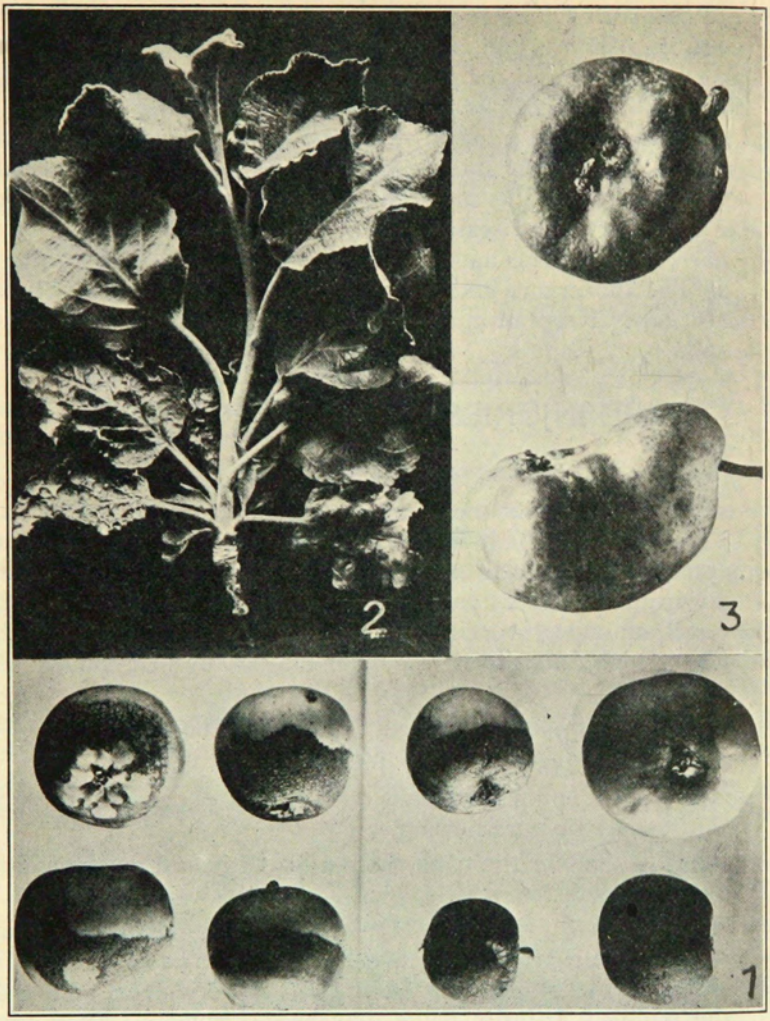

Plate XVII. Fig. 1. Frost injury on apples. Fig. 2. Leaves blistered by frost. Fig. 3. Pears deformed as a result of frost injury.

affected, turn yellow, and fall. In some instances the affected surface may slough off. The effect produced may sometimes resemble shot-hole of plum and cherry.

Control.—(1) Use pure chemicals.

(2) Apply spray as a fine mist, using high pressure and good nozzles.

(3) Apply spray in clear weather.

(4) Stir solution well before application.

(5) Follow carefully directions for making spray mixture. Do not get it too strong.

"NITER" INJURY (Plate XVIII.—The leaves of fruit trees af-

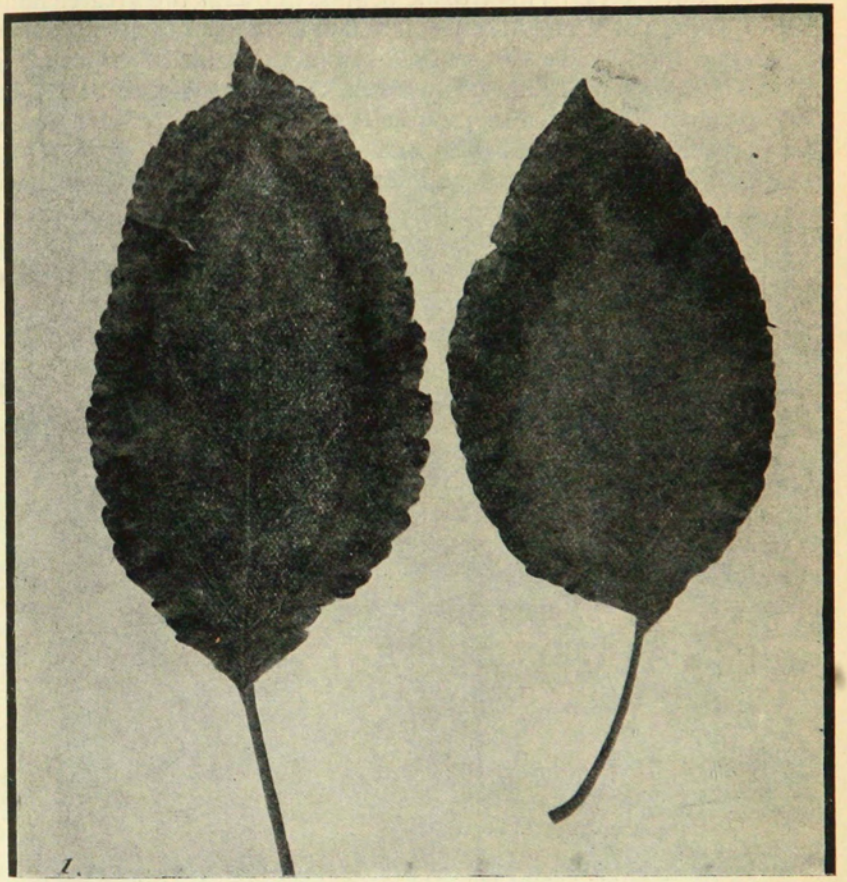

Plate XVIII. Apple leaf with "niter" injury. Note the characteristic browning along the margins.

fected by excessive quantities of niter in the soil have a characteristic appearance. The burning and shrivelling of the leaf begins at the tip, progresses rapidly along the margin, and finally involves the entire leaf. A few limbs, or the whole tree may be attacked. Of all our fruit trees, the apple seems to suffer the most.

ARSENICAL POISONING.—Headden ("Arsenical Poisoning of Fruit Trees," Bulletin 131 (1908) and Bulletin 157 (1910), Colo. Agri. Exp. Sta.), showed that many cases of death of orchard trees in Colorado were due to the action of the arsenic applied to trees

as a spray. A part of the arsenical spray, especially when used in excessive amounts, eventually reaches the base of the tree, and brings about injury to the crown of the tree.

Headden says, "This trouble begins, in by far the greater number of cases, at the crown of the tree and subsequently involves both trunk and roots. The first marked symptom is an early ripening of the foliage, usually followed by death about midsummer of the ensuing year. The crown of the tree is found to be girdled, the bark on portions of the trunk dead and sunken, and most of the roots dead, their bark destroyed and the woody tissue discolored, usually a light shade of brown, and sometimes exteriorly blackened."

Arsenical sprays constitute our most valuable insecticides and their use is not to be discouraged. But they should not be applied in excessive amounts. There is a tendency with some to give more applications than necessary.

"SEEPAGE."—Trees dying from too much water show symptoms markedly different from those affected with "niter." All the leaves of the tree may turn yellow. Discoloration of the leaf does not progress from the tip along the margins, as in "niter" leaves, but the leaf seems to be affected as a whole. Affected portions of "niter" leaves are brownish in color from the first, never yellowish. Trees killed by too much water never show girdling at the crown as do those killed by arsenic.

PREPARATION OF SPRAY MIXTURES AND DISINFECTANTS.

BORDEAUX MIXTURE.

Materials Used—

Copper sulfate (blue vitriol)	4 lbs.
Stone lime	5 lbs.
Water	50 gals.

This makes a 4-5-50 mixture of the spray. The amount of copper sulfate can be varied according to the formula given. The weight of stone lime should be equal to or exceed the weight of copper sulfate.

Apparatus—

2 half barrels with a capacity of about 30 gallons, made by sawing in two a 60-gallon barrel.
1 60-gallon mixing barrel.
2 or more wooden pails.
1 strong paddle, about 7 feet long.
1 pair hand scales.
1 strainer, of cloth or 20-mesh brass gauze.

Preparation—

4-5-50 *Formula From Fresh Material.*

1. Dissolve 4 pounds copper sulfate in hot water, place in half barrel and add water to make 25 gallons.

2. Slake 5 pounds of stone lime in the second half barrel and add water to make 25 gallons.

3. Mix solutions by having two operators, each provided with a bucket, dip up equal amounts of the copper sulfate and lime solutions, respectively, and pour them together at the same rate at a height of two or three feet above a mixing barrel (Plate XIX).

Plate XIX. Showing method of mixing copper sulfate and lime solutions in preparation of Bordeaux spray mixture.

4. Mix the whole thoroughly by stirring vigorously.

5. Strain the mixture when putting into the spray tank.

6. Apply to the plants with any good pressure spray pump. Use as soon as made.

If other than a 4-5-50 formula is given, take respective pounds as indicated in formula. For example, to make a 3-2-50 formula, take 3 pounds of copper sulfate and dissolve in 22 gallons of water, and 2 pounds of lime and slake and add to 23 gallons of water. Mix the two as before indicated.

Stock Solution.

Where spraying is to be done on a large scale, "stock solutions" of copper sulfate and lime are made up in advance.

1. Place 50 pounds of copper sulfate in a clean gunny sack and suspend it just beneath the surface in a barrel containing 50 gallons of water. This dissolves in 12 to 24 hours. One gallon of the solution contains 1 pound of copper sulfate.

2. Slake 50 pounds of good quality stone lime in a barrel and add water to make 50 gallons. When stirred, 1 gallon contains 1 pound of lime.

Preparation of 4-5-50 Formula From Stock Solutions.

1. Stir stock solution thoroughly.

2. Put 4 gallons of stock solution of copper sulfate in one of the half barrels and add water to make 25 gallons.

3. Put 5 gallons of stock solution of lime in the other half barrel, and add water to make 25 gallons.

4. Mix, following directions as given in preparation of 4-5-50 formula from fresh solutions, under 3, 4, 5, and 6.

5. After removing enough of the stock solutions for one spraying, mark on the barrels by nailing strips of boards just at the top of the solutions. Before the next spraying, add water to bring the solution up to these marks. This replaces the water lost by evaporation and gives a solution of known strength.

If other than a 4-5-50 formula is given, take respective gallons as indicated in formula. For example, to make a 3-2-50 formula, take 3 gallons of stock solution of copper sulfate and put into 22 gallons of water, and 2 gallons of stock solution of lime and put into 23 gallons of water. Mix the two as before indicated.

Preparation of Bordeaux Mixture With Addition of Resin-Fish-Oil Soap.

1. Dissolve 2 pounds of resin-fish-oil soap in 2 gallons of water.

2. Add only enough water to the slaked lime, before mixing, to make 23 gallons.

3. After the copper sulfate and lime solutions have been mixed, add the 2 gallons of soap solution.

4. Mix, strain, and spray as before indicated.

COMMERCIAL LIME-SULFUR SPRAY.

Buy the commercial product from some reliable dealer and use as directed.

SELF-BOILED LIME-SULFUR SPRAY 8-8-50 FORMULA.

Materials—

Stone lime	32 lbs.
Flowers of sulfur	32 lbs.
Water to make	200 gals.

In this preparation 4 times the 8-8-50 formula is used because it has been found that these quantities give more satisfaction and convenient conditions for cooking than when smaller or greater amounts are used.

Apparatus—

1 strong 50-gallon barrel.
1 strong paddle, about 7 feet long.
1 sifter (flour sifter).
2 or more buckets.
1 pair hand scales.
1 strainer, of cloth or 20-mesh brass gauze.

Preparation—

1. Weigh out 32 pounds each of lime and sulfur, having first sifted the sulfur.
2. Place lime in barrel and add about 4 gallons of water.
3. Add sulfur as soon as the lime begins to slake vigorously.
4. Stir preparation vigorously with the paddle, adding enough water from time to time to avoid "burning," and still not enough to "drown" the lime.
5. Add at least 25 gallons of cold water with vigorous stirring as soon as the lumps of lime are thoroughly slaked. It is very necessary to cool the preparation at this time by adding the water as indicated.
6. Make up to 200 gallons, or dilute fractions of the stock solution correspondingly.
7. Strain before putting into spray tank by running the solution through a cloth strainer or a 20-mesh brass wire strainer. Work through any lumps of sulfur with a small paddle.
8. Apply the spray with any good pressure spray pump.

AMMONIACAL COPPER CARBONATE.

Copper carbonate	5 oz.
Ammonia	3 pints
Water	45 gals.

Preparation—

1. Add water to the carbonate to make a thin paste.
2. Dissolve the carbonate in ammonia, diluted with about 2 gallons of water.
3. Make up to 45 gallons.

FORMALIN.

Non-poisonous to animals.

Formaldehyde (40%), also called Formalin	1 pint
Water	40 gals.

The above is the usual formula for formalin. The amount of water used varies with the use to which solution is put and with length of treatment. Use as directed in special cases.

CORROSIVE SUBLIMATE.

Deadly poisonous to animals.

Corrosive sublimate crystals	4 oz.
Water	30 gals.

Dissolve the corrosive sublimate in 2 or 4 quarts of hot water, and dilute this strong solution with water to make 30 gallons.