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FRUIT AND VEGETABLE DISEASES AND THEIR CONTROL

BY

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DIVISION OF PLANT PATHOLOGY AND BOTANY



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FRUIT AND VEGETABLE DISEASES AND THEIR CONTROL

BY E. C. STAKMAN AND A. G. TOLAAS

This bulletin is designed to meet in some measure the demand for information as to the control of plant diseases, which is made annually on the Minnesota Experiment Station by orchardists, small-fruit growers, and vegetable-growers. Many details are necessarily omitted, but these can be supplied in correspondence between those interested and the Station's Section of Plant Pathology.

The intelligent application of control measures depends on a knowledge of the cause and nature of the diseases. For this reason brief explanations as to cause and nature are included.

SPRAYING

Measures for the control of diseases of fruit and vegetable crops vary. The idea that spraying will not only prevent but also cure nearly all of the serious diseases is still too prevalent. It cannot be stated too strongly that precautionary measures should be taken. It is absolutely necessary to prevent most diseases, since it is impossible to cure them. Too little attention is paid to the selection of disease-free seed, to sanitation, and to proper pruning.

Seed selection, seed disinfection, rotation of crops, sanitation in its strictest sense, the use of varieties of plants resistant to a given disease, proper pruning, control of insects, and systematic and intelligent spraying may have to be resorted to in order to prevent serious losses from diseases. These measures are mentioned specifically in the discussion of the diseases. A brief general discussion of spraying, however, may be of value.

WHEN TO SPRAY

No general statements applicable to all conditions can be made. Spraying, in order to be effective, must be done at the proper time. The time depends on the disease, on the peculiarities of the disease in a given locality, and very largely on local conditions. Recommendations are given, where possible, in the text of the bulletin.

Weather conditions should always determine, at least to a certain extent, when the spray material should be applied. It must be remembered that spraying only protects plants from infection, and does not cure them after they are once infected. For this reason it is much

better to spray before a rain instead of after, as most infection takes place during periods of wet weather. Whenever it is possible, therefore, to take advantage of weather reports, spraying should be done before general periods of rainy weather. If spray mixtures are allowed to dry for an hour or two, they will usually stick, even through heavy, driving rains.

WITH WHAT TO SPRAY

Any substance which kills a fungus is known as a fungicide. Various fungicides are used in spraying fruit trees and vegetables. Of these the most common are lime-sulfur and Bordeaux mixture. For spraying apples and plums, commercial lime-sulfur has now displaced Bordeaux mixture to a large extent in Minnesota, because of its convenience. It is merely necessary to dilute it with water. It is very effective against such diseases as apple scab and brown rot of plum. However, Bordeaux mixture is considered more effective than lime-sulfur against such diseases as downy mildew of grape, tomato leaf spot, bitter rot and black rot of apple. Spray injury may sometimes result from either mixture, but Bordeaux is probably more likely to cause injury than lime-sulfur, especially on fruit. There should be no very great difference in the cost of the two, altho exorbitant prices are sometimes charged for lime-sulfur. When this is the case, it is advisable either to substitute Bordeaux mixture or make lime-sulfur at home. Iron sulfide has also been used with excellent results for general orchard work and can be highly recommended.

Other materials, too, are used as fungicides for certain diseases. For instance, potassium sulfide is considered especially effective against such diseases as the powdery mildews. There are, again, several patent fungicides on the market, some of which are advertised as being both fungicides and insecticides. Some of these have been tried at the Minnesota Station, but as a rule they are no cheaper than the standard fungicides and give no better results, and in a great many cases not such good results. There is no question as to the efficiency of lime-sulfur or Bordeaux mixture when used in the proper manner, at the proper time, and against the proper diseases. For this reason there is ordinarily no particular advantage in substituting some highly advertised but untried commercial preparation.

An insecticide can often be combined with a fungicide and both applied at the same time. The most common combination in orchard and garden work is arsenate of lead with either Bordeaux mixture or lime-sulfur. Often there are insect pests, as well as fungous pests, to be controlled. For this reason combination sprays should be applied whenever both are needed. The general spraying schedule,

together with the combination spray, will be found in the Spray Calendar on page 66.

HOW TO SPRAY

A great deal depends on the thoroughness of the spraying. In order to spray thoroughly, a good machine should be used. The size is of less importance than the quality. The size and type of machine will vary with the kind and amount of work to be done. For a large orchard, a power sprayer or a good barrel pump which can be carried on a wagon should be used. There are also small gasoline engines attached to barrel pumps which cost from \$100 to \$125. A small outfit can be bought for from \$30 to \$40. Sprayers suitable for small gardens or bush fruits can be purchased for still less. One of the greatest essentials in all machines is a good pump, one which is durable and with which it is possible to maintain a high and constant pressure. A high-pressure tank attachment is very desirable. With such a tank it is possible to maintain a pressure of 200 pounds or more with a hand pump. The average orchardist or gardener in Minnesota does not use enough pressure in spraying. At least 200 pounds should be used when trees are being sprayed. This is both economical and effective. The reason for it is simple. When the spray material is applied under high pressure it is blown out in very fine drops and the plant parts can be covered very quickly without drenching. In this way material is saved. When low pressure is used, necessitating the use of a greater amount of the material, the spray material often collects along the margins and veins of leaves and causes spray injury. All parts of the plant should be uniformly covered with the spray material. It is only in this way that protection against infection is assured. To get the best results a good type of nozzle is also necessary. In the last few years in experimental work at this Station, comparisons have been made of Bordeaux types of nozzles and the Vermorel types. The results were not consistent. When high pressure was used they both gave good results. In general, any type of nozzle which gives a good, fine spray will be effective if sufficient pressure is used.

Caution: Never spray trees when in full bloom; it is not necessary and may injure bees.

COST OF SPRAYING

Several items enter into the cost of spraying. These can be summed up as follows: (1) Location of the grower with respect to the manufacturer of spray materials; (2) materials used; (3) type of machinery used; (4) convenience in preparation and application.

A grower at a considerable distance from the manufacturer may

have to pay more for his material than one who is nearer. This added cost can be considerably reduced if several growers cooperate and buy the materials in large quantities. Bluestone, in 100-pound lots, usually costs from 8 to 10 cents a pound. (Because of the European war the price is now abnormally high.) Commercial lime-sulfur costs 20 or 25 cents a gallon in 50-gallon barrels. Powdered sulfur in barrel lots costs from 2 to 4 cents a pound, and stone lime usually less than 1 cent.

The kind of sprayer to be used depends a great deal on the size of the orchard. A power sprayer, costing several hundred dollars, is best for an orchard of more than five acres, while for smaller orchards or gardens sprayers may be had for from \$10 to \$75.

An important consideration is the convenience with which the spray materials can be mixed. This involves the location of the mixing tanks in relation to the orchard and the source of the water supply, and the kind of mixing tanks used, consideration being given to the ease and quickness with which the sprayer can be filled. The greater the convenience with which these things can be done, the smaller will be the cost of labor.

Experiments at the Minnesota Experiment Station and in cooperation with some of the fruit-growers have been carried on with a view to determining the actual cost of spraying a tree with different fungicides. The results have shown only a small difference between the cost of the Bordeaux mixture and the different lime-sulfur sprays. The average cost of spraying large apple trees four times varies from 18 to 25 cents a tree. This includes cost of materials, labor, and depreciation of machinery.

The question always arises as to whether or not it pays to spray. The following figures, based on 100 trees per acre, were obtained from careful records kept for several years on the value of spraying apples:

	Average Yield	Marketable Fruit, No. 1
Sprayed fruit.....	375 bushels	282 bushels
Unsprayed fruit.....	300 bushels	144 bushels
Difference		<u>138 bushels</u>

At 50 cents a bushel there is a difference of \$69 an acre in favor of the sprayed trees. After deducting \$17.60, the average cost of spraying, a net increase of \$51.40 an acre remains.

FUNGICIDES

AMMONIACAL COPPER CARBONATE

Copper carbonate, 5 ounces
 Ammonia, 3 pints
 Water, 50 gallons

Ammoniacal copper carbonate is not so good for general purposes

as Bordeaux mixture. It is used instead of Bordeaux when it is desirable to avoid the spotting of leaves or of ripening fruit. It is prepared as follows: Make a paste of 5 ounces of copper carbonate and water. Add 3 pints of ammonia to 3 gallons of water and dissolve the copper carbonate paste in it. Add this to 47 gallons of water. This should be used fresh; it loses strength by standing.

BORDEAUX MIXTURE

Copper sulfate, 4 pounds
 Quick lime, 4 pounds
 Water, 50 gallons

Bordeaux mixture is made of copper sulfate (bluestone), quicklime, and water. It is used in various strengths, the 4-4-50 probably being most commonly used. Four-four-fifty simply means that 4 pounds of copper sulfate, 4 pounds of lime, and 50 gallons of water are used in the preparation of the spray, and 2-2-50 means that 2 pounds of copper sulfate, 2 pounds of lime, and 50 gallons of water are used. The number of pounds of copper sulfate is indicated by the first figure, the number of pounds of lime by the second, and the number of gallons of water by the third.

Bordeaux mixture may be made in two ways: It may be made for immediate use, or a stock solution may be made and diluted whenever the fungicide is needed. In making the spray for immediate use, put 4 pounds of copper sulfate into a cloth sack and hang it in a barrel containing 25 gallons of water. Being suspended, the copper sulfate will dissolve much more readily than if resting on the bottom of the barrel. It dissolves more quickly in hot than in cold water. Now slake carefully 4 pounds of good quicklime, using just enough water to slake it slowly. Be sure to use the best quicklime available. When the lime is slaked, add enough water to make 25 gallons. Stir it carefully and then pour together the copper sulfate solution and the milk of lime, so that the streams mix in pouring. A slight excess of lime is desirable, as it prevents any injurious action of the copper salts. This excess will always be present if the lime is of good quality. If there is an excess of copper, foliage injury is likely to result. Therefore, simple tests may be made to determine whether or not the mixture is safe to use. Put a piece of newly filed iron or steel into the mixture for about a minute. If it has a copper coating when it is taken out, there is an excess of copper, and more lime should be added. To determine whether or not there is enough lime in the mixture, pour some of it into a flat dish and blow on it for a few moments. If a film forms on the surface, enough lime is present, if not, more should be added. If the mixture is alkaline it is perfectly safe. This can be determined by the use of litmus paper which can be obtained at

drug stores with directions for its use. Bordeaux mixture should be used the same day it is made. If it is necessary to keep it for a day or two, add 2 ounces of cane sugar to each 50 gallons of the mixture.

In making stock solutions, dissolve copper sulfate in water at the rate of 1 pound to 1 gallon of water. Slake the lime slowly in another vessel, and, when slaked, add water until a thick lime milk, 1 pound to 1 gallon of water, is formed. When using the stock solution in making up the spray mixture, 1 gallon of copper sulfate solution represents 1 pound of copper sulfate, and 1 gallon of lime water represents a like amount of lime—more or less, depending on the quantity of water used in making the stock solution. The stock solutions should be diluted separately before they are poured together. The stock solution of lime should first be run through a fine-mesh sieve, to remove all lumps which might clog the nozzle of the sprayer. Stock solutions can be kept indefinitely.

COPPER SULFATE WASH

Copper sulfate, 3 pounds
Water, 50 gallons

Copper sulfate is sometimes used as a wash on dormant trees. It must never be used on trees after the buds have burst.

CORROSIVE SUBLIMATE SOLUTION

Mercury bichloride (corrosive sublimate), 2 ounces
Water, 15 gallons

Corrosive sublimate solution is extremely poisonous when taken internally, and should be handled with great care. It is not injurious to the skin, however. It is very effective in treating seeds and is used for disinfecting pruning instruments when cutting out fire blight or cankers. It should not be placed in metal vessels, as it may corrode them.

FORMALDEHYDE SOLUTION

Formaldehyde (40 per cent), $\frac{1}{2}$ pint
Water, 15 gallons

Formaldehyde solution is used in treating seeds.

IRON SULFIDE MIXTURE

In preparing iron sulfide solution it is recommended that a self-boiled lime-sulfur mixture be prepared, as hereinafter described; except that 10 pounds of lime and 10 pounds of sulfur are used. The mixture is diluted to 40 gallons, and then 3 pounds of iron sulfate (copperas), dissolved in about 8 gallons of water, is added.

Commercial lime-sulfur may be used instead of the self-boiled mixture. When this is done, add $1\frac{1}{4}$ gallons of the commercial mixture to 50 gallons of water and then dissolve 3 pounds of iron sulfate di-

rectly in this solution. If more convenient, the iron sulfate may be dissolved in the water before the commercial lime-sulfur is added. Or a stock solution of iron sulfate may be made, if it is used in large amounts, and kept until ready for use. Iron sulfate is not in general use in this state, but experiments have been made with it at the Experiment Station for several years and it has given excellent results.

The iron sulfate should always be put into a cloth sack and hung in the water or the lime-sulfur mixture. It dissolves better in this way.

This method may be varied without appreciably decreasing the effectiveness of the mixture.

LIME-SULFUR, CONCENTRATED

Concentrated lime-sulfur may be bought already prepared or it may be made at home. When made at home it is necessary to have a Baumé hydrometer to determine the density of the material. The following directions for making it, and the table of dilutions, are taken from Geneva, New York, Bulletin 329.¹

Lime (pure lime, CaO, used as basis), 36 pounds
Sulfur, high-grade, finely divided, 80 pounds
Water, 50 gallons

When lime containing impurities is used, more than 36 pounds must be taken in order to obtain 36 pounds of pure lime. (Use 40 pounds of lime containing 10 per cent of impurities, i.e., 90 per cent pure.)

Make a paste of the sulfur with about 10 gallons of hot water. Add the lime. As the lime slakes add hot water as necessary to prevent caking. When the lime has slaked add hot water to make 50 gallons and boil for one hour. Stir the mixture constantly, especially the sediment in the bottom of the kettle. Add water frequently during the boiling so as to keep the level of the mixture near the 50-gallon mark. Store in air-tight, hardwood barrels.

When ready for use, test the concentrate with a Baumé hydrometer and dilute according to the following table:

Concentrate Testing	Dormant Spray	Apple Summer Spray	Cherry and Plum Summer Spray
Degrees (Baumé)			
35.....	I-16½	I-43½	I-56
34.....	I-16	I-42½	I-54
33.....	I-15½	I-41	I-52
32.....	I-15	I-40	I-50
31.....	I-14½	I-39	I-48
30.....	I-14	I-37½	I-46
29.....	I-13½	I-36	I-44
28.....	I-13	I-35	I-42
27.....	I-12½	I-33½	I-40½
26.....	I-12	I-32½	I-38½
25.....	I-11	I-31	I-37

¹ Van Slyke, L. L., Bosworth, A. W., and Hedges, C. C. Chemical Investigation of Best Conditions for Making the Lime-Sulfur Wash. N. Y. Agr. Exp. Sta., Geneva, Bul. 329. 1919.

Arsenate of lead may be added to the diluted concentrate at the rate of from 2 to 3 pounds to 50 gallons. Do not use Paris green, arsenite of lime, or arsenite of soda with lime-sulfur.

LIME-SULFUR, COMMERCIAL

Dormant wash	}	Lime-sulfur, 1 gallon
		Water, 9 gallons
Summer spray	}	Lime-sulfur, 1 gallon
		Water, 40 gallons

Commercial lime-sulfur is a manufactured preparation and may be used according to the above formulas instead of the homemade preparations. It has the advantages of being ready for use, and of not clogging the nozzles.

LIME-SULFUR, SELF-BOILED

Lime, 8 pounds
Sulfur, 8 pounds
Water, 50 gallons

Self-boiled lime-sulfur is especially valuable in cases where Bordeaux is injurious to foliage or fruit. The stone fruits, such as plums, are sometimes injured by Bordeaux, while some varieties of apples are badly russeted by it. There is slight danger of injury by the self-boiled lime-sulfur preparation, and it is an efficient fungicide when properly made. It stains the fruit, as does Bordeaux. In making it, 8 pounds of lime of good quality should be put in a barrel, and enough water added to nearly cover it. While the lime is slaking, add the sulfur, which should be run through a sieve to break up the lumps. The sulfur should be thoroly stirred into the slaking lime, enough water being added to make a pasty mass and to keep the mixture from burning. While the slaking is going on the mixture should be constantly stirred. The slaking will be completed in from five to fifteen minutes and enough cold water to bring the total to 50 gallons should be immediately added. In applying the mixture a good agitator in the sprayer is necessary.

POTASSIUM SULFIDE SOLUTION. (LIVER OF SULFUR)

Potassium sulfide, 3 to 5 ounces
Water, 10 gallons

Potassium sulfide solution is sometimes used in place of Bordeaux, to avoid spotting of foliage and fruit, and is considered especially effective against powdery mildews, such as the gooseberry mildew. It is also quite extensively used in greenhouses and on shrubbery.

COMMERCIAL PREPARATIONS

There are several patent spray preparations on the market that have been used by growers with some success in preventing certain

diseases. Sufficient experiments with most of these preparations have not been carried on at this Station to warrant recommending them instead of the standard mixtures.

All available information concerning them may be obtained by application to the Section of Plant Pathology, University Farm, St. Paul, Minnesota.

RESIN-LYE MIXTURE

The resin-lye mixture is often used in combination with a fungicide or an insecticide to insure the sticking of the necessary poisonous material to smooth, glossy leaves. The formula is:

Pulverized resin,	5 pounds
Concentrated lye,	1 pound
Fish or other animal oil,	1 pint
Water,	5 gallons

Put the oil, the resin, and 1 gallon of the water in an iron kettle and heat until the resin softens; then add the lye and stir thoroly. Add to this 4 gallons of hot water, and boil until a little of the boiled material mixed with cold water gives a clear, amber-colored liquid. Add water to make 5 gallons.

This is the stock solution. In spraying with Paris green or Bordeaux mixture, add 2 gallons of this mixture to 8 gallons of water, and add to 40 gallons of the spray mixture. The spray mixture to which this is added should be made with 10 gallons less water than the formula indicates, because this will be added with the resin-lye.

SULFUR

Flowers of sulfur (ordinary powdered sulfur) is often dusted on plants to prevent such diseases as the powdery mildews.

DISEASES

(For a brief summary of treatment for various crops, see calendar, page 66.)

APPLE

Scab (*Venturia inaequalis* (Cke.) Wint.)

Scab attacks fruit, leaves, and young twigs. On the fruit the disease first shows as small, olive brown patches. Later, large scabby spots are formed. The skin of the apple may crack and the entire fruit may be deformed. Before the fruit is formed the flower stalks may be attacked, causing many of the blossoms to fall. The spots first appear on the leaves as small, dark, velvety or sooty spots. The entire leaf is sometimes affected, giving it a dark appearance, the

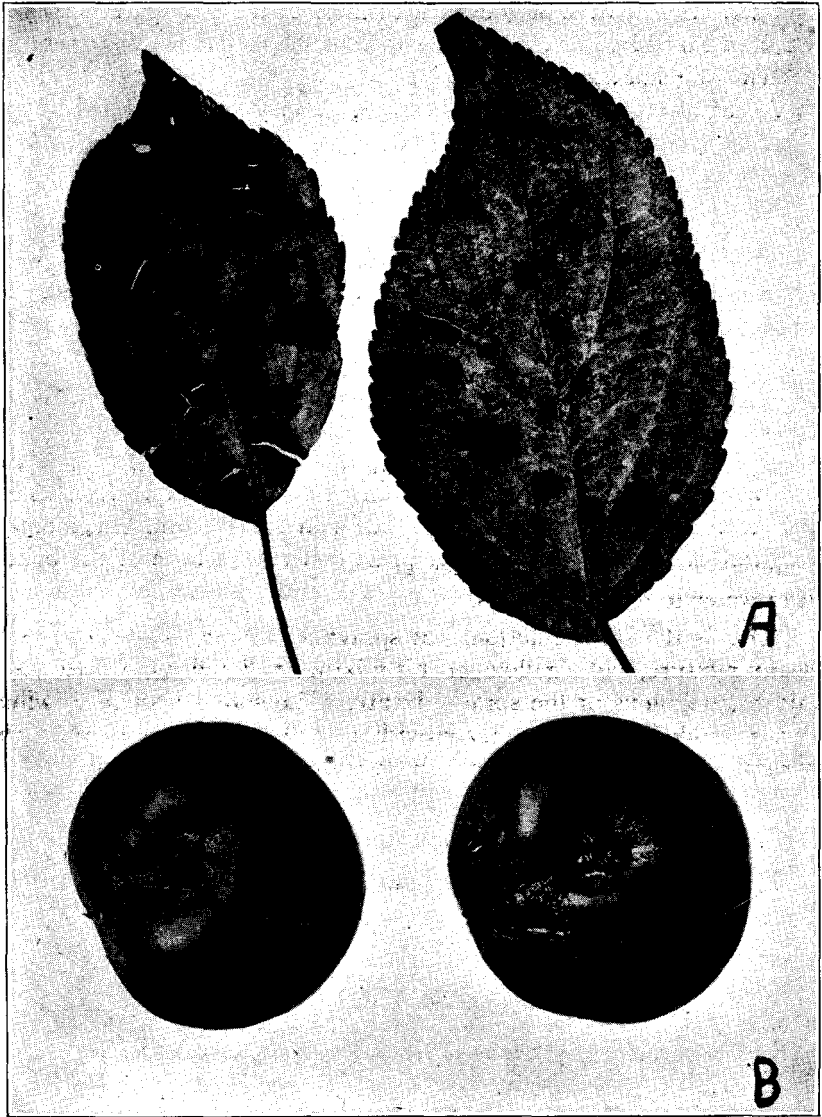


Fig. 1. Apple Scab

Scab causes olive green, felty patches on leaves, fruit, and twigs. May cause fruit to crack as shown in B. Can be controlled by thoro spraying.

veins often appearing reddish. Badly affected leaves may fall from the tree. The disease appears less often on the twigs than on the leaves or the fruit.

The causal fungus probably lives over winter mainly on the fallen leaves and possibly also to a certain extent on the affected fruit and

twigs. The first infection in the spring comes very largely from fallen leaves, possibly also from the diseased twigs. In attempting to control the disease, therefore, the leaves should be disposed of. If practicable, collect and burn them; if not, plow them under in the fall or very early spring, deep enough to remove the danger of infection.

Scab can be almost entirely controlled by means of proper spraying. Under Minnesota conditions it is sometimes possible to control it by means of two sprayings. When only two sprayings are given, the first should be given when the flower buds are almost ready to burst, and the center flowers of the clusters are beginning to show pink. The second spraying should be given just after the petals have fallen or when about two-thirds of them have fallen. Some growers apply sprays 2 and 3 (see calendar), instead of 1 and 2, and have good results if there is only a little early infection.

When the weather is wet late in the season a late scab infection may sometimes occur. Under such conditions another spraying may be necessary. As a matter of fact, the best results have been obtained as a result of three sprayings: the first, when the flower buds are almost ready to burst; the second, after the petals have fallen, and the third, about three weeks later. Whether a fourth application pays, on an average of several years, is doubtful. However, if infection occurs very late in the season, a fourth spraying may pay.

Much depends on weather conditions, the location of the orchard, the denseness of foliage on the trees, and the rapidity with which it dries after a rain. In a dry season and in a well-pruned orchard, two sprayings may suffice; in a wet season or in a crowded orchard, more will be necessary.

The application of a dormant wash before the leaf buds open probably does not pay. In experiments covering a number of years, practically no increase in perfect fruit was obtained as a result of applying a dormant wash in addition to the other sprayings, and on the average it did not pay. This does not mean that a dormant wash never pays. If there are scale insects in the orchard, a dormant wash should, by all means, be given.

Various fungicides have been used in controlling the scab. Commercial lime-sulfur and Bordeaux mixture have both proved very effective. In a large number of experiments covering several years, 4-4-50 Bordeaux mixture, commercial lime-sulfur (1-40), and iron sulfide all gave excellent results.

Success in controlling the scab depends very largely on the timeliness and thoroughness of spraying. In general, if weather conditions can be forecasted, it is better to spray before a rain than after, since the greatest protection is needed during a rain. Precaution should, of

course, be taken to spray long enough in advance to give the material time to dry on the leaves. Ordinarily, if the spraying has been thoro, and if it has had an hour or two in which to dry, the material will remain on the plant during the rain.

Spraying should be thoro. It must be remembered that only those parts of the plant which are covered with the spray material are protected against the attack of scab. It is probably better to apply a fine, mist-like spray in order to cover the surface evenly, than to use a driving spray in which certain parts of the plant are likely to be over-sprayed and other parts under-sprayed.

Experiments have been conducted at the Minnesota Experiment Station to determine the type of nozzle which gives the best results under varying conditions. The results, however, were somewhat conflicting, and no definite recommendations can be made. As a general rule the spray material should be applied under high pressure, rather than under a low pressure which requires the use of more material. If some of the material collects on the margins of the leaves or along the veins, injury may result. It is much better to use a spray which will cover the surfaces evenly than to apply the material in such a way as to drench the leaves and fruit.

Fire Blight (*Bacillus amylovorus* (Burrill) De Toni)

The most striking characteristics of fire blight are the browning of leaves and blackening of twigs. The dead leaves remain on the trees for some time. On close examination the blighted twigs or branches are seen to be very distinctly blackened. Small branches, large limbs, and sometimes even the trunks may be affected.

Fire blight is so called because in severe cases whole trees may appear to have been scorched. The disease is caused by a bacterium and is very contagious. Usually the microbe is carried to the tree by insects which visit the flowers or twigs. When it is deposited on a flower it multiplies very rapidly and the blossom is blackened and killed. This phase of the disease is known as blossom blight.

The infection may extend along under the bark, killing and blackening the twig and often progressing into the branches. It may also get into the trunk, either through wounds or through shoots growing out from the trunk, and may then cause the so-called body blight. When it gets into the base of the tree it may cause what is known as collar rot or collar blight. When the affected parts have been killed, wood-rotting fungi may enter and cause still more damage.

Infection takes place not only through the flowers, but also through tender shoots, water sprouts, suckers, or spurs. For this reason, in orchards where the blight has gained a foothold, nothing should be

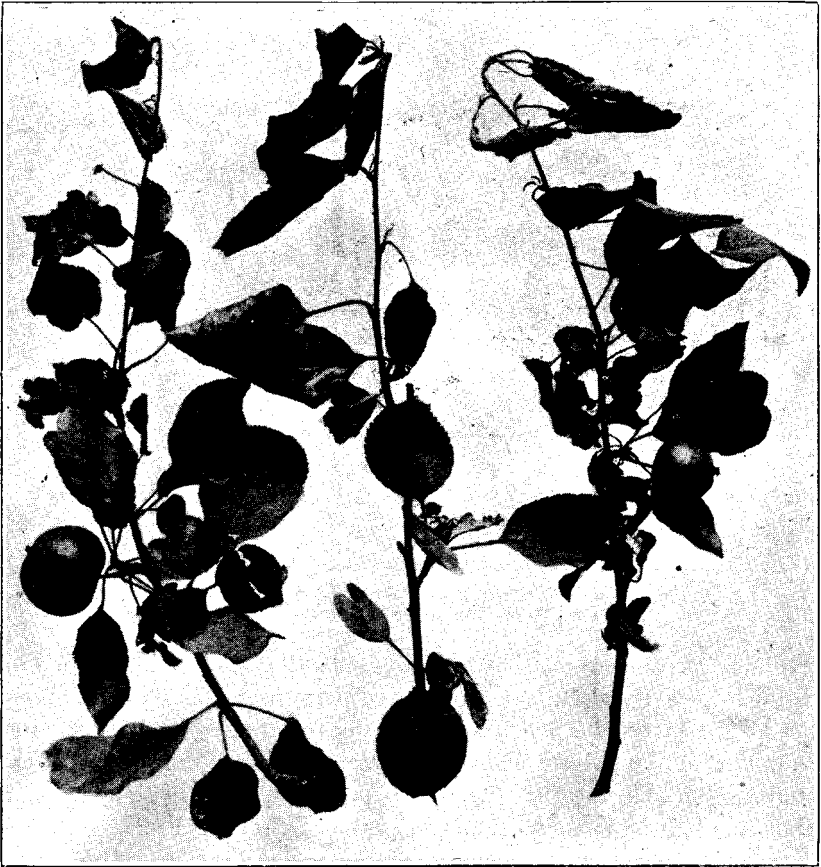


Fig. 2. Fire Blight on Young Twigs

done which would encourage the growth of many tender shoots. It may even be advisable to put in a cover crop for a while.

In many of the branches the germs are killed during the winter, but in some they remain alive and become active again in the spring. These so-called holdover cankers are sources of new infection. On such cankers a milky liquid is often exuded, sometimes so abundantly that it runs down the trunk. The liquid contains countless bacteria and insects are attracted to it and thus carry the bacteria to other trees. It is, therefore, important to control harmful insects, such as plant lice and the tarnished plant bug.

The only practicable method of eradicating the blight from an orchard is to cut away all blighted wood. This is most conveniently done in late summer, in the fall after the season's growth is over, or early in the spring. At this time the blighted portions are easily detected. Every bit of blighted wood should be cut out, even if the whole

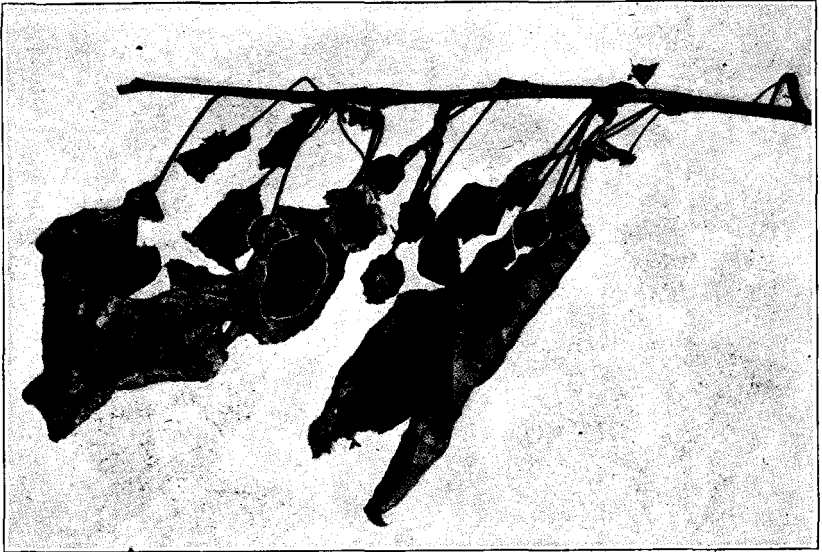


Fig. 3. Twig Blight (Fire Blight) of Apple
Note dead leaves, dead wood, and dead shrunken fruit.

tree must be sacrificed. The branches should always be taken off some distance back from the clearly diseased parts in order to insure cutting out all the infected wood. In the spring the trees should be carefully examined and any limbs which may have been missed in the fall should be removed. During the summer frequent inspections should be made and the blight cut out wherever it appears. Since the disease is contagious, the pruning knife should be disinfected after each limb is cut. Corrosive sublimate dissolved in water at the rate of 1 part to 1,000 parts of water is best for this purpose. The pruning instrument may be swabbed with a cloth soaked in the solution, or dipped directly into the solution.

The wild crabapple, thornapple, Juneberry or service berry, and the mountain ash may be affected with the same disease. These should, therefore, be treated the same as apple trees. Cut out old trees—sources of infection.

Coöperation is absolutely necessary. Cutting the blight out of one orchard when a neighboring one is still affected will do little good. That blight can be controlled in Minnesota orchards, even when present in serious form, has been definitely shown.

Rust (*Gymnosporangium juniperi-virginianae* (Schw.) Schr.)

Rust attacks leaves, fruit, and sometimes young twigs. At first, honey-colored spots are produced on the upper surface of the leaves, usually in June or July. Later, orange-colored spots, sometimes sur-



Fig. 4. Fire Blight Cankers Caused by Infection of the Young Fruit Spurs at X. Such cankers should be cut off and burned. Borders of cankers are shown by lines.

rounded by a red area, are developed on the lower surface. If these are closely examined it will be seen that they are composed of little cup-like structures with fringed edges.

The disease is caused by a fungus which overwinters on red cedar trees, on which it produces the galls or so-called cedar apples. (See Figure 6.) From the red cedar the infection again spreads in the

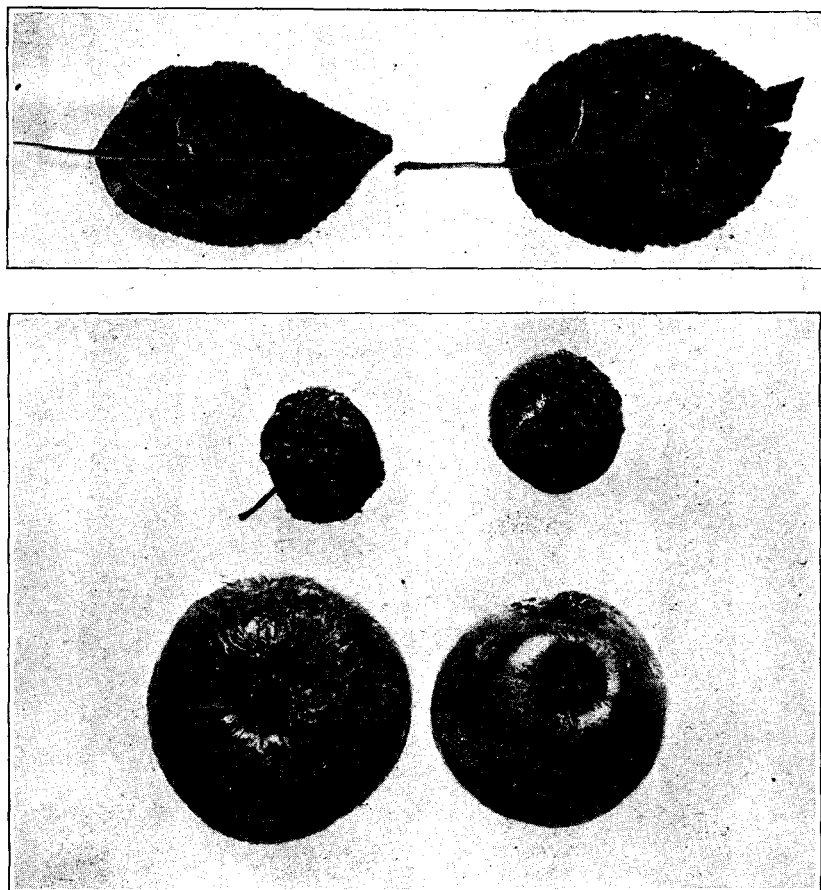


Fig. 5. Apple Rust, Summer Stage on Leaves and Fruit

spring or early summer to the apple trees. This takes place especially during wet weather.

Control measures are difficult unless the red cedars are removed from the vicinity of the orchard. Very thoro spraying, especially if given just before a rain, controls the disease to some extent. It is probable that if the cedars were closely watched and the spray material applied to the apple trees just before the cedar galls gelatinize, the trees would be fairly well protected. However, this is not very practicable. Rust sometimes is serious in orchards which have been thoro-ly sprayed for scab. If the orchard is valuable, and susceptible varieties are grown, red cedars should be removed from the neighborhood of the orchard. This is the surest method of controlling the disease. If possible, all should be removed within a radius of three-quarters of a mile. Spraying the cedar trees has been tried, but with only in-different results.

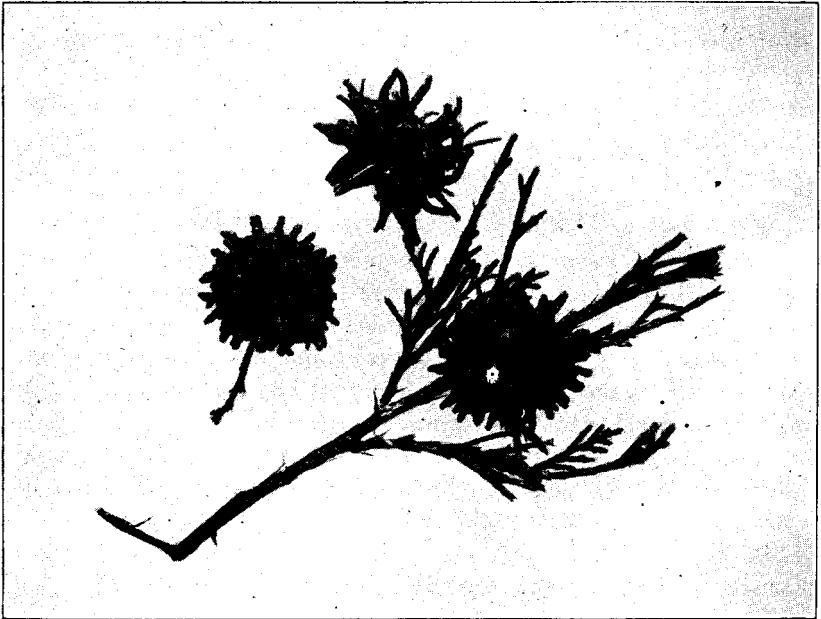


Fig. 6. Apple Rust, Winter Stage on Red Cedar. Above, Gelatinizing; below, Non-Gelatinizing
In spring millions of spores are produced on these cedar apples which blow to the apple leaves and young fruit. Rust can be controlled by cutting out cedars.

Of the large apples commonly grown in Minnesota, only the Wealthy is really susceptible, but several crabs are affected. The losses occur, not only as a result of defoliation of the tree and consequent decrease in yield, but also as a result of decreasing the vigor of the entire tree.

Bitter Rot (*Glomerella cingulata* (Stonem.) S. and v. S.)

Bitter rot occurs on fruit and branches. On the fruit it appears first as small, brownish patches beneath the skin. These patches rapidly enlarge until they are of considerable size, when they form sunken, often wrinkled, areas, which may be corky and bitter around the edges. Often, in later stages, threadlike strings of spore masses, usually arranged in concentric circles, appear. The color is first pink; later, gray; and finally, very dark. The fruit is especially liable to attack while it is ripening, but it may become infected earlier. Warm, damp weather is very favorable to the rapid spread of the disease.

On the branches cankers are formed. They are usually round or somewhat elongated spots, sometimes several inches long. The bark becomes very dry, cracks, and causes a characteristic sunken, wrinkled appearance. The disease probably persists largely in these cankers and also on the "mummied" fruit.

All rotten apples should be destroyed, and the cankered twigs pruned out. This, together with spraying, will control the disease, since it is usually not very serious in Minnesota. If spraying to prevent this disease alone, about a month after the petals have fallen would probably be early enough to begin, using 4-4-50 Bordeaux mixture. One spraying may be sufficient, but another, about a week later, may be necessary.

Powdery Mildew (*Podosphaera oxycanthae* (De C.) De Bary)

Powdery mildew has the characteristics of the powdery mildews in general—the affected parts appearing dirty gray. It is not often found on mature trees in this state, but sometimes occurs on nursery stock. Control measures consist in spraying very thoroly as soon as the leaves begin to unfold, and repeating the operation as often as is necessary. Iron sulfide is said to be most effective.²

Cankers

Several cankers occur on apple trees in Minnesota. Besides fire blight cankers, bitter rot cankers, and black rot cankers, there are various others caused by different fungi which are destructive in certain localities.

²Ballard, W. S. and Volck, W. H. Apple Powdery Mildew and Its Control in the Pajaro Valley. U. S. D. A. Bul. 120. 1914.

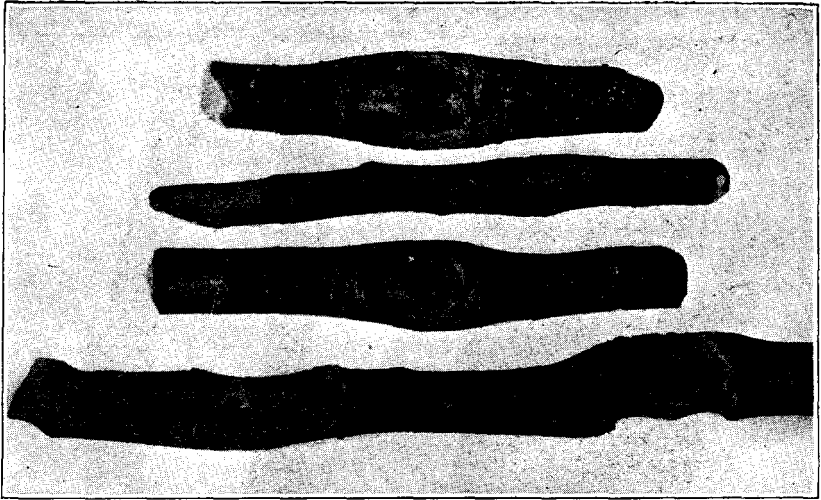


Fig. 7. Coniothyrium Canker on Apple

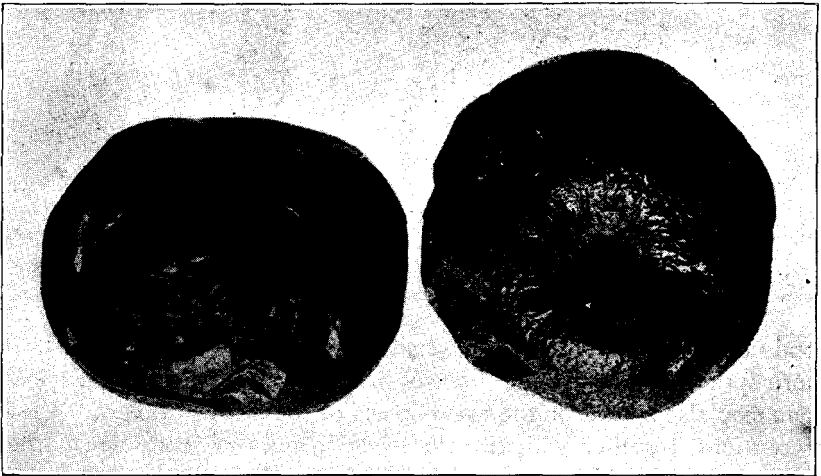


Fig. 8. Black Rot of Apple

Note the small black eruptions over the entire surface. These are the fruiting bodies of the fungus and serve as a source of infection to healthy fruit. Black rot is also produced on the twigs.

In general, in controlling these cankers, all wounds and bruises on the trees should be protected. When the cankers appear they should be pruned out. If valuable limbs or the trunks are affected, it is sometimes sufficient to scrape out all of the diseased area, taking pains to do this very thoroly. The wounds may then be disinfected and covered with coal tar or liquid asphaltum. Wounds from an inch to an inch and a half in diameter do not usually require treatment. After this pruning a very thoro dormant wash will sometimes keep the trees in



Fig. 9. Black Rot Canker on Apple

Note the numerous small, pimple-like bodies. These produce millions of spores which are blown to healthy trees, causing infection on them.

good condition. This dormant wash should always be followed by a thoro spraying to control all diseases of leaves and fruit, since some of them may also appear on the woody parts of the tree as cankers. These precautions, together with care in selecting nursery stock when trees are replaced, should keep the cankers fairly well in check. Whenever tree surgery is necessary, the work should be done by an experienced person.

Black Rot (*Sphaeropsis malorum* Pk.)

Black rot attacks the fruit, the twigs, and the leaves. On the fruit it closely resembles bitter rot, especially in the earlier stages, altho the diseased areas are usually darker than those formed by bitter rot. The color becomes darker until eventually the apple dries out, leaving only a black, much shrunken and shriveled, mummied fruit. Beneath the skin many small black eruptions may appear. In the bitter rot spots threads are formed; in the black rot spots these are not produced.

The woody parts of the plant may also be affected. The fungus often gains entrance through wounds and causes cankers which may girdle limbs. Treatment consists in carefully pruning out all cankered areas and in destroying all mummied fruit, together with a thoro cleansing wash during the dormant season and careful spraying, beginning from thirty to forty days after the petals have fallen.

Bordeaux mixture proved much superior to lime-sulfur in controlling the disease in some states. Two applications, late in the summer, controlled the disease very well. No experiments have been made in Minnesota, but it is very probable that careful pruning, such as should always be practiced, together with the spraying for scab followed by a later spraying, usually thirty or forty days after the petals have fallen, will be sufficient to keep it in check, since it is not serious in most localities.



Fig. 10. Wood Rot of Apple
Wood rot often follows fire blight and other injuries.

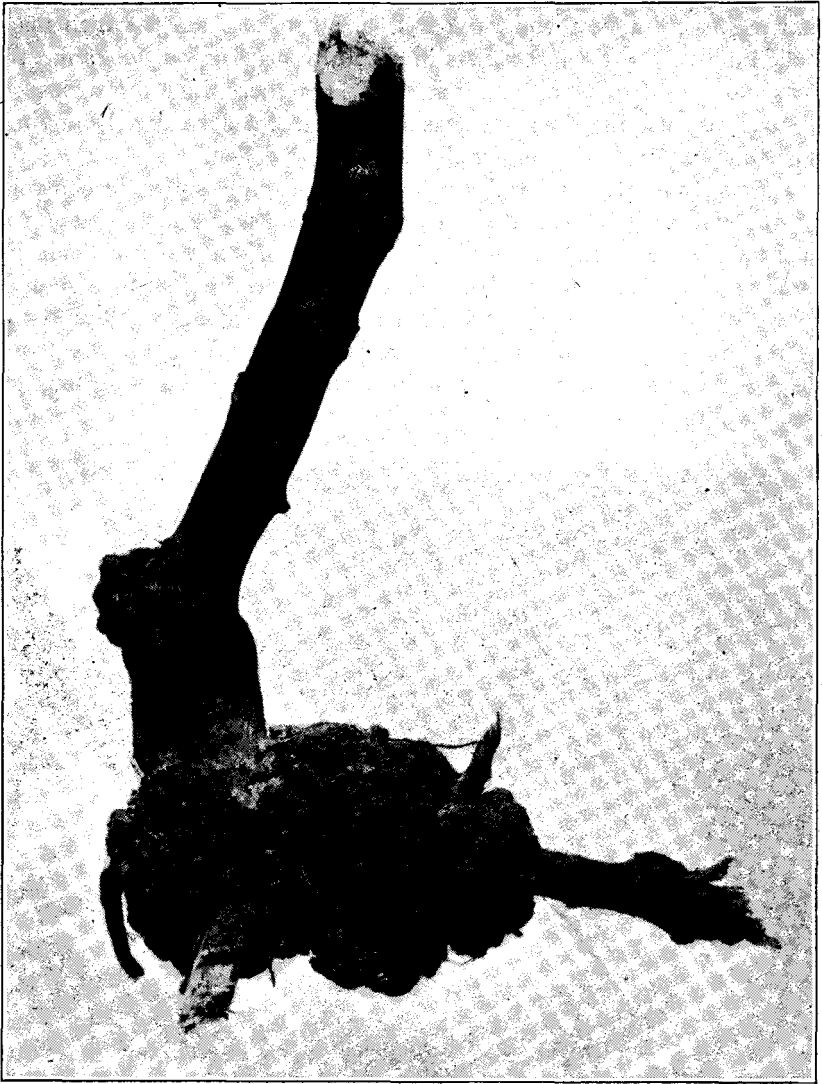


Fig. 11. Crown Gall on Apple

Crown Gall (*Pseudomonas tumefaciens*. (S. and T.) Stev.)

Crown gall is very common on apple trees. Large, irregular galls, as shown in Figure 11, are produced. These require no more extended description, since they are probably well known to most fruit-growers. There is some diversity of opinion as to the damage done by crown gall on apple trees. There is no question as to its destructiveness on raspberries and blackberries. The same germ causes both and is transferable from one host to the other. This should be remembered in

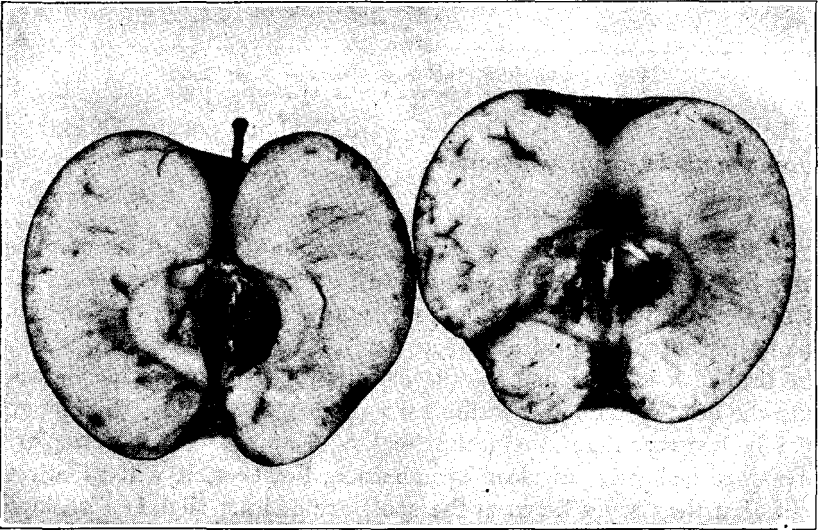
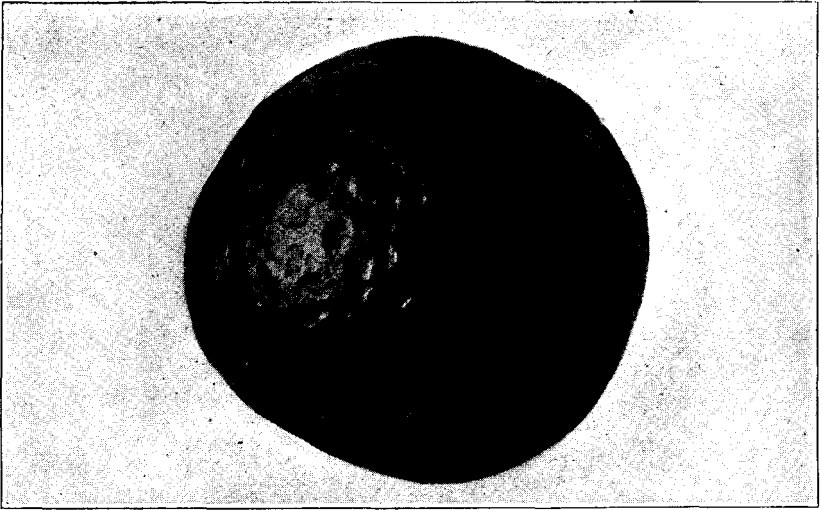


Fig. 12. Bitter Pit (Baldwin Spot)

Bitter pit resembles the Wealthy fruit spot externally, but penetrates the tissues further. The browning occurs mainly in the water-conducting tissues.

dealing with the disease. The only method of prevention is to set out healthy trees on uninfected soil.

FRUIT SPOTS

Stigmonose

This is a term applied to spots caused on apples and other fruit by the sting of various insects. It is mentioned briefly because it is not generally recognized as having been caused by insects. The spots are usually sunken, greenish in color, sometimes with a reddish tinge,

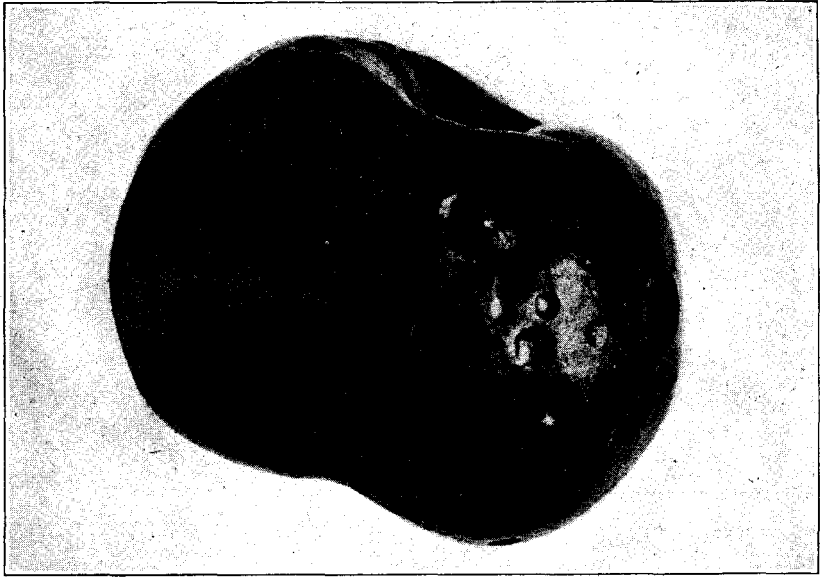


Fig. 13. Wealthy Fruit Spot (Jonathan Fruit Spot)
Note sunken areas. Occurs mostly on overripe fruit.

and the tissues in the spots become hard, dry, and corky. In extreme cases the apple may be deformed.

Bitter Pit; Baldwin Spot; Fruit Pit

Bitter pit first appears on apples as slightly depressed areas, which later become more sharply sunken and turn brown. The affected part is sometimes bitter. The spots are usually small, being seldom more than one-fourth of an inch in diameter. The tissues beneath the spots are brownish in color and the discoloration extends for some distance into the flesh of the apple in the form of irregular bands. Some parts may be browner than others, thus making it appear that the discolored areas are isolated; on close examination, however, it will usually be seen that the tissues between the spots are at least slightly discolored. The discolored bands of tissue are most numerous within half an inch of the surface, altho some may extend deeper.

The disease is not of parasitic origin. It seems to be especially common on large apples and is thought to be due to sudden changes in weather, sudden changes in the water supply, sudden checking of the evaporation of water from the leaves of the trees, or to great changes in temperature when the apples are in storage.

The only possible methods of control which can be suggested are to avoid alternately forcing and checking growth and to pick the apples before they are dead ripe and put them into storage, preferably cold storage, as quickly as possible.

Wealthy Spot; Jonathan Spot Rot

Wealthy spot is sometimes very common on Wealthy and Wolf River apples. It also occurs on other apples in the state. It resembles very closely, or is possibly identical with, at least one type of what is commonly known as Jonathan spot, or Jonathan spot rot in Eastern and Northwestern apple-growing districts.

Superficially the spots resemble those of bitter pit. The borders are usually quite sharp and the color is a very dark brown or sometimes black. The spots are usually very distinctly sunken. They can be very easily distinguished from bitter pit, as the discoloration of the tissues beneath the spot does not extend far, often not more than one-sixteenth of an inch, while the discoloration of bitter pit very commonly extends half an inch or more into the tissues. In this state, a fungus is very often associated with one type of spot. Control measures are not well worked out. It is suggested that apples be picked before they are very ripe and immediately stored under good conditions.

Storage Rots

Storage rots are caused by several different fungi. However, the entire problem is rather one of fruit handling than of plant diseases. It may simply be said that different kinds of molds may cause the rotting. These usually require a fairly warm temperature and rather moist air in order to work most effectively. It follows, therefore, that the rot can be lessened somewhat by storing only sound apples and keeping them under proper conditions, that is, low temperature and reasonably dry air.

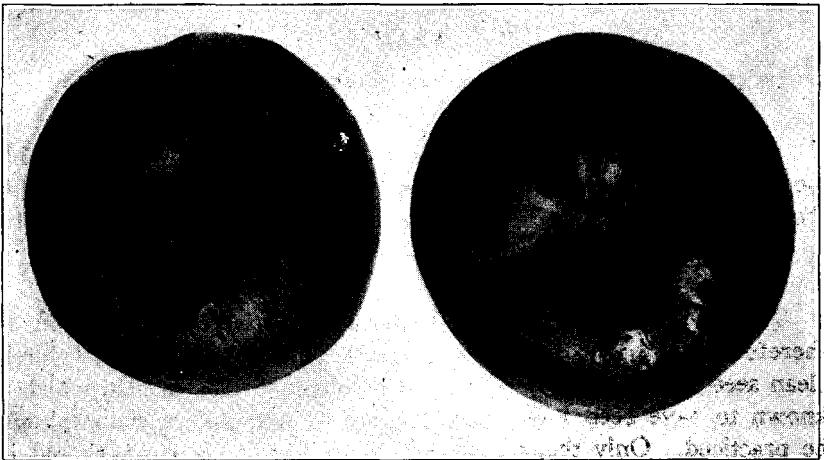


Fig. 14. Sooty Blotch and Fly Speck

Sooty Blotch and Fly Speck (*Leptothyrium pomi* (Mont. and Fr.) Sacc.)

It is probable that sooty blotch and fly speck are caused by the same fungus. The sooty blotch, as the name indicates, is characterized by a dark greenish or black growth on the surface of the apple. Sometimes the spots are very small and are arranged in more or less of a circle and closely resemble fly specks, hence the name. The fungus does not do a great deal of damage, except to render the fruit unsightly, since it does not get into the tissues of the apple. It is most prevalent in moist weather, especially when the foliage is thick, thus preventing good ventilation. Spraying will control the disease.

ASPARAGUS

Rust (*Puccinia asparagi* D. C.)

The rust of asparagus is sometimes destructive in Minnesota. It forms the familiar brownish, rusty patches which are followed later in the season by black or brownish-black patches. The disease is most prevalent on dry soils; therefore a good rich soil, very thoroly cultivated and kept fairly moist, aids somewhat in preventing serious losses. Good aeration should also be provided. If the disease is very destructive, spraying with resin-Bordeaux mixture may be financially profitable. Spraying should be begun after the cutting season, when the new shoots are about eight inches high. Subsequent applications should be made every ten days or two weeks until about the middle of September. Progress has recently been made in the Bureau of Plant Industry, United States Department of Agriculture, in developing rust-resistant strains. This seems to be a promising method of control.

BEAN

Anthracnose (*Colletotrichum lindemuthianum* (Sacc. and Magnus.) Briosi and Cavara)

Anthracnose attacks the leaves and pods mainly. It is probably most conspicuous on the pods, where it forms dark, sunken spots. On the leaves it may become serious enough to involve large areas and very materially decrease the surface, rendering the production of a normal crop impossible.

The disease is carried over winter in the seed. In controlling it, therefore, one of the greatest essentials is the selection of absolutely clean seed. If possible, seed should be obtained from a field which is known to have been free from disease; if not, pod selection should be practiced. Only those pods which are absolutely clean should be used. Beans to be used for seed should not be threshed on a floor

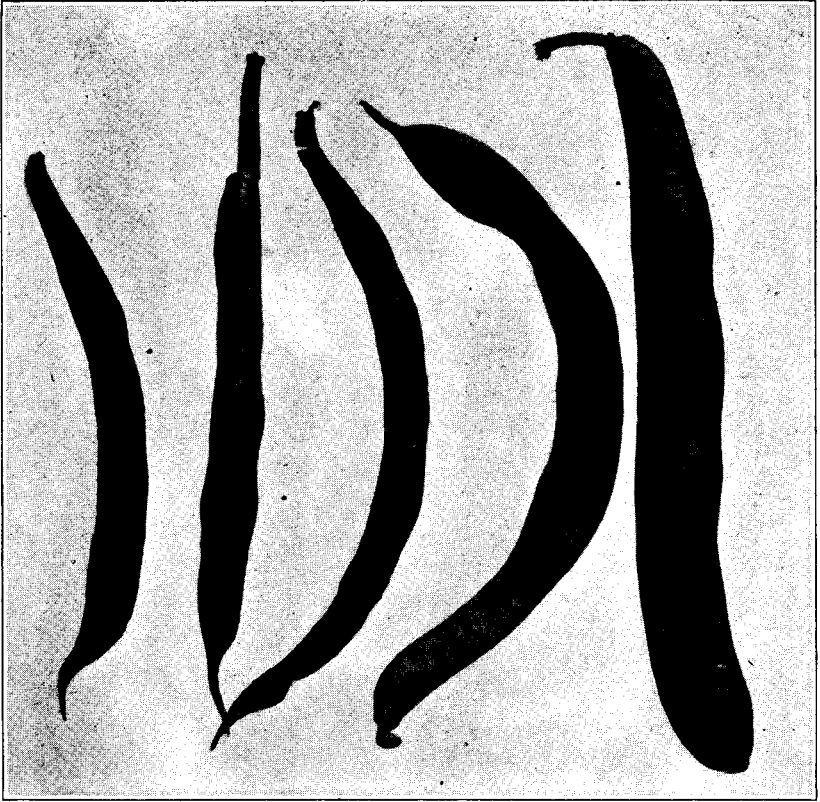


Fig. 15. Bean Blight

on which diseased pods have been threshed, and should not come in contact with anything which has contained diseased seed until the container has been very thoroly disinfected. It is sometimes helpful to soak the seed in corrosive sublimate (1-1000) or in formaldehyde solution, 1 pint to 30 gallons of water, for twenty minutes; but this alone cannot be relied on, as shown by three years' experiments at this Station. This selected and treated seed should be planted on soil which has not grown beans for several years. If the disease appears, the vines should not be cultivated when they are wet, since this may infect other plants.

The strictest sanitary precautions should be observed in addition to the specific methods mentioned. A cultivator which has been used on a diseased field should not be used on a clean field unless it is thoroly disinfected by washing with a strong solution of either formaldehyde or corrosive sublimate. Refuse from a diseased crop should not be allowed to accumulate in or near a field which is to be used for beans. Spraying may, under certain conditions, be of some value,

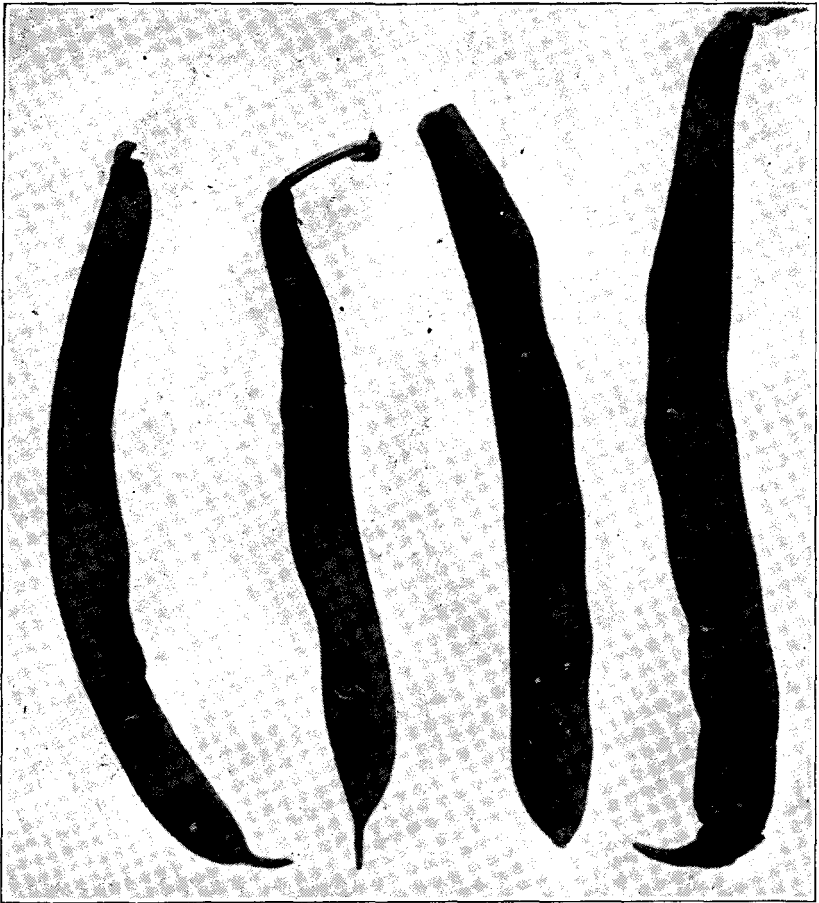


Fig. 16. Bean Anthracnose

but experiments covering several years have not proved financially successful in Minnesota.

Blight (*Pseudomonas phaseoli* E. F. Sm.)

All of the above-ground parts are susceptible to blight. The disease is very noticeable on the leaves, where it may form large water-soaked areas which later become thin and papery. All of the leaves may sometimes be very seriously affected. On the pods fairly large spots, resembling somewhat those of anthracnose, are formed. However, the spots are shallower, more reddish in color, and have more irregular outlines than those caused by anthracnose.

Blight, like anthracnose, is carried over winter in the seed. Seed should therefore be obtained from fields known to have been free from the disease. Pod selection is not always successful, as some of the

seeds may be infected and no very distinct indications appear on the surface. When diseased seed is planted, the disease may spread very rapidly by means of insects and dust, and by means of cultivation when the vines are wet.

Experiments have been tried at this Station in an attempt to devise a method of treatment which would kill the bacteria under the seed coat. These were only partly successful. Whether they were of sufficient value to warrant their recommendation under Minnesota conditions is very doubtful. The methods of control are:

1. Select seed from healthy fields or pick by hand seed from healthy pods and reject all diseased pods.
2. Plant beans only on clean soil, i.e., soil which has not produced a diseased crop for several years.
3. Do not cultivate while the vines are wet.
4. Practice sanitation: Destroy all refuse from the bean field; do not bring clean seed into contact with anything which has contained diseased material; do not let the dust from bean fields or from diseased beans blow to seed beans.
5. Rotate crops.
6. Establish a seed plot if necessary. Locate this plot as far as possible from a field that is or recently has been planted to beans, and observe all the precautions mentioned under anthracnose and blight in selecting and treating the seed. Use the seed from this plot for the general planting.

Downy Mildew (*Phytophthora phaseoli* Thaxter)

Downy mildew is usually not serious in Minnesota. It attacks the pods and leaves and sometimes the stems. It produces white moldy patches which may be sufficiently severe on the pods to cause their death, and may also get into the seeds. For this reason clean seed should be selected; clean culture, including the burning of old vines in the fall, and crop rotation, should be practiced. Thoro spraying with Bordeaux mixture will control the disease to a certain extent.

Rust (*Uromyces appendiculatus* (Pers.) Le'v.)

This refers to the true rust—not the bacterial spot often called rust. Small brownish pustules which later become black are produced, usually on the under surface of the leaves. On the upper surface the spots may appear pale and yellow. The disease is not very prevalent in Minnesota. Clean culture methods will probably aid considerably in keeping the disease in check.

Powdery Mildew (*Erysiphe polygoni* De C.)

Powdery mildew is usually not severe. Spots appearing as tho

they had been dusted with a grayish powder indicate the presence of the disease. It can probably be controlled by means of thoro spraying.

BEEET

Leaf Spot (*Cercospora beticola* Sacc.)

Grayish to brownish spots with purplish borders are quite frequently found on leaves affected with leaf spot. Usually they are not sufficiently numerous to cause much damage. However, on both garden and sugar beets they may sometimes be serious enough to cause a great decrease in vigor. On garden beets a very thoro spraying, if begun early enough, gives good results. If the beets are grown on a fairly large scale, clean culture methods and strict sanitary precautions should be observed.

CABBAGE

Black Rot (*Pseudomonas campestris* (Pam) E. F. Sm.)

Black rot is a bacterial disease which usually appears first at the tips or the margins of the leaves. When attacked the leaves first become yellowish and may then dry and fall off, leaving nothing but the naked stalk. One of the most characteristic symptoms is the blackening of the veins. Cabbage harvested from diseased fields may become affected in storage. For this reason, all heads which show any indication whatever of the rot should be rejected.

Control measures consist in planting disease-free seed; preparing a very good seed bed; careful rotation of crops; control of insects; pulling and burning of affected parts; and clean culture methods, including the keeping of stock out of a diseased field, especially if it is afterwards allowed to run in fields which may be used for cabbage in the future. The seed should be soaked for fifteen minutes in formaldehyde used at the rate of $\frac{1}{4}$ pound ($\frac{1}{4}$ pint) to 7 gallons of water, and then washed with water and dried. In planning the rotation, remember that the disease attacks not only cabbage, but also closely related plants of the mustard family, both wild and cultivated, including cauliflower, turnip, kale, rape, kohlrabi, Brussels sprouts, collards, rutabaga, radish, and wild mustard. None of these vegetables, therefore, should be used in a rotation, and wild mustard should be kept out of the cabbage patch. The control of insects is necessary, as they very frequently spread the disease. Manure from stock which has been fed diseased cabbage should never be put on cabbage soil. Cattle, or stock of any kind, may very easily spread the disease from one field to another if allowed to roam over the fields in the fall after the cabbage has been cut.

Club Root (*Plasmodiophora brassicae* Wor.)

Club root is caused by a slime mold and produces large tumor-like

outgrowths or galls on the roots of practically the same plants that are attacked by the black rot. Affected plants are usually below normal in vigor, in many cases failing to head. The same general sanitary precautions mentioned under black rot should be practiced in attempting to control club root. A rotation should always be practiced. Excellent results were recently obtained at the Vermont Station by thoroly working 150 bushels of air-slaked lime per acre into the soil to a depth of from 6 to 9 inches. This was done shortly before planting.³

Soft Rot (*Bacillus carotovorus* Jones)

The bacteria causing soft rot usually gain entrance through wounds or injury of some kind. Plants may be affected in the field or in storage. When storage conditions are favorable to the spread, a large amount of cabbage may be destroyed in a comparatively short time. The affected portions usually become soft and slimy. When the rot gets into the fleshy portions it may cause them to become almost amber colored and nearly transparent. When these parts are handled, they often fall apart into a slimy, foul-smelling mass.

The disease can be controlled very largely by means of proper rotation and the maintenance of proper storage conditions. When plants are harvested, they should be dried in the sunshine before storing. Care should be taken not to bruise them in any way. The temperature of the storage house should be kept only a few degrees above the freezing point and good ventilation provided. Soft rot may occur on several vegetables, including turnips, rutabagas, and other root crops; for this reason, susceptible plants should not be grown in the rotation. (See Soft Rot of Vegetables.)

Blackleg (*Phoma oleracea* Sacc.)

Cabbage and cauliflower are susceptible to blackleg. The plants are usually attacked when they are young, but they may also become affected when they are older. Sunken spots appear on the leaves and stems. When stems are affected the lesions usually progress toward the roots. Before their death the plants usually become purplish, this change constituting one of the most characteristic features of the disease. The entire plant may wilt and die. Large numbers of very small black eruptions may be found scattered over affected parts.

Control measures consist in rotation and clean culture methods. The Ohio station recommends treating the seed beds with 4-4-50 Bordeaux mixture at the rate of one gallon to ten square feet of soil, just before sowing the seed.⁴ The Bureau of Plant Industry, United States Department of Agriculture, has also shown that steam sterilization of

³ Cunningham, G. C. Studies With Club-Root. Vermont Agr. Exp. Sta. Bul. 185. 1914.

⁴ Manns, Thomas F. Two Recent Important Cabbage Diseases of Ohio. Ohio Agr. Exp. Sta. Bul. 228. 1911.

the soil in a seed bed for one hour at a temperature of 212 degrees F., is effective.⁵ Two additional applications of Bordeaux mixture are made, one two weeks before the plants are set out in the field and another just before transplanting. Clean culture methods should prevail,—all diseased plant parts should be disposed of, and stock should be kept away from diseased patches. In addition to this, crop rotation should be practiced and the seed should be disinfected as for black rot.

Yellows; Wilt; Yellow Sides (*Fusarium conglutinans* Wr.)

Yellows usually appears from two to four weeks after the plants are set out. However, it may also occur in the seed bed. The outer and lower leaves first become yellow, quite often between the veins and near the margins. Later they dry and drop from the plant. Sometimes this occurs on one side of the plant only, while the other side remains fairly healthy. The disease practically always causes the lowest leaves to drop off first and progresses until nothing but the bare stalk may be left, heads being very rarely formed. The stem may become brown, especially in the woody portions, the dark color often forming a more or less incomplete ring.

Control measures consist in obtaining clean seed and planting it in a clean seed bed, and in clean culture methods. The seed should be disinfected as for black rot. The seed bed should be very thoroly prepared and sterilized whenever possible. Any plants which become diseased in the seed bed or show any signs whatever of disease should be destroyed. Stock should not be allowed to feed on diseased plants and then go to other fields which may again be used for cabbage. Clean culture methods, including the destruction of diseased plant parts, should always be practiced. Manure from stock which has been fed diseased plants should not be put on cabbage land. Much progress has recently been made at the Wisconsin Station in developing resistant strains of cabbage.⁶

Downy Mildew (*Peronospora parasitica* (Pers.) De By.)

Downy mildew appears usually in the seed beds, very seldom in the fields. It produces grayish-white patches on the under surface of the leaves, while on the upper surface the spots appear as yellowish or light brown areas. Ordinarily the disease is not serious enough to excite much attention.

Control measures consist in clean culture, rotation, and care in the seed bed, especially in planting and watering. The plants should never be crowded too much and should not be kept too wet. As soon as the

⁵ Harter, L. L. Diseases of Cabbage and Related Crops and Their Control. U. S. Dept. of Agr. Farmers' Bul. 488. 1912.

⁶ Jones, L. R. and Gilman, J. C. The Control of Cabbage Yellows Through Disease Resistance. Wis. Agr. Exp. Sta. Research Bul. 38. 1915.

disease appears, all of the affected parts should be removed and destroyed. Spraying with 4-4-50 Bordeaux mixture when the plants are very young will keep the disease in check. When the plants are set out in the field all that show any signs of the disease should be rejected.

CELERY

Early Blight; Leaf Spot (*Cercospora apii* Fr.)

Yellowish, angular spots with somewhat raised borders appear on both sides of the outer leaves and later on the inner leaves of plants affected with early blight. As the disease progresses the centers of the spots become ashy gray in color, the leaves wilt and dry, and may fall from the plant. The disease may progress in storage if diseased plants are stored. Muggy weather is very favorable to the spread of the disease and this should be taken into consideration in attempting to control it.

Control measures consist in spraying and in clean culture methods. The spraying should be begun in the seed bed if the disease has previously been severe or has been in the neighborhood. It should be continued at intervals of ten days or two weeks, depending upon weather conditions and the severity of the disease. Either 5-5-50 Bordeaux mixture or ammoniacal copper carbonate may be used. It is important to use high pressure and apply the spray material in the form of a fine mist in order to avoid staining the celery too much. Severely affected plants should not be stored. As an added precaution, if the disease has been severe, the plants which are stored should be dipped into Bordeaux mixture or ammoniacal copper carbonate before being stored.

Late Blight (*Septoria petroselimi* Desm. var *apii* Br. and Cav.)

Leaf spots, at first somewhat like those of early blight, appear on leaves affected with late blight. A characteristic feature is that, as the affected part becomes older, numerous small, black eruptions appear. The disease also attacks the petioles, and in extreme cases may cover almost the entire plant, rendering it extremely unsightly and lessening its salability very materially. The leaves may rot entirely, either in the field or in storage. The disease may spread on stored plants, especially if the storage cellar is warm and moist.

Control measures are practically the same as those for early blight. It is especially important that spraying be begun as soon as the plants come up, as the disease often appears on the young plants and is difficult to control after it once gets started.

CHERRY

Brown Rot (See Plum.)

Shot Hole (See Plum.)

CUCUMBER

Wilt (*Bacillus tracheiphilus* E. F. Sm.)

Wilt is a disease of bacterial origin which attacks cucumbers as well as other cucurbits. The signs of the disease are rather striking. The leaves or any part of the vine may droop and wilt in a very short time. The appearance is simply that of plants wilting from lack of moisture. If a wilted vine is cut, a white ooze usually comes out from the sap tubes. It is very viscid and can be drawn out into long, fine threads. The disease is spread very largely by biting insects, especially the striped cucumber beetle, which should, therefore, be controlled. All diseased vines should be immediately destroyed.

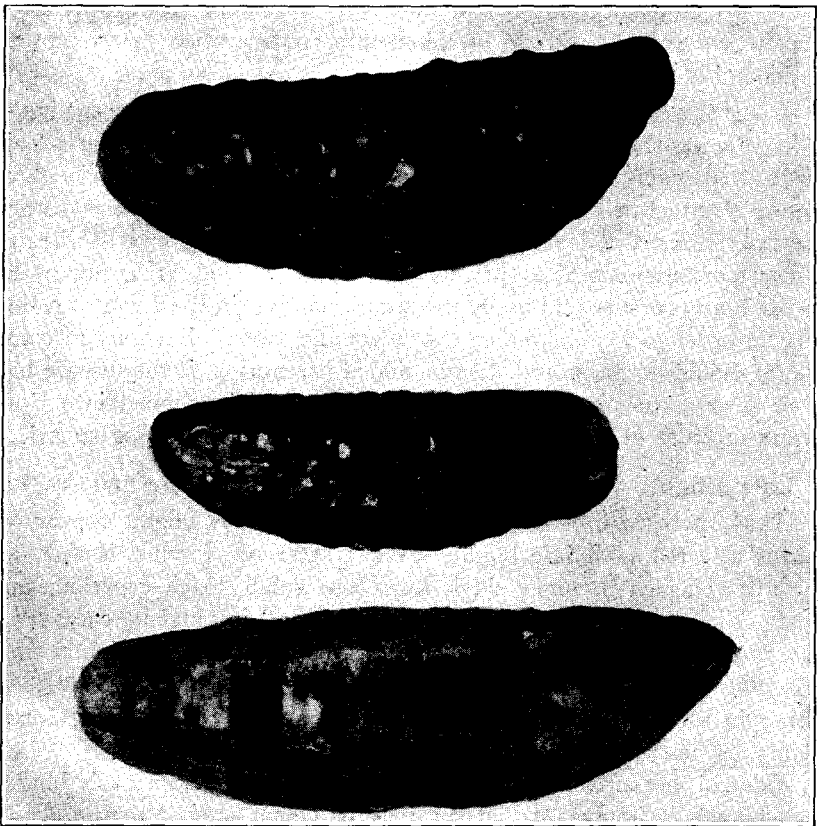


Fig. 17. Cucumber Nubbin

Nubbin; Wart Disease; White Pickle

Nubbin appears both under glass and in the field. It may be accompanied, especially under glass, by a wilting of the vines. In the field it may appear quite independent of distinct foliage disturbances.

Affected cucumbers show raised patches irregularly scattered over the surface, and sometimes have a mottled appearance, yellowish patches alternating with normal green. The disease is infectious, but control measures cannot be definitely prescribed.

Downy Mildew (*Plasmopara cubensis* (B. and C.) Humphrey)

Downy mildew is usually not serious in Minnesota. Yellow spots appear first on the old leaves and later on the younger ones. The disease may spread rather rapidly in warm, moist weather. Affected portions may dry and fall. In extreme cases few fruits are produced, and those which mature are usually small and deformed. The disease can be controlled by means of thoro spraying with 5-5-50 Bordeaux mixture. This should be begun as soon as the vines begin to run and should be continued at intervals of ten days or two weeks, the time depending on the prevalence of the disease.

Powdery Mildew (*Erysiphe cichoreacearum* De C.)

Powdery mildew produces characteristic powdery patches. It is ordinarily not destructive and the control measures suggested for downy mildew should keep it in check.

Scab (*Cladosporium cucumerinum* Ell. and Arth.)

Fortunately, scab has not been very prevalent in Minnesota. It has, however, caused extremely large losses in other states, in several cases causing the abandonment of the pickle industry. It is mentioned so that if the disease should appear, growers will be able to recognize it and practice proper control measures.

It occurs on both the leaves and fruits. On the leaves, watery, semi-transparent spots are first produced. A wilt soon follows and in a short time the entire leaf rots. An infected plant may be entirely destroyed in a few days.

The fruits are attacked shortly after being formed. The spots appear as velvety, gray, sunken patches about one-eighth of an inch in diameter. They soon unite, causing large irregular areas which later become greenish-black, especially near the flowering end. A gummy liquid is often exuded.

The disease can be fairly well controlled by thoro spraying with 3-6-50 Bordeaux mixture when the vines begin to run, followed at ten-day intervals throughout the growing season by applications of 4-4-50 Bordeaux mixture. Clean culture is also very essential.

Anthracnose (See Melon.)

CURRANT

Leaf Spot (*Pseudopeziza ribis* Kleb. and *Septoria ribis* Desm.)

Several leaf spots of currant occur in Minnesota. They can all be

discussed together since control methods are approximately the same. Altho not always serious, they may sometimes cause the leaves to fall prematurely and consequently decrease the amount of fruit produced.

Plants should be sprayed with Bordeaux mixture or ammoniacal copper carbonate as soon as the leaves unfold. This should be followed by subsequent applications as necessity may demand. It is especially important to begin spraying early. The disease may become quite prevalent before much notice is taken of it; for this reason, if it has been at all prevalent, precautions should be taken to spray very early in the season. Destruction of all of the diseased leaves will also aid in controlling the disease.

Powdery Mildew (*Sphaerotheca mors-uvae* (Schw.) B. and C.)

The fungus of powdery mildew produces grayish patches which later become brown and felt-like. The leaves and fruit are most often affected. Potassium sulfide, used at the rate of 1 ounce to 4 gallons of water, is fairly effective. Bordeaux mixture as applied for leaf spot will also aid somewhat in keeping the disease in check.

Rust (*Puccinia ribis-caricis* Kleb.)

Rust is not usually injurious in Minnesota. No attempt has been

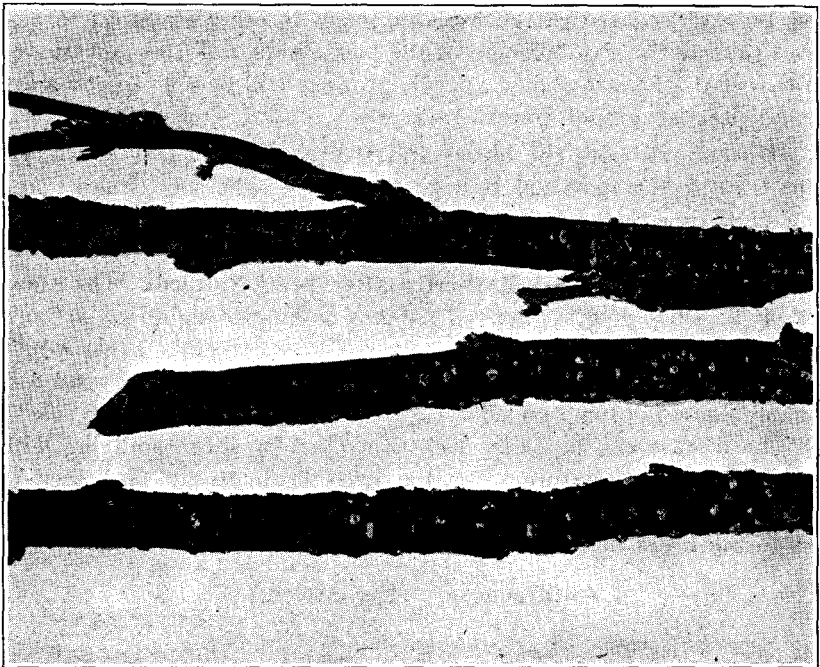


Fig. 18. Nectria Canker on Currant

Millions of spores which spread the disease are produced in the light-pink disks scattered about the canes.

made to control the disease, but it is very probable that spraying as for leaf spot will prevent it to a certain extent.

Cane Blight (*Nectria cinnabarina* (Tade) Fr.)

There is some question as to whether cane blight is really an independent disease or whether it only follows other injury. Affected canes may be practically covered with small, pinkish or salmon-colored disks. The only control methods which can be suggested are to avoid injury to the cane and cut out and burn affected canes when they appear.

GINSENG

Blight (*Alternaria panax* Whetzel)

Ginseng blight is sometimes so serious that large patches are almost entirely destroyed as a result of its attack. Both leaves and stems are affected. Large watery spots, which later become dry, are produced on the leaves, and brownish canker-like areas are produced on the stems. Infection often takes place just as the shoots appear above ground.

Control measures consist in spraying and sanitation. The first spraying should be given before the plants come up. At this time copper sulfate solution made up at the rate of 1 pound of copper sulfate to 10 gallons of water should be used. As soon as the plants appear above the surface of the ground they should be thoroughly sprayed with 3-3-50 Bordeaux mixture. The spraying should be repeated at frequent intervals, the object being to keep the leaves and stems well covered with the spray material in order to protect them, especially during wet weather. All diseased parts should be destroyed. If possible, the beds should be covered with straw and burned over after the tops have died.

GOOSEBERRY

Powdery Mildew (*Sphaerotheca mors-uvae* (Schw.) B. and C.)

Leaves, stems, and berries may be affected with powdery mildew. The affected bushes look as if they had been dusted with flour. Later, the affected areas become brownish in color and the spots may spread to such an extent as to involve large areas of the leaves and berries. Powdery mildew is one of the most serious diseases on gooseberries, but it can be controlled almost entirely by proper spraying. Potassium sulfide, used at the rate of 1 ounce to 2 gallons of water, has proved very effective. The first spraying should be given just as soon as the leaf buds begin to break, and spraying should be repeated at intervals of about ten days or two weeks.

Leaf Spot (*Septoria ribis* Desm.)

Leaf spot of gooseberry sometimes become quite serious, the chief

loss resulting from defoliation. Spraying as for powdery mildew will control the disease.

Rust (*Puccinia ribis-caricis* Kleb.)

Rust is sometimes abundant on the leaves, but seldom does much damage. It appears as yellowish to orange cluster cups. Spraying as for leaf spot will probably prevent much of it.



Fig. 19. Black Rot on Grape

GRAPE

Black Rot (*Guignardia bidwellii* (Ell.) Viala and Ravaz)

Black rot appears on the leaves of grape as circular tan-colored or brownish patches. On the berries it first appears as small brownish or purplish spots which may enlarge very rapidly under favorable

weather conditions until the entire fruit is rotted. The berries shrink and become very much wrinkled, forming hard, dry mummies. Young shoots may sometimes be affected. On the shoots the spots are usually reddish in color.

The disease overwinters very largely on the mummied berries which have fallen to the ground. In attempting to control the disease, therefore, clean culture methods should be practiced. All of the mummied fruit which still remains on the vines should be destroyed. The vine-



Fig. 20. Downy Mildew of Grape
Note the mildewed appearance of the leaves and branches.

yard should be cultivated early in the spring to turn under all mummied berries and affected leaves. All grasses and weeds should be kept down and the lower sprouts of the vines should not be allowed to spread over the ground. These clean culture methods should be combined with thoro spraying with 4-4-50 Bordeaux mixture. The first application should be made about the time the second or third leaf appears, and the second one soon after the blossoms fall. These may be followed by two or more applications as necessity demands. The spraying should be very thoro and applied under good pressure.

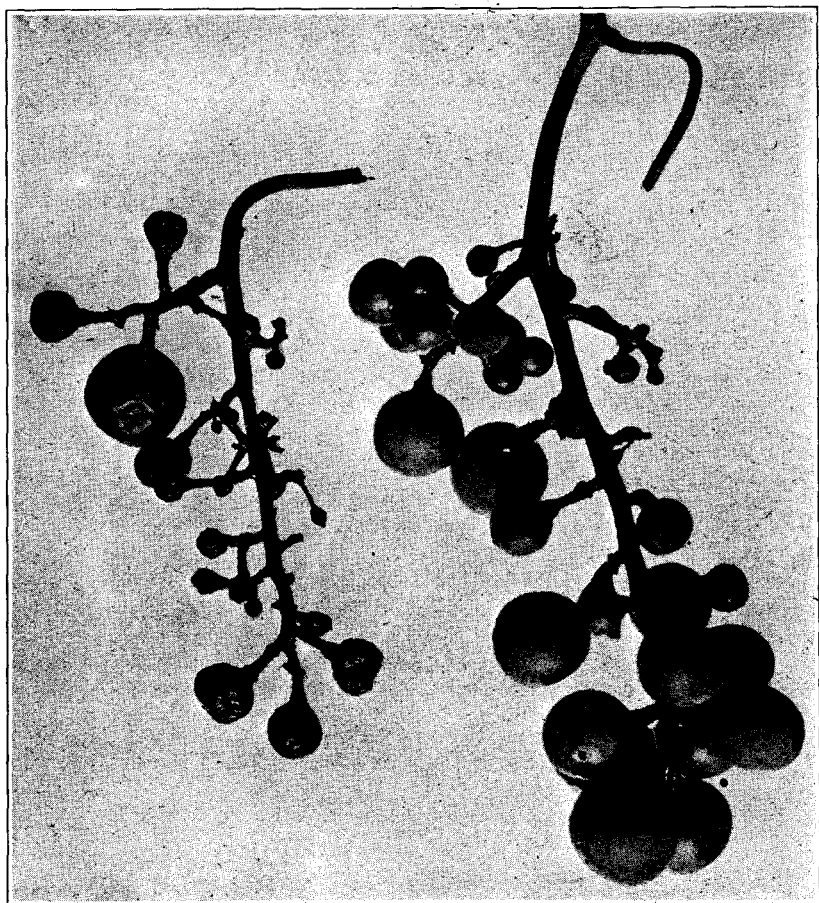


Fig. 21. Mummied Grapes Caused by Downy Mildew

Downy Mildew (*Plasmopara viticola* (B. and C.) Berl. and De Toni)

In downy mildew grayish, felty masses of fungous threads appear, usually on the lower surface of the leaves. The upper surface appears yellow. If green fruit is attacked, the berries become hard.

If the berries are older they become brownish in color, and for this reason the name brown rot is sometimes applied. The berries shrivel, but do not become so hard and dry as in the case of black rot. Control measures are the same as for black rot.

Powdery Mildew (*Uncinula necator* (Schw.) Burr.)

More or less circular spots appearing as though they had been dusted with flour may be seen on plants affected with powdery mildew. The disease is not often severe in Minnesota, altho under favorable weather conditions it may do some damage. Lack of ventilation, too much shade, and dampness are especially conducive to its spread. The control measures suggested for black rot will keep powdery mildew in check.

LETTUCE

Gray Mold (*Botrytis cinerea* Pers.)

Gray mold appears almost entirely in the greenhouse. The edges of the leaves first wilt and later the entire leaf may droop and die. After death the plants are often covered with a dirty, grayish brown fuzz. Control measures consist very largely in proper cultural methods. Good ventilation, together with a fairly constant temperature and avoidance of too much water, aid very much in keeping the disease in check.

Drop (*Sclerotinia libertiana* Fuckel)

Drop also appears mainly in the greenhouse. Affected leaves appear to have been scalded. On the dead parts a dense, white, fungous growth may appear. The disease persists in the soil in the form of storage organs which live over winter. All affected plants should be immediately removed, and the soil from which they are taken sprayed with Bordeaux mixture in order to prevent the formation of these storage organs. Sanitary measures as suggested under gray mold will aid very much in keeping the disease in check. All trash should be destroyed, and manure which may be contaminated should not be used. When the soil becomes infected it may be disinfected with formaldehyde, used at the rate of 1 pound to 10 or 12 gallons of water. If soil disinfection, either by means of the formaldehyde method suggested or by means of heat, does not prove satisfactory, or in cases where the disease is extremely serious, it may be necessary to change the soil entirely.

Downy Mildew (*Bremia lactucae* Reg.)

Downy mildew occurs mainly under glass. Affected leaves first become paler in color and afterwards wilt. The downy, mildewed ap-

pearance can then be noticed. Sanitation, good ventilation, and plenty of sunlight are the best control measures.

MUSKMELON

Anthracnose (*Colletotrichum lagenarium* (Pers.) Ell. and Hals.)

All parts of the vine and the fruit may be affected by anthracnose. The tendrils, buds, and petioles may blacken and die. On the leaves, fairly large, dark blotches which later dry and sometimes fall out may

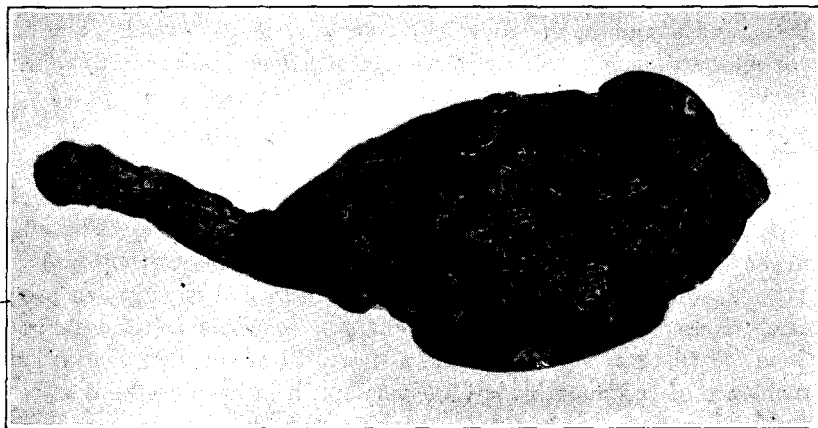


Fig. 22. Anthracnose on Gourd.
This is the same as anthracnose on muskmelon

appear. On the stems, the spots are elongate and light brown in color. On the fruit, deeply sunken, more or less circular spots, sometimes with pinkish centers are developed. Spraying should be practiced as for downy mildew of cucumber. A rotation which avoids the use of the land for related crops should be practiced, and all diseased material should be collected and burned.

Leaf Blight (*Macrosporium cucumerinum* E. and E.)

Leaf blight is sometimes rather serious in Minnesota. In some cases it practically destroys fairly large patches of melon vines within a short time. The disease appears as small, brown spots on the leaves. Frequently there are concentric rings in the spots while a dark, velvety, moldy growth may appear in the center. The spots may enlarge and coalesce, causing the leaves to curl and shrivel. They finally dry and are entirely dead. The leaf petioles and veins are also affected. The disease causes premature ripening and consequent lack of flavor in the fruit. Very systematic and thoro spraying should be practiced. The general directions given under downy mildew of cucumber may be followed. In addition to the spraying, a rotation should be practiced and

clean culture methods should prevail. The Pollock strain of the Rocky Ford cantaloupe is said to be very resistant to the disease.

Downy Mildew (See Cucumber.)

Wilt (See Cucumber.)

ONION

Blight; Downy Mildew (*Peronospora schleideniana* De By.)

The tips of the plants are first attacked by blight and present a water-soaked appearance which is quite often followed by a moldy growth on the affected parts. Later the plants may collapse, thus interfering with the formation of normal bulbs. Crop rotation, clean culture, and spraying will prevent the disease. If it has been serious it may be advisable to spray shortly after the plants appear above ground. The first spraying may be given with 5-5-50 resin-Bordeaux mixture and should be followed, when the disease is severe, by one or two subsequent applications of the same material.

Smut (*Urocystis cepulae* Frost)

Smut appears on the plants as black, dusty patches. It lives in the soil, and for this reason a rotation should always be practiced if the disease has been present. If the disease has been very prevalent, a mixture of 120 pounds of sulfur and 50 pounds of air-slaked lime may be drilled into the rows when the seed is planted. According to the Geneva, New York, Station, this gives good results. Plants from sets are much less frequently diseased than those grown from seed. If the disease has been serious, it may be advisable to sow the seed in a seed bed which is known to be free from the smut, and transplant the young onions to the field. A drip attachment is sometimes used on the drill and formaldehyde, 1 pint to 30 gallons of water, applied. If sets are used, from 500 to 700 gallons per acre is needed; and if seed is used, about one-fourth of this amount.

PEA

Blight (*Ascochyta pisi*. Lib. and *Septoria pisi* West)

There are two diseases of peas which are very common in Minnesota, and are variously referred to by the growers as blight, pod spot, leaf spot, and rust. There are differences between the two, but for practical purposes they may be considered together. The leaves and pods are attacked, and other parts of the vine may also sometimes become affected. On the leaves, grayish spots with darker borders are often prevalent enough to interfere very seriously with the development of the plant. Sometimes small, black eruptions are seen in these spots. On the pods, the same general type of spot is developed. These

are usually somewhat sunken and may, in extreme cases, extend through the pod. The seeds may also become infected. A discoloration quite often indicates this infection, altho in cases of rather light infection there may be no external evidence of the presence of the fungus. Few seeds from diseased pods germinate. As a matter of fact, it has been shown that only 6 per cent of the seeds selected from diseased pods were capable of germination.

Obviously, since the disease is carried over very largely within the seed, one of the first essentials is to get absolutely clean seed. Pod selection should be practiced, and all pods which show any indications whatever of the disease, rejected. After selection, the peas to be used for seed should not again come in contact with any diseased material or anything which has contained diseased material. Clean culture methods and crop rotation should be practiced, nonsusceptible crops being used. Spraying experiments covering several years were tried at the Minnesota Station, but they did not give sufficiently good results to warrant their recommendation. Experiments made at the Wisconsin Experiment Station show that when diseased vines undergo fermentative processes in the silo the blight spores are readily destroyed and the vines make excellent silage. This is preferable to using them for manurial purposes or burning them.

Powdery Mildew (*Erysiphe polygoni* De C.)

Powdery mildew may attack the leaves, pods, and vines. It is similar to the powdery mildews in general; forming dirty gray, powdery spots which are sometimes sufficiently large to involve the entire leaf or pod. The disease is carried over by means of seed taken from affected pods. For this reason all of the precautions which were mentioned under blight should be observed in attempting to control the disease. Thoro spraying, if begun early, will also aid in controlling the disease.

PLUM

Black Knot (*Plowrightia morbosa* (Schw.) Sacc.)

Altho black knot is very common on wild plums, choke cherries, and closely related forms, it seldom does much damage in orchards in Minnesota.

The first signs of the disease are usually the development on young twigs of a velvety, greenish or olive-colored swelling. Later in the season these affected parts become black and brittle. Young twigs are most often affected, but larger branches may also be involved. Sometimes the affected portions are killed, altho this does not necessarily follow. Infection probably takes place very largely through wounds; for this reason precaution should be taken to keep the trees in good



Fig. 23. Black Knot of Plum
 Note how the infected twigs are bent almost at right angles. The spores which spread the disease are produced in these black swellings.

condition and to protect all wounds and bruises whenever the disease is troublesome. The disease spreads very rapidly while the knots are still young, and careful pruning and burning of the diseased parts at that time will aid very considerably in keeping the disease in check, but cannot be depended on to control it. Spraying should, therefore, be practiced. A dormant spray would be very valuable, altho this does not seem necessary or profitable in all cases. Spraying as for brown rot will lessen the amount of infection.

Brown Rot (*Sclerotinia cinerea* (Bon.) Schröter)

Brown rot attacks the blossoms, fruit, leaves, and even the woody portions of the plant. The appearance of the blighted blossoms is very characteristic. They become brown and, on close examination, a light tan-colored powder can often be seen. The fruit is usually attacked rather late in the season, when it is nearly or quite ripe. However, green fruit may also be attacked, especially after injury. Very frequently a large percentage of infection can be traced to the injury caused by curculio. The appearance of the rotted plums is familiar to all growers. Brownish patches first appear and these may enlarge very rapidly, especially during warm, moist weather, until finally the plum is entirely rotted and tufts of grayish-brown spore-bearing bodies appear on the surface. The plums may remain on the tree and be-

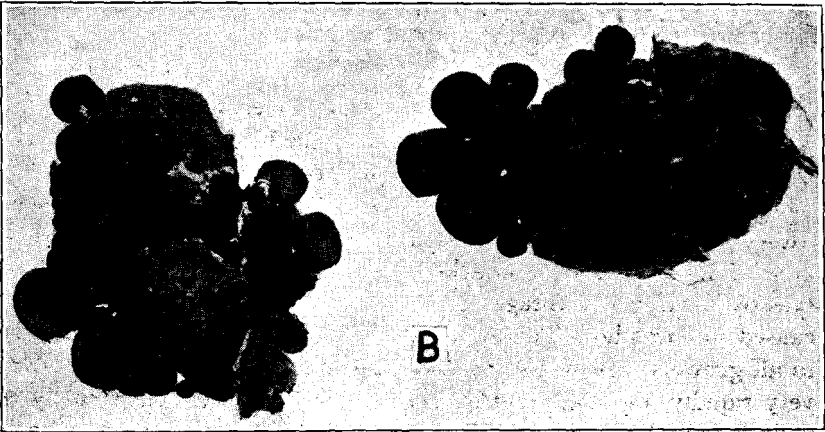


Fig. 24. Brown Rot of Plum

A, summer stage showing small, grayish-brown tufts of spores on the fruit. B, mummified plums showing cup-shaped bodies which contain spores.

come very much dried and shriveled. The spores may live during the winter or the fungous threads may live inside of the mummies. When such plums fall to the ground and are covered with leaves or a small amount of soil they may produce, in the spring of the second year, a cup fungus from which the infection is again carried to the plums.

Control measures, therefore, must include the destruction of mummied fruit. No mummies should be left hanging on the trees, and if possible, all that have fallen to the ground should be collected and burned. If this is not practicable, they should at least be plowed under so deep that they can do no damage. Pruning and treatment of cankers may sometimes be necessary if an orchard is severely affected. The disease has been almost entirely controlled under Minnesota conditions by three sprayings. The first application was made when the center blossoms of the cluster were just beginning to show pink; the second, when the young fruit was about the size of a pea, and the third, when the fruit was turning color. Excellent results were obtained with commercial lime-sulfur, 1-40, with 2-4-50, and 3-4-50 Bordeaux mixture, with iron sulfide mixture, and with self-boiled lime-sulfur. The disease was reduced from an average of 35 per cent on the unsprayed plots to 3 per cent or less on the sprayed plots.



Fig. 25. Brown Rot of Plum; Twig and Blossom Blight



Fig. 26. Plum Pocket, Bladder Plums, Fool's Plums
 Note the puffed, pitless, misshapen fruit. Can be partially controlled by pruning and spraying.

Plum Pocket (*Exoascus pruni* Fuckel)

Plum pocket is most conspicuous on the fruit. It appears rather early in the season, especially when the weather is cold and wet at blossoming-time, destroying the pit and causing an overgrowth of the fleshy part, so that instead of the normal fruit, a large bladder or sack-like structure is produced. On the surface a bluish-gray powder often appears. The fungus is supposed to live over winter very largely in the twigs, but this requires investigation. It is usually recommended that the affected parts be pruned out, and that a tree which bears pocketed plums several years in succession be cut down and burned. The whole question must be thoroly studied under Minnesota conditions. The effect of spraying on the disease has been rather imperfectly worked out. Indications are that spraying with copper sulfate wash while the trees are still dormant, followed by sprayings as for brown rot, will reduce the amount of the disease.

Shot Hole (*Cylindrosporium padi* Karst. and *Phyllosticia prunicola* Sacc.)

Very numerous, rather small, brown spots appear on leaves affected by shot hole. Later the diseased areas drop out, giving the leaves the appearance of having been riddled with shot. The damage results mainly from the defoliation of the trees, thus making the production of a normal crop impossible. Thoro spraying as for brown rot, together with the destruction of diseased leaves, controls the disease fairly well. Shot hole should not be confused with spray injury which

sometimes results from drenching the trees with too strong spray mixtures.

Scab (*Cladosporium carpophilum* Thum.)

Scab appears on the fruit in the form of brownish, scabby spots, especially during moist weather. Infection is superficial but renders the plums rather unsightly. Spraying as for brown rot controls the disease fairly well under Minnesota conditions.

Powdery Mildew (See Apple.)

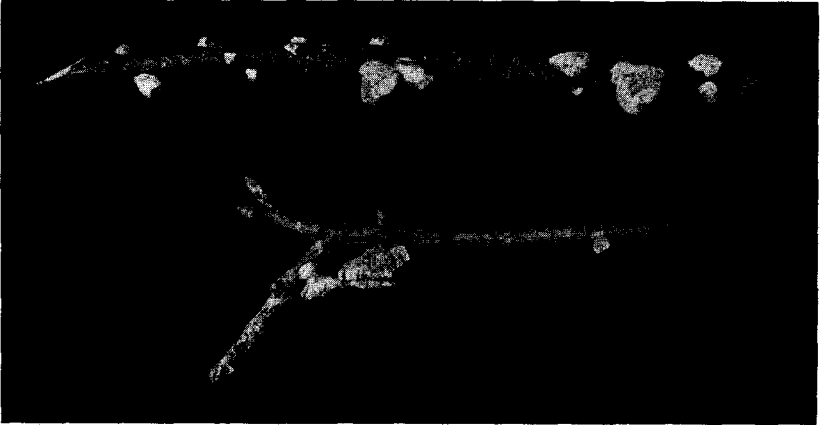


Fig. 27. Wood Rot on Plum Twigs.
Wood rot follows other diseases or injuries.

Wood Rot

Various wood-rotting fungi attack plum trees and may eventually kill them. When branches are affected, pruning may sometimes prevent the further spread of the rot. The general recommendations given under apple cankers may be followed. Tree surgery, aside from being of somewhat doubtful commercial value, is more difficult than on apple trees on account of the tendency of the plum tree to produce large amounts of gum.

Gummosis

Plum and cherry trees often exude considerable amounts of a gummy substance which is first very sticky and on drying becomes hard. This does not necessarily indicate the presence of a specific disease; gummosis may follow injury or fungus attack. It may be brought about by several causes. No recommendations for control can be made except to keep the trees in healthy condition and avoid bruises and overfertilization.

POTATO

The diseases of potatoes are fully discussed in Minnesota Extension Bulletin No. 35, Potato Diseases, now out of print, and in Experiment

Station Bulletin No. 158, a copy of which may be obtained on application to the Office of Publications, University Farm, St. Paul. They are therefore not discussed in this bulletin.

RADISH

Club Root (See Cabbage.)

White Rust (*Albugo candida* (Pers.) Roussel)

The white rust, which is not a true rust, appears upon the leaves and flowers as smooth, white blisters. When the flowers are attacked they become very much deformed, interfering with the production of seed. The chief damage occurs in this way. All affected parts should be collected and burned, if the disease is serious enough to warrant any attention.

RASPBERRY AND BLACKBERRY

Anthracnose (*Gloeosporium venetum* Spg.)

Anthracnose affects the canes and the leaves. On the canes, ashy gray, sunken areas with purplish borders may be formed in great numbers. On the leaf petioles and on the leaves themselves, grayish spots with purplish borders are very frequently produced. This is one of the very serious diseases in raspberry plantations in Minnesota. After the fruit is picked, all of the affected canes should be pruned out and burned. In the spring the very young canes may be sprayed with 4-4-50 resin-Bordeaux-mixture, altho this is of somewhat doubtful value. However, an early spraying shortly after the canes begin to grow, followed by one or two subsequent sprayings, sometimes protects them to a certain extent. A rotation should be practiced. Raspberries should never be set out on land which has grown affected canes until several years have elapsed.

Cane Blight (*Coniothyrium fuckelii* Sacc.)

The most striking sign of cane blight is the wilting of the canes. This usually progresses from the tip downward, killing the branches and generally reducing the yield. Diseased canes should be cut out and burned. Care should be taken to avoid bruising the plants. Diseased canes should never be set out. Examine canes carefully before setting them out and make sure that none are at all affected. The site of the plantation should be changed if the disease has been at all serious. Spraying as for anthracnose may be of some value, but will not control the disease to any great extent.

Gray Bark Disease; Spur Blight (*Mycosphaerella rubina* (Pk.) Jacz.)

During the last few years gray bark disease has been extremely common in Minnesota. Bluish or brownish patches are first produced

on the canes. Later, the outer bark becomes grayish in color and peels off. Small black eruptions usually appear, showing very clearly against the gray background. The wood is usually discolored, assuming a smoky or somewhat purplish tinge. The disease can be distinguished from cane blight by the graying of the bark. The canes do not wilt as they do when affected with the true wilt.

There is some question as to whether the disease alone causes material damage or whether it appears mostly on canes weakened by winter injury or other agencies. It certainly is quite constantly associated with unproductive canes. Some growers believe that it prevents the normal development of laterals and predisposes canes to winter injury. The disease is now being studied.

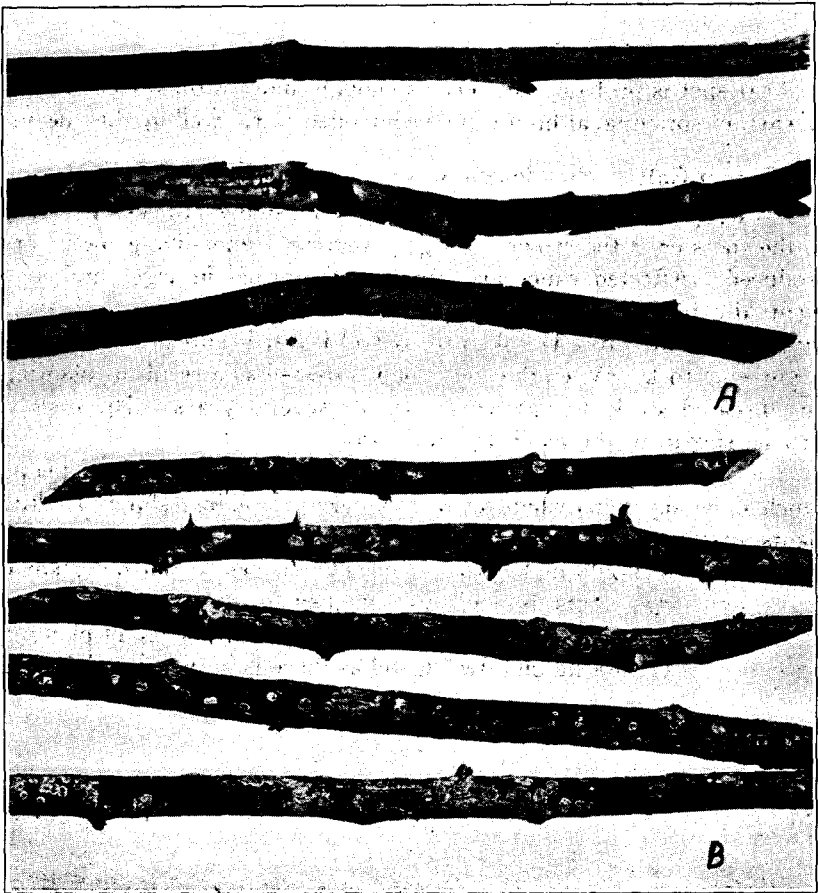


Fig. 28. A, Gray Bark Disease of Raspberry

Note the grayish bark, which is peeling. The wood is dead, and purplish or almost black in color.

B. Anthracnose. Grayish Spots with Purplish Borders.

To control both of these diseases cut out and burn all diseased canes. Spray young canes with resin-Bordeaux mixture.

Until more definite recommendations can be made, it is suggested that the affected canes be cut out and the new ones sprayed with resin-lye-Bordeaux mixture while they are still very small.⁷ The spraying should be repeated often enough to keep the canes well covered. It is best not to spray when the berries are ripening.

Rust (*Gymnoconia inerstialis* (Schl.) Lag.)

Rust appears on the leaves as large, bright, orange-colored patches. It also attacks the canes and may often get into the roots. Once a cane is infested it remains so indefinitely. For this reason, spraying is of minor value in controlling the disease. All affected canes should be immediately removed and burned.

Leaf Spot (*Septoria rubi* West.)

Leaf spot is probably not serious enough under ordinary conditions to warrant spraying, altho it can be controlled fairly well by this means.

Crown Gall (*Pseudomonas tumefaciens*. (S. and T.) Stev.)

Crown gall is a bacterial disease which usually attacks the plant on the roots or at the crown. Large, irregular, tumor-like growths are produced. Affected canes are usually sub-normal in vigor and may eventually be killed. The disease is extremely prevalent and great pains should therefore be taken to control it. It is spread very largely in nursery stock. When the soil is once infested as a result of planting this diseased stock it may remain so for several years. The disease may be spread in the patch by cultivation.

The greatest precaution should be taken never to set out any plants which show any signs whatever of this disease; neither should healthy plants be set out on land which has grown a crown-galled crop. All affected plants should be burned. Not only raspberry, but other small fruits, and large fruits as well, are attacked by the same bacterium. Indications are, however, that there is not so much danger in planting trees of a different kind on affected soil as there is in planting the same kind.

Yellows

Yellows is not due to bacteria or fungi. The affected plants are usually shorter than healthy ones. The entire plant may be very bushy in appearance. The leaves are yellowish or mottled, green and yellow patches alternating. The parts of the leaf between the veins are quite often raised, giving the leaf a peculiar curled appearance. The cause has not been definitely determined. It seems, however, that plants

⁷ Sackett, Walter G. Spur Blight of the Red Raspberry Caused by *Sphaerella Rubina*. Colo. Agr. Exp. Sta. Bul. 206. 1915.

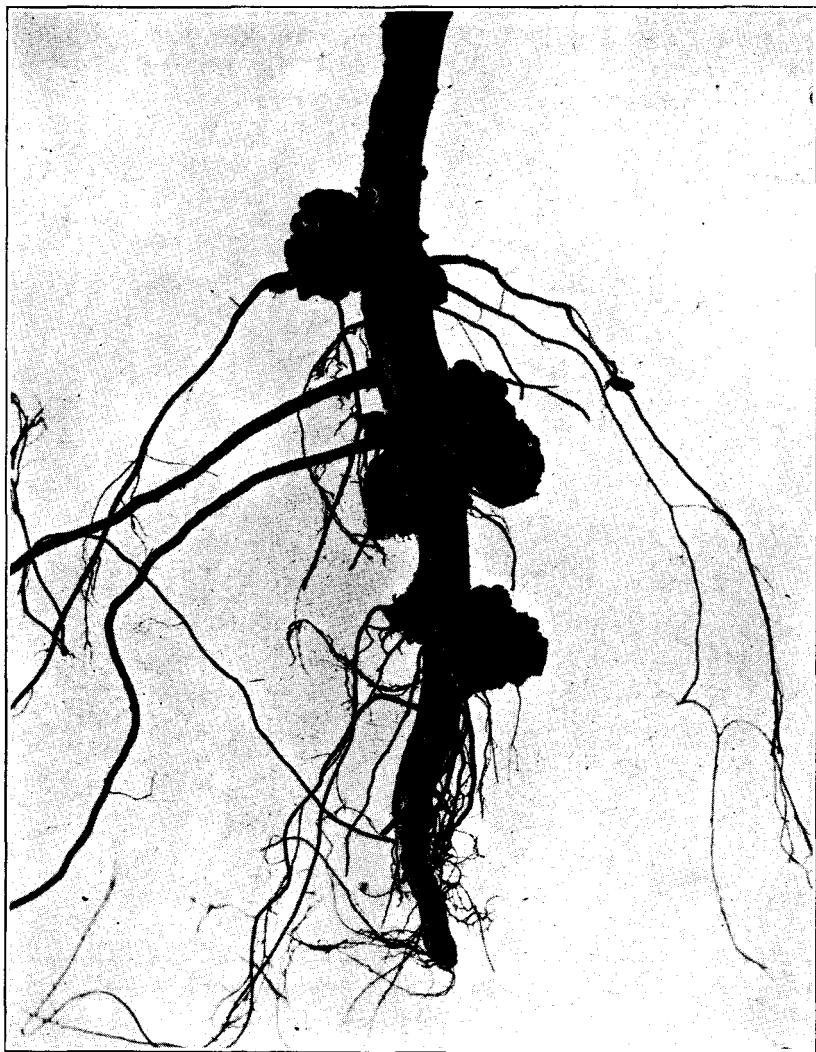


Fig. 29. Raspberry Crown Gall

grown in heavy soils with poor drainage are much more severely affected than are those grown in lighter, better-drained soils.

Raspberry plants which are to be used for planting should be obtained from localities in which the disease has not been serious. They should be set out on soil of medium texture, not too heavy, and well drained. A judicious application of barnyard manure is sometimes of some value. Where it is possible, the plants should be irrigated during periods of especially hot and dry weather. As soon as plants show distinct signs of the disease they should be removed and burned, as

neighboring plants may become affected. Cuthbert and Marlboro are very susceptible, while Early King is more resistant and is reported by some growers as giving excellent results when the first named varieties were seriously injured.

SQUASH

Wilt (See Cucumber.)

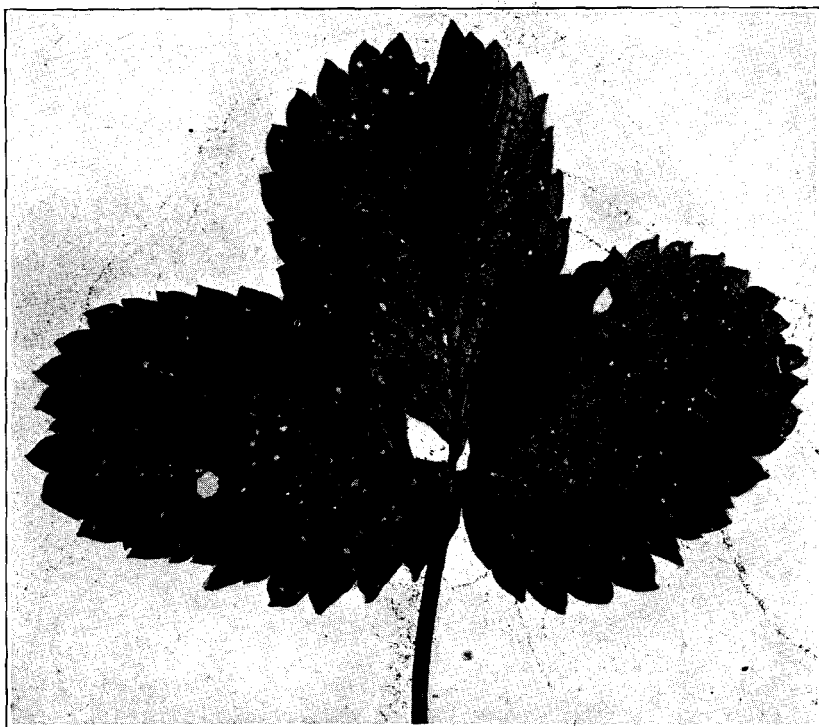


Fig. 30. Strawberry Leaf Spot. Grayish Spots with Reddish Borders

STRAWBERRY

Leaf Blight (*Mycosphaerella fragariae* (Tul.) Lindau)

Leaf blight appears on the strawberry leaves about the time the fruit sets. If nothing is done to control it; and conditions are favorable, it may cause considerable injury.

At first the spots are small, round, and reddish or brownish purple in color, increasing in size until they may become one-eighth to one-fourth of an inch in diameter. As the spots increase in size their centers become ashy-gray surrounded by a purple border which shades into the healthy green color of the leaf. In severe cases the spots may become so numerous as to discolor and finally kill the entire leaf.

Such a reduction in leaf surface may result in the production of small berries. The stems may also be involved, causing the berries to dry before they ripen.

The disease can be fairly well controlled by spraying with 4-4-50 Bordeaux mixture, once just before the blossoms open and once or twice after the fruit is picked. The leaves may be cut off late in the fall or early in the spring and burned. Care should also be taken when setting out young plants to pick off and destroy all diseased leaves.

TOMATO

Leaf Spot (*Septoria lycopersici* Speg.)

Tomato leaf spot has been serious in Minnesota during the last few years. It appears on the leaves as grayish spots with dark, somewhat raised borders. Sometimes small, black eruptions can be seen in the spots. The lower leaves are first affected and the disease progresses upwards. The spots may be so numerous as to involve practically the entire leaf, thus materially decreasing the yield.

The disease can be almost entirely controlled by spraying. As a result of three sprayings with 5-5-50 Bordeaux mixture, the first being applied soon after the blossoms fell, and the others at intervals of about two weeks, a net profit of from \$70 to \$128 an acre was realized. The spraying must be thoro enough to cover all parts of the vines. Altho the disease was almost entirely controlled by three sprayings during the last three years, it may sometimes be necessary to give a fourth spraying, depending very largely upon the severity of the disease. However, during the summer of 1913, when a net gain of \$128 an acre was realized, the disease was extremely serious, and was very largely controlled by three sprayings.

Point Rot; Blossom End Rot

Point rot, as the name indicates, appears on the blossom end of the fruit. It attacks the tomatoes when they are green. The first indication of the disease is a sunken area at the blossom end, either grayish or brown in color. This diseased area may enlarge quite rapidly until the entire fruit is involved. The affected portions appear to have been dipped in boiling water for a short time.

The cause of the disease has not been fully determined, but it does not seem to be due to any fungi or bacteria. Plants are more likely to be affected when they are growing rapidly. Either too much water or a sudden cutting off of the water supply may cause the plants to become affected. Plants growing on ground very heavily fertilized with horse manure quite often show more of the disease than those growing on other soil. It seems to be less prevalent on sandy loam

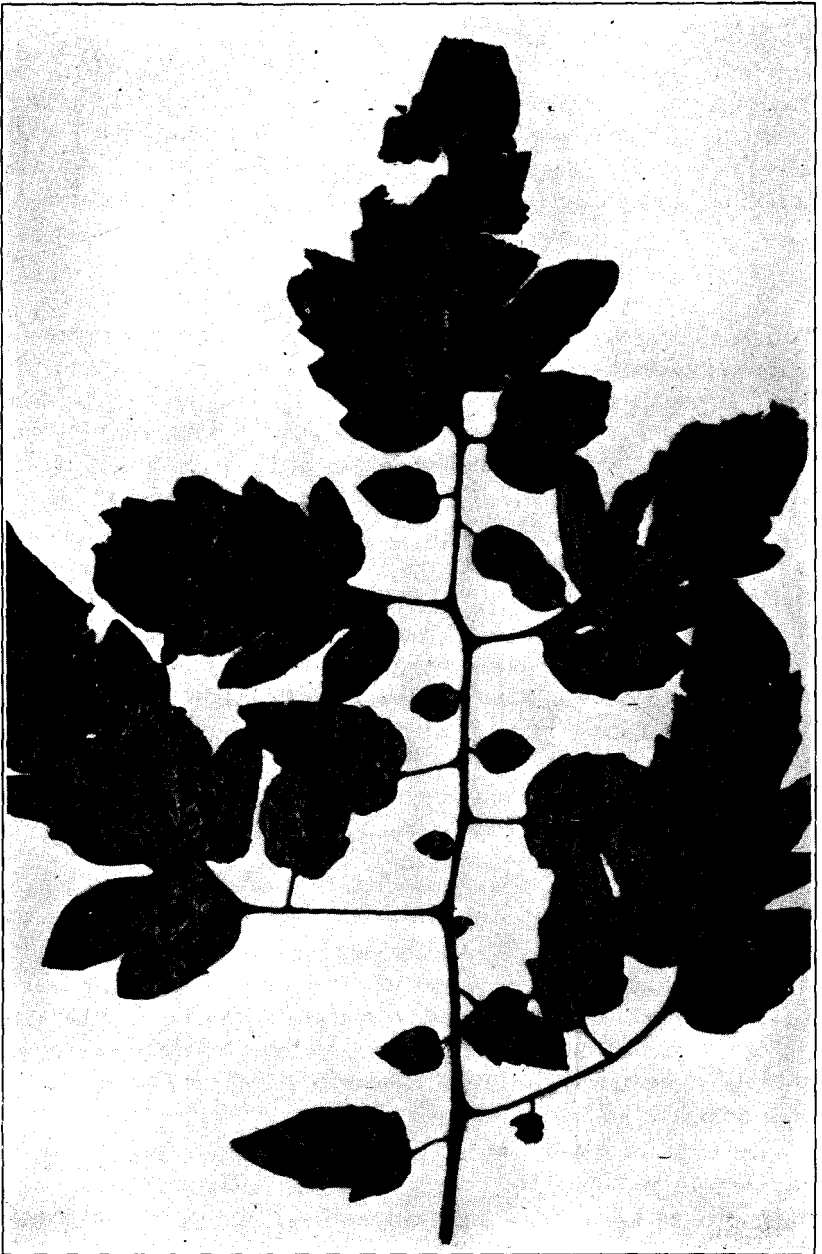


Fig. 31. Tomato Leaf Spot
This can be controlled by spraying with Bordeaux mixture.

than on heavy clay loam. Control measures, as far as can be suggested at present, must depend upon these facts.⁸

Black Rot; Ripe Rot (*Alternaria solani* (E. and M.) Jones and Grout.)

Black rot is very easily distinguished from point rot, since it may appear on any part of the tomato, and instead of attacking the green fruit, as the point rot does, it attacks the ripe fruit. It causes sunken spots in which a black or olive-colored, velvety mold later appears. It is most serious when the weather is fairly warm and moist. For this reason, when the vines are trained in such a way as to provide good ventilation, the disease is less severe. This training, together with thoro spraying, will control the disease to a great extent. Spraying as suggested for leaf spot will prevent a certain amount of the disease, but it is sometimes necessary to give a fourth spraying in order to prevent late infection.

Leaf Mold (*Cladosporium fulvum* Cke.)

Leaf mold is the most important disease of tomatoes in greenhouses. In Minnesota it is seldom, if ever, found on tomatoes in the field.

It appears first on the lower leaves from which it spreads rapidly upward until the leaves may all fall. Irregular greenish-brown patches occur on the under side of the leaves. On the upper side opposite these patches a yellow discoloration occurs. When the entire leaf is involved it soon dries up and drops off. The loss of leaves obviously prevents the proper development of fruit. Good ventilation is essential in controlling the disease. Spraying the vines with 4-4-50 Bordeaux mixture when the mold first appears, and keeping the vines covered throughout the growing season will aid materially. Clean culture should be practiced.

Mosaic; Calico

Mosaic, or calico, appears on the leaves. Yellowish patches alternate with darker green areas, giving the leaf a peculiar mottled appearance. The affected leaves are often curled somewhat and are sometimes abnormal in shape. Filiform or thread leaf is often associated with mosaic; the leaves may become extremely narrow and almost threadlike.

The disease is not due to visible parasites, but is infectious and contagious. It is a common experience for growers to notice that they have spread the disease by means of the pruning knife, especially under glass. The following precautions should be observed: (1) Do not set out calicoed plants; (2) do not set plants in soil which has

⁸ Brooks, Charles. Blossom-End Rot of Tomatoes. Phytopath. Vol. 4, No. 5, pp. 345-373. Oct. 1914.



Fig. 32. Tomato Mosaic Disease
A diseased plant is shown at right, healthy plant at left.

produced a calicoed crop without first sterilizing it with steam (This applies to greenhouses.); (3) destroy calicoed plants when they first appear; (4) do not touch healthy plants after having touched diseased ones without first washing the hands thoroly with soap and water; (5) disinfect the knife used for trimming diseased vines, with corrosive sublimate, 1 to 1000, before using it again.⁹

Anthracnose (*Colletotrichum phomoides* (Sacc.) Chester)

Anthracnose is characterized by the presence of dark sunken spots on ripe fruit. These may become so numerous as to destroy the entire tomato. Control measures for black rot should aid in keeping the disease in check.

TURNIP

Black Rot (See Cabbage.)

Soft Rot (See Cabbage.)

Club Root (See Cabbage.)

WATERMELON

Anthracnose (See Muskmelon.)

Downy Mildew (See Cucumber.)

Wilt (See Cucumber.)

VEGETABLE ROTTS

Soft rots of vegetables are sometimes very destructive. One species of bacterium is quite often responsible for a great deal of this rot on the various vegetables. The indications are that carrots, turnips, rutabagas, onions, parsnips, cabbage, and cauliflower are all affected by the same organism. The rot is especially serious in the field when the weather is fairly warm and wet. The germ may live in the soil for several years and it is therefore advisable to practice a rotation in which a non-susceptible crop is grown on the land. The greatest care should be taken in handling the vegetables, if the disease has been present, as the germ gains entrance almost entirely through wounds. The germ is killed rather quickly by drying and exposure to sunlight. It is, therefore, sometimes very beneficial to dry the vegetables as much as possible before storing them. The amount of damage in storage depends very largely on the conditions. High temperature with a considerable amount of moisture is most favorable to the spread of the rot. The temperature of the storage cellar should be maintained just a little above freezing and good ventilation should be provided.

⁹ Clinton, G. P. Chlorosis of Plants with Special Reference to Calico of Tobacco. Conn. Agr. Exp. Sta., New Haven, Ann. Rept. Pt. VI. 1914.

SPRAYING

PLANT	PEST	SPRAY	FIRST SPRAYING
Apple	Codling moth Curculio Scab Black rot Bitter rot Aphids or plant lice Scale insects	Arsenate of lead (3-50) plus concentrated lime-sulfur diluted (1 to 40), or Bordeaux mixture (4-4-50)	As center bud in flower cluster begins to show pink.
		Bordeaux mixture (4-4-50) Tobacco extract, like Black Leaf No. 40 Lime-sulfur (1-9)	When insects appear Before buds burst
Asparagus	Rust	Resin-Bordeaux mixture	After cutting season; when about eight inches high
Cabbage Cauliflower	Cabbage worm	Arsenate of lead (3-50) or Paris green (1-50) Dust with the powdered form or with wood ashes	When worms appear
Celery	Early blight Late blight	Bordeaux mixture (5-5-50) or Ammoniacal copper carbonate (3-50)	In seed bed
Cucumber	Downy mildew Cucumber beetle Larvae or grubs	Bordeaux mixture (5-5-50) Arsenate of lead or air-slaked lime or ashes Tobacco extract on roots	When vines begin to run Dust as soon as insects appear
Currant	Currant worm Leaf spot	Arsenate of lead or hellebore Bordeaux mixture	When insects appear Just as leaf buds break
Ginseng	Blight	Bordeaux mixture (3-3-50)	When plants come up
Gooseberry	Currant worm Mildew	Arsenate of lead or hellebore Potassium sulfide (Liver of sulfur)	When insects appear Just as leaf buds are breaking
Grape	Black rot Downy mildew Leaf hopper	Bordeaux mixture (4-4-50) Some miscible oil or kerosene emulsion	Before blossoms come out As soon as possible after they appear
Muskmelon	Anthraxose Leaf blight	Bordeaux mixture (5-5-50)	When vines begin to run
Plum and Cherry	Brown rot Curculio Plum pocket Shot hole Scales	Arsenate of lead (3-50) plus concentrated lime-sulfur diluted (1 to 40), or Bordeaux mixture (3-4-50) Copper sulfate Bordeaux mixture Same as for apple	Just before flower buds break Copper sulfate before any growth starts in spring
Potato	Blight— early and late Beetle	Bordeaux mixture (5-5-50) Paris green (1-50) or arsenate of lead (3-50)	When plants are eight inches high As soon as beetle eggs hatch
Raspberry and Blackberry	Anthraxose Gray bark disease (Spur blight)	Resin-Bordeaux mixture	Before leaves open
Strawberry	Leaf blight	Bordeaux mixture (4-4-50)	Just before blossoms open
Tomato	Tomato worms Leaf mold Leaf spot Black rot	Arsenate of lead (3-50) Bordeaux mixture (5-5-50)	When worms appear Just after the fruit sets
Shrubbery	Red spider Powdery mildew	Water or some tobacco decoction Potassium sulfide (Liver of sulfur)	As soon as first seen Whenever mildew appears
Sweet pea	Plant lice Mildew	Soap solution or nicofume liquid Potassium sulfide	As soon as noticed As soon as it appears

*Prepared in cooperation with Section of Tree Insects and Spraying, Division of Entomology. Other spraying formulas can be had by writing to the Division of Entomology or the Division of Plant Pathology, University Farm, St. Paul, Minn.

CALENDAR

SECOND SPRAYING	THIRD SPRAYING	REMARKS
Just after petals fall	Two to three weeks later	Spraying just after the petals fall, getting as much of the liquid into the calyx cups as possible, is most effectual for codling moth. Make a fourth application, about 30 or 40 days after petals fall, if black rot or bitter rot is present. Destroy fallen leaves and all rotted fruit; prune out and burn all cankers; disinfect wounds. Trees should be thoroly covered.
A week or ten days later		Spray every week or ten days until the middle of September.
Repeat when necessary		The poison will stick better to the leaf if used in soapy water. With cauliflower, great care must be taken if the plant is heading.
Repeat when necessary		Destroy diseased parts. If severe, dip plants in Bordeaux or ammoniacal copper carbonate mixture before storing.
Repeat when necessary		The adult insects do not seriously injure cucumbers in cold frames, nor do larvae under field conditions.
Repeat when necessary		When berries begin to turn, use hellebore.
Keep leaves well covered		Vines should be covered throughout season, especially during wet weather.
Repeat when necessary		Same as for currant. When mildew is abundant, spray every ten or twelve days.
When fruit has set	Two weeks later	The leaves should be kept well covered with Bordeaux mixture, especially during wet weather.
Every ten days to two weeks		
When plums are size of small peas Bordeaux mixture (3-4-50) or lime-sulfur (1-40) as soon as blossom buds swell	When fruit begins to color	Destroy all mummies (shriveled fruit). Prune and burn affected branches in the fall. Destroy affected plums.
Repeat when necessary		Vines should be well covered with Bordeaux mixture throughout the season. This usually involves spraying every ten days or two weeks.
		Cut out and burn diseased canes; keep old canes cut out. Protect with Bordeaux mixture until canes are at least two-thirds grown.
After fruit is picked		Cut off and destroy diseased leaves in fall or spring.
Repeat when necessary		Vines should be well covered with Bordeaux mixture throughout the season. Provide good ventilation.
Five or six days later	Ten days later	A flour paste made of 8 lbs. flour to 100 gals. water, added to the tobacco extract, is very effective.
Repeat when necessary		Spray should be very fine and put on forcibly. A spray of water alone is often very effective.

Never spray when trees are in full bloom.

In almost every case, an insecticide can be combined with a fungicide, and it pays to make the combination when possible.