TOMATO DISEASES

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TOMATO DISEASES*

INTRODUCTION

The tomato is grown extensively in Canada; there is hardly a garden that does not have at least a dozen or more plants. Gardeners and farmers in suitable localities grow large acreages for the market and canning factories. In Canada the tomato industry is therefore of special importance.

Tomatoes thrive best on a well drained and fertile sandy loam, but they will also do well on heavier types of soil, provided they are well drained. The tomato is a rank feeder, and unless well supplied with plant food, will grow feebly and be more subject to disease. Irrespective then of the physical state of the soil, this crop should be planted in land with high fertility, good drainage and of high humus content. However, if earliness of ripening is essential, a fertile, sandy loam is preferable to the heavier types of soil, which of course are quite satisfactory for a crop of late tomatoes.

In looking for the cause of unhealthy conditions in tomatoes, one should first consider to what extent they may be due to unfavourable soil, temperature, and moisture conditions. Attention is directed here to the natural dying of the earlier formed leaves, which is often regarded as a diseased condition. Many of these, before they are cast, show leaf spots, dead areas, and become yellow in colour. Aside from serving as a breeding ground for leaf spot and other fungi, the condition of such leaves is generally of no importance and should occasion no alarm.

There are several diseases of the tomato that may, under certain conditions, cause serious losses to the tomato-grower. There is considerable loss due to the leaf spot fungus which prevents the maturing of the late-formed fruit, or to severe outbreaks of some one or more diseases in certain districts, due to local conditions such as lack of sanitation, crop rotation, etc. Generally speaking, tomato diseases are not usually very serious, for which reason it is difficult to estimate accurately the annual loss due to diseases affecting the crop. However, in some years these losses must be considerable.

From the standpoint of plant-disease prevention and control the following facts should be carefully noted.

SEED

Growers are beginning to find that it pays them to use only the best of seed. When purchasing seed, deal only with good, reliable seedsmen and insist on the best strain of the desired variety. Many growers prefer to grow their own seed, which is commendable, since by a careful selection a grower may build up a superior strain which meets his requirements. For instance, a much earlier strain has been secured by the use of seed taken year after year from the first ripe and otherwise perfect fruit.

Disinfect all tomato seed before planting. For this purpose corrosive sublimate (mercuric chloride) 1:2000—that is, one tablet of poison to two pints water—is very satisfactory. The seed to be treated should be tied in a cheesecloth or muslin bag and then submerged in the disinfecting solution for

* Revised edition of Bulletin 51, New Series "Tomato Diseases" by G. H. Berkeley. First edition published in 1924.

ten minutes. The seed in the bag should be stirred with a stick or rod, so as to ensure each seed coming in direct contact with the fungicide. After treatment the seed should be rinsed two or three times in clean water, and then be spread out to dry, or better still, be planted before it becomes dry.

THE SEEDLING

The grower must realize that a good many of the troubles affecting tomatoes, such as leaf spot, leaf mould, mosaic, wilts, etc., may be started in, and spread from, the seed-bed. This means that special care should be taken to protect the small seedlings from becoming infected. To this end the disinfected seed should be sown in clean or sterilized soil, which should be kept free from weeds. The seed should not be sown too densely, as a crowded seed-bed is more subject to "damping-off." Also since a continuous damp surface in the seed-bed is favourable to "damping-off" it is good practice to have the soil of the seed-bed covered with a light layer of sand, so as to ensure a more rapid drying of the surface soil. Preferably, seedlings should be grown under glass so that on successive cloudy, humid days the excess humidity may be more readily driven off by heat and proper ventilation. This is particularly applicable to the seedlings for the fall greenhouse crop, which are so often severely attacked by the leaf mould fungus. Seedlings should not be grown in close proximity to weeds or old plantings of tomatoes, or potatoes. As an added precaution tomato plants should be sprayed with Bordeaux 2:3:40, while still in the seed-bed, or plant-bed, and before transplanting to the field or greenhouse.

If the above simple measures are faithfully carried out the grower will then start with sound, healthy plants and under sanitary conditions in the field or greenhouse, will have gone a long way in avoiding tomato diseases.

In this connection it is good practice to thoroughly fumigate the greenhouse just previous to planting therein. Such fumigation may be double the usual strength, since there is no vegetation in the house, and will not only destroy insects but will kill many forms of destructive fungus life as well. It should be pointed out that fumigation with sulphur is specially recommended for prevention of the leaf mould disease, since this fungus is specially susceptible to sulphur fumes. Sulphur, however, should not be burned in the greenhouse after the tomatoes have been set in.

SANITATION

Sanitation is a very important factor in the prevention of most tomato diseases. Many fungus diseases, such as leaf spot, black rot, leaf mould, anthracnose, etc., are readily spread from plant to plant during the growing season by means of wind, rain, insects, and even man. In the greenhouse particularly, it is good practice to destroy the leaves that first show leaf spots, etc., and under certain conditions to destroy the whole plant, in order to prevent spread of diseases. Also, diseased plant refuse left in the field, plant-bed, or glass house often harbours the disease in a dormant state until the next season. Therefore all diseased material should be destroyed so that the refuse from one crop will not be left in the soil to carry over the disease to another.

In this connection growers would be well advised to destroy all weeds in close proximity to tomatoes, whether they be in the seed-bed, plant-bed, glasshouse or field, since recent investigations have shown that the mosaic disease as well as leaf spot and other fungus diseases are found on certain weeds, particularly those of the same family (*Solanaceae*) such as horse nettle, jimson weed, bitter sweet, etc. Particularly should all weeds be destroyed in or near the seed and plant-bed, since mosaic, leaf spot, etc., is often in this way passed over from the diseased weeds to the young tomato seedlings. In addition it is

exceedingly good practice to have the tomato crop free from weeds, since they rob the soil of moisture and fertility and harbour insects. Many growers have found from experience that strict sanitary measures are generally sufficient to ensure a clean tomato crop.

In the greenhouse where moisture and temperature conditions can be maintained as desired, regularity in watering is a prime necessity. Good ventilation, especially in the early seedling stage, is also greatly to be desired. The soil in the greenhouse should be rich, well drained and clean (sterilized if necessary). Maintain strict sanitary conditions. If these suggestions are carefully carried out, spraying will generally be unnecessary.

In the field, practise a systematic crop rotation, along with good sanitary conditions. Set out only strong, vigorous, healthy stock. Destroy all weak, sickly plants, when noticed. Practise frequent cultivation to effectively kill the weeds.

CROP ROTATION

The organisms causing some tomato diseases, such as " wilts ", accumulate in the soil in a virulent state; consequently, if the same or a kindred crop (in this case potato, egg plant, etc.) is grown in the same soil year after year, these diseases are likely to prove very destructive. Rotation of crops is, therefore, highly desirable, if not absolutely essential.

SOIL DISINFECTION OR STERILIZATION

Where tomatoes have suffered from disease-organisms living over in the soil in greenhouse or seed-bed, the grower must either provide new soil, or else disinfect or sterilize the old. In obtaining new soil he should be very careful not to use soil that has previously grown the same crop. In the case of tomatoes, soil that has previously been planted to tomatoes, potatoes, egg plant, etc. should not be used. In large commercial greenhouses steam sterilization is generally employed to ensure clean soil. Several methods of steam sterilization are in use, all of which are good.

STEAM DISINFECTION

1. *Pipe Method.*—Pipes, with small holes to allow the escape of steam, are buried in parallel rows about 18 inches apart and about 1 foot beneath the surface of the soil. Steam is then passed through under pressure.

2. *Harrow or Sargent Method.*—Similar to above in principle, but consists of a steam system in the form of a harrow with perforated teeth. The teeth are forced into the ground, and the main pipe connects to a boiler.

3. *Inverted Pan Method.*—In this case steam is passed into an inverted pan whose sharp sides are forced into the ground. The steam under pressure penetrates the soil below the pan. Before the pan is placed over the soil, the ground should be well worked up so as to permit easy penetration of the soil by the steam.

4. *Drain Tile.*—Many growers to-day are making use of the tile-drain system for sterilization of the greenhouse soil. The tile (3-inch tile is satisfactory) is laid in rows 12 to 15 inches below the soil surface, with the rows generally from 15 to 20 inches apart. The heating pipes along the side or end of the greenhouse may be used for carrying the steam to the tile, or else it may be necessary to have a shorter direct line, depending upon equipment.

This system of sterilization has many advantages over the other methods, in that it is more permanent; nor does it require the same amount of attention as do the other methods and in addition the tile is necessary, in most greenhouses for drainage purposes.

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Treatment of steaming from two to three hours with at least 50 pounds pressure is generally satisfactory. This depends upon equipment, length of piping, etc. Treatment however, should be continued until the soil temperature reaches at least 150°F. and should be maintained at this temperature for at least two hours.

FORMALDEHYDE DISINFECTION

Where the generation of steam, for soil-sterilization purposes is not possible, the use of formaldehyde is recommended.

For formaldehyde treatment the soil should be in a loose condition, and be uniformly moist. The formaldehyde solution is made up in the proportion of 3 pints of formaldehyde to 40 gallons of water, and is applied at the rate of 1 gallon of solution, to 1 cubic foot of soil. Bags that have been dipped into formaldehyde solution should be placed over the soil for at least twenty-four hours, so as to retain the formaldehyde fumes in the soil. Thereafter the formaldehyde should be removed by spreading out and stirring up the soil every three or four days for about two weeks, when it may be used for planting. This method is readily adaptable to the small greenhouse and seed-bed of the grower who grows his own plants from seed.

ADDITIONAL DISINFECTANTS

The following fungicides are also recommended as an aid in controlling soil organisms.

1. *Copper Sulphate* (bluestone) is sometimes used as a protection to the seed-bed, only when for some reason steam or formaldehyde sterilization of the soil has been neglected, because copper sulphate is not so efficient as either of these other methods. The amount of copper sulphate generally recommended is 1 pound dissolved in 18 to 20 gallons of water and used at the rate of 1 pint to each square foot of space. This method is very satisfactory for checking "damping off" and may be applied to the seed-bed, after the seed has been planted but before the seedlings are up.

Copper sulphate is also used to disinfect the soil for a distance surrounding a plant or group of plants attacked by soil organisms. For instance in the case of Fusarium-wilted plants that have been removed, it is advisable to apply copper sulphate to the soil not only in the spot where the plant was removed, but for some considerable distance surrounding it, in order that the spread of the disease may be checked.

2. *Cheshunt Compound.*—This compound, which consists of finely ground copper sulphate and fresh ammonium carbonate (both chemicals may be purchased from any druggist) in the proportion of two parts by weight of the former and eleven parts by weight of the latter, is in general use in many vegetable-growing sections of England. To make the stock mixture, take, for example, 2 ounces sulphate of copper and 11 ounces ammonium carbonate, and crush them to a fine powder. After being well mixed together, the powder is put into a tightly stoppered glass or stone jar and stored for at least twenty-four hours. The solution is prepared in dissolving ½ ounce of the mixture in a little hot water and then further diluting with water at the rate of one gallon to each ½ ounce of the dry mixture. Larger quantities may be prepared so long as the proportions remain the same. One advantage of the cheshunt compound is that it can be applied to seed-beds, plant-beds, and soil in which plants are growing, and will destroy fungus parasites without injuring the plants. This compound is therefore of special benefit in the prevention of "damping-off." It is also recommended for use around plants that have been attacked by soil organisms, such as various wilts, etc., as a check to the further spread of the disease. In

making the application, the soil should be liberally sprinkled with the cheshunt solution. We have used this compound in our greenhouse at St. Catharines, on tomato, celery, lettuce, aster, and cucumber seedlings, and have found it very satisfactory.

3. *Corrosive Sublimate* (mercuric chloride) at the rate of 1 ounce of the poison to 8 gallons of water is also sometimes used to disinfect soil surrounding individual plants or group of plants. This will not sterilize the soil, but merely disinfects a small area directly about the roots of the plants where applied. In most tomato crops grown in the greenhouse there are always a few cases of wilt, tomato rot, or some such soil-borne diseases, and applications of copper sulphate, cheshunt compound, or corrosive sublimate around such areas help in checking the spread of the disease. Corrosive sublimate is a deadly poison and should be handled with great care. In its preparation use glass or earthenware utensils as it corrodes metal.

SPRAYING AND DUSTING

The spray most generally used for tomatoes is Bordeaux 4:6:40. It is to be remembered that spraying is essentially a method of prevention, or checking of further spread, and is not in itself a cure. It is, therefore, always advisable to be on the lookout for the presence of disease in the tomato field, and to spray in plenty of time, if the fungus attack warrants. If flea beetles or tomato worms are troublesome, lead arsenate at the rate of 2 pounds to each 40 gallons of Bordeaux should be added.

A copper-lime dust is also satisfactory for control of fungus diseases. If insects are to be combated, a copper-lime dust containing calcium arsenate should be used. The composition of a good dust for this purpose should be 16 per cent to 20 per cent copper sulphate, 20 to 25 per cent calcium arsenate, and 64 per cent to 55 per cent finely screened hydrated lime. Such dust preparations can be purchased ready to use, and may be applied either by hand or by power duster.

Dry mixture (wettable sulphur), or finely ground sulphur dust, are also quite satisfactory for preventing fungus diseases on tomatoes, in fact, sulphur is far superior to Bordeaux mixture for controlling the leaf mould disease, as has been shown by experiments carried on at St. Catharines and elsewhere.

STAKING

Staking of tomatoes has many advantages: 1, earlier ripening; 2, better quality; 3, larger fruits; 4, cleaner fruits; 5, greater freedom from disease; 6, more convenient cultivation and harvesting. It also has some disadvantages: 1, greater cost; 2, less total yield per plant; 3, more sunscald of fruit. However, from the standpoint of disease control alone, it is good practice to stake tomatoes. Staking permits better air and light circulation, as well as easier and more thorough spraying. It is now generally recognized that not only are staked tomatoes much freer from disease, but also that they produce an earlier crop of better quality than unstaked tomatoes. In this connection it should be pointed out that the leaves of tomato plants pruned to a single stem (as in staked tomatoes) have a tendency to curl. It has been shown by Güssow[1] and others that this phenomenon is not a disease and that it does not interfere with the yield and quality of fruits. It is generally considered that this non-parasitic curling of leaves of staked tomatoes is the result of interference in the translocation of reserve food material, due to excessive pruning of laterals.

[1] Güssow, H. T.—"Leaf Curling of Tomatoes." Phytopathology Vol. 11, 380-383, 1921.

MARKETING

For local markets the fruit can be left on the vine until well matured, but for long-distance shipment it should be packed before a high colour is attained. This is necessary because the tomato when ripe is very tender, easily crushed and bruised; the skin is readily ruptured by careless picking, handling, and packing. In transit such fruit readily falls a prey to fungi and bacteria, resulting in almost total loss of the affected fruit. This is particularly true if the car, during transit, has a still, warm, humid atmosphere. On the other hand pink-matured fruit which shows the first signs of colour, is not so tender, and its skin is not so readily punctured. Such fruit does not readily become infected with fungi or bacteria, and accordingly arrives at its destination in first-class condition.

Great care should, therefore, be taken in picking, handling, and packing tomatoes, so as to ensure clean, sound, firm, pink-mature fruit in the long-distance pack.

LEAF SPOT (*Septoria Lycopersici* Speg.)

The leaf spot, or "blight" disease, as it is often called, is a fungus disease which causes numerous, small, circular spots on the leaves, stems, and petioles of the tomato plant. In severe cases even the fruit is spotted (fig. 1). These spots are generally greyish in colour with a black border, although sometimes continuous black spots are found. The disease starts on the older, weakened, bottom leaves and, under favourable conditions, works its way upwards. Leaves that are badly affected turn yellow, dry up, and fall, so that in bad attacks the tomato plant becomes defoliated and the stems are left bare.

The damage to the crop comes largely from loss of the leaf surface. Since the leaves of a plant are the manufacturing units which produce the starches, sugars, proteins, etc., that ultimately make up the bulk of the solid matter of the ripe tomato, it can readily be seen that anything which impairs the production of these substances is bound to have a direct effect on the quantity and quality of the crop. A leaf disease, such as leaf spot, reduces the manufactured output of the leaf surface of a plant in direct proportion to the number and size of diseased spots produced thereon, because in a diseased spot the manufacturing units are dead. Hence the fruits grow slowly or not at all. Half-matured fruit often fails to ripen, and fruit from "leaf spot" plants is characteristically watery.

Leaf spot is caused by a fungus, called *Septoria Lycopersici*, which lives and feeds on the tissues of the tomato plant. Leaf-tissue that is thus invaded by the leaf spot fungus dies, and the characteristic grey spots on the leaves result.

This disease is present in almost every tomato field; in some localities, however, it is not generally considered of sufficient importance to warrant spraying, since it seldom becomes plentiful until late in the season. At this time the damage to the crop is of much less importance than when the disease becomes prevalent on young plants early in the growing season.

CONTROL

Since the leaf spot fungus lives over winter on dead tomato vines and leaves left lying on the surface of the ground, it is essential that the refuse from a crop be destroyed by burning, or ploughing under.[1] In the greenhouse all diseased leaves and tops should be carefully gathered and burned.

Not only is it essential to practise strict sanitary measures as outlined above but since the leaf spot fungus is capable of living on certain weeds as well as the potato and egg plant, these facts should be taken into consideration in connection with sanitation and crop rotation. Weeds should not be tolerated in or near the seed-bed, plant-bed, glass-house, or field where tomatoes are growing. In a crop rotation plan the fact that tomato, potato, and egg plant

[1] Control of Leaf Spot—U.S.D.A. Bulletin 1288.

Figure 1

TOMATO LEAF SPOT. In bad attacks the leaves turn yellow, dry up and fall off.

Figure 2

BLOSSOM END ROT
(After Brooks.)

Figure 3

BLACK ROT. The three upper fruits show the rot as it occurs in the field. The rot spots in the two lower fruits were produced by inoculation with cultures of the fungus.

are equally susceptible to the leaf spot fungus, should not be lost sight of. A good general recommendation, is to plough under thoroughly or rake up and burn tomato, potato or egg plant refuse at the end of the season and keep the tomato crop free from weeds. Crop rotation and disinfection of seed should always be practised. A grower who practises a systematic rotation of crops and whose fields are kept in a good sanitary condition, has gone a long way towards preventing leaf spot.

In some seasons it may be necessary to supplement sanitary measures by spraying, particularly if an early infection of "leaf spot" has shown up. Bordeaux resin fish-oil soap 4:6:3:40 is the most satisfactory spray to use. That is copper sulphate 4 pounds, hydrated lime 6 pounds, soap 3 pounds, water 40 gallons. Two or three applications at intervals of ten days should be sufficient. In districts where leaf spot has shown itself to be a very destructive disease, the first application should be applied in the seed-bed, the second shortly after blossoming, and another in about two weeks' time. However, in some seasons one or two additional applications may be necessary.

It has been demonstrated repeatedly that staked tomatoes are much freer from this disease than unstaked tomatoes. This is due to better air circulation and less humidity around the plant.

LEAF MOULD, BROWN MOULD (*Cladosporium fulvum* Cke.)

As the name suggests, this fungus appears as a mould on the leaves of the tomato plant, where it causes indefinite, pale-yellow areas. On the under side of the leaf dense brown masses of the fungus are to be seen. Owing to the immense number of spores produced by this fungus, spread takes place very rapidly, especially in the warm humid atmosphere found in greenhouses. It is for this reason that this fungus is so prevalent in the greenhouse, where it often causes considerable loss to the tomato crop. When conditions are favourable for leaf mould development, the stems, blossoms, and fruits, as well as the leaves may be affected. On the fruit, a black stem-end rot, often involving a considerable portion of the fruit, is sometimes caused by this fungus.

CONTROL

1. Keep humidity at as low a point as possible consistent with good growth. This may be done by supplying more heat, and opening the ventilators.

2. Water the plants at the roots, and thus avoid wetting of the leaves as much as possible.

3. Cleanliness (sanitary measures) is a very important factor in the prevention of this disease. All diseased dead plant material should be removed from the greenhouse and destroyed. It is also advisable to pick off the first leaves affected, before they have had much chance to initiate spread.

4. If proper manipulation of ventilation, heat, and watering is unsuccessful, it may be necessary to make two or three spray applications. Dry mixture (wettable sulphur) is a very satisfactory spray to use for leaf mould prevention. Bordeaux mixture has been generally recommended in the past, but it is not as toxic to the leaf mould fungus as sulphur. Self-boiled lime-sulphur, or sulphur dust, are also to be recommended.

DAMPING-OFF

This is primarily a seed-bed trouble caused by various soil-inhabiting fungi. The small seedlings are attacked at or below the surface of the ground, and the plants wilt, fall over, and die. Occasionally entire beds fall a prey to such attacks. Plants of considerable size are sometimes lost through the infestation of the soil with *Rhizoctonia*.

Although *Rhizoctonia Solani* Kühn is by far the greatest offender in this connection, *Pythium de Baryanum Hesse*, and *Fusarium* spp., etc., are also known to cause damping-off of various seedlings.

CONTROL

Control measures are based upon the fact that "damping-off" is caused by soil-infecting organisms. Therefore, always use clean soil in the seed-bed. If soil previously used in seed-beds is to be used again it should be disinfected or sterilized as described under "Soil Disinfection and Sterilization".

1. Disinfect the seed.

2. Avoid heavy seedings, since a crowded seed-bed is favourable to "damping-off" fungi.

3. Do not keep the surface of the soil continuously damp, but water plants only when necessary, and preferably in the forenoon, so that the surface of the soil will be dry by night. It is essential that the surface of the soil be kept as dry as possible. In this connection it is good practice to have a thin layer of sand as a top dressing on the seed-bed, for an aid in keeping the surface of the bed dry.

4. Good ventilation is an absolute necessity.

5. Copper sulphate, 1 pound in 20 gallons water applied on the seed-bed after the seed has been sown, is a further precaution against "damping-off." The solution is applied at the rate of 1 pint to each square foot. A good soaking of the soil with the copper sulphate ammonium carbonate compound (cheshunt compound) is also highly recommended for "damping-off." (See "Additional Disinfectants").

TARGET SPOT, BLACK ROT, RIPE ROT (*Alternaria Solani*. E. & M.)

This fungus causes both a leaf-spot and a fruit-rot, though the rotting of the fruit is by far the most important phase of the disease (fig. 3). The rot on the fruit starts usually in some small wound, crack, or most often probably in the punctures or bites made by insects. The disease is always much more prevalent and severe in early tomatoes which are allowed to become weedy towards the end of the season. Such weed growth holds the humidity around the plants and makes conditions very favourable for infection by rot fungi. It is also probable that insects find such growth a favourable retreat. The resulting rot-spots slowly increase in size and become black, leathery, sunken areas. On the leaves circular, dark brown to black spots of various sizes are produced. The spots, often up to one-half inch in diameter, are readily distinguished by their peculiar ring-like, or concentric markings, hence the name "target spot." When these spots occur around the edges of the leaf, as they often do, their symmetrical ring-like appearance is often lost due to the uneven outline of the edge of the leaf.

Since this same fungus is ascribed as the cause of the early blight of potatoes, and is said to be carried over winter on old, dead leaves, tops, and rotten fruit, care in destroying or burying all such affected material is a fundamental step in the control of this disease.

CONTROL

Spraying with Bordeaux as outlined for leaf spot will give a good measure of protection, but, according to the experience of numerous growers, cleanliness and proper rotation are usually sufficient to protect the crop. However, in districts where black rot is prevalent, spraying should be started in the seed-bed and followed by regular applications at two-week intervals.

Figure 4

Typical case of filiform or spindly leaf, associated with the Mosaic disease.

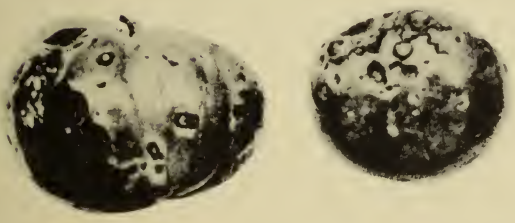

Figure 5

ANTHRACNOSE.
(After J. C. Humbert.)

Figure 6

A WILTED PLANT
(After De Baun.)

PHOMA ROT (*Phoma destructiva* Plowr.)

Farther south this rot has been met with to some extent and, on account of the yearly importation of early southern tomatoes, it may be introduced here. In one case reported by the Dominion Botanist a carload of Florida tomatoes entered Montreal, in which practically all the fruits were attacked by this rot. It is chiefly known as a fruit-rot, though the fungus may attack the leaves and produce spotting. On the ripe fruit dark, sunken spots are produced. The older spots are dark in colour and are surrounded by a zone of water-soaked tissue. In the dark centre are to be found numerous black or brownish specks, the spore-bearing organs (fig. 8). On green fruits the spots are smaller and the water-soaked border is not so evident. The fungus is apparently able to enter the skin of the fruit only through wounds or insect punctures, and will, therefore, seldom become a serious pest. Leaf-infection may take place more readily. Irregular, blotchy, dead areas are produced, and when these are plentiful the leaves are cast. On both leaves and fruit infection takes place most readily under humid conditions.

Destruction of old diseased plant material would appear to afford sufficient protection from this disease.

ANTHRACNOSE (*Colletotrichum phomoides* [Sacc.] Chester)

Anthracnose on tomato is not very general, nor very important in Canada. It is first apparent as small sunken spots with dark centres, which increase in size, and often cover the greater part of the surface of the fruit (fig. 5). Such fruit is unfit for the market. In these spots the spores of the fungus *Colletotrichum phomoides* are produced in great numbers. These spots are often overrun by other fungi or bacteria which follow up the attack by the anthracnose organism, and greatly extend the rot, rendering the fruit worthless.

CONTROL

1. Destroy all diseased material as soon as noticed.
2. Spray with Bordeaux mixture (4:6:40) as soon as the disease has made its appearance, and two or three times following, at ten-day intervals.

LATE BLIGHT (*Phytophthora infestans* [Mont.] de Bary)

This disease, so serious in potatoes, occasionally attacks tomatoes, when it causes the death of the plant much as it does with the potato. Moist, cool, growing seasons are favourable for an attack by this fungus. The first evidence of the disease is the appearance of black, water-soaked spots on the older leaves and stems. The spots enlarge and under favourable conditions, the plant rapidly turns black and dies. On the fruit, discoloured, sunken spots occur, generally at the stem end. In dry weather the spots become dry, brown, and brittle. On the lower surface of the leaves, the spots show a white, mildewy, fungous growth. This growth is the fungus *Phytophthora infestans,* the causal organism of the disease.

CONTROL

Serious damage from this disease may result, but spraying with Bordeaux, as described for leaf spot and other leaf diseases, is generally sufficient to give satisfactory control.

WILTS

There are several wilt diseases of the tomato which show similar symptoms, in that the foliage turns yellow and wilts. If the attack is severe the plant dies. One of these wilts is caused by the fungus *Fusarium Lycopersici* Sacc., another

by a species of *Verticillium*, another by a bacterium known as *Bacillus Solanacearum* E. F. Smith. Various "damping-off" fungi also cause wilt symptoms in the seed-bed. Besides these specific diseases, there are several other factors that may produce wilt symptoms; such as drought conditions, fertilizer, or stem injury of any kind which results in an interruption of the flow of sap. Centipedes, millipedes, and grubs of various kinds which girdle the stem are often responsible for considerable wilting in the seed-bed or hotbed. However, wilting due to these causes is readily recognized.

FUSARIUM WILT, SLEEPING DISEASE (*Fusarium Lycopersici* Sacc.)

This trouble is due to a fungus which gets into the stalks from the soil by way of the roots, and clogs the sap-conducting tissues, thereby bringing about a wilting and slow death of the tops (fig. 6). Very often the plants are attacked in the seed-bed, but do not show any sign of the trouble till they have been set out for some time. When hot, dry weather occurs, the fungus in the sap-conducting vessels prevents the upward passage of sufficient water for the top, and the leaves wilt, or turn yellow, and finally fall. Often weaker portions of the leaves are killed by the hot sun, and the foliage becomes curled or rolled in a very striking way. In all cases the crop is greatly reduced, and the plants are likely to die. Affected stems and leaves show a brownish discoloration of the water-conducting tissues, which can easily be observed by making a slanting cut through the stem and petioles.

The fungus lives in the soil, often for years, and, accordingly, plants set out in an infected soil will readily take the disease. However, perhaps the greatest spread is due to plants set out from an infected seed-bed, since the disease attacks young plants, but the effect is usually not noticeable until they approach maturity. Thus the affected plants may appear healthy and be transferred into the field. Once in the soil the fungus may remain there for some years in a very virulent state, ready to attack new plants when set out. Tomatoes should not be set out in such soil. Practise a long, systematic rotation of crops. Every plant that shows any symptom of the disease should be pulled up and destroyed.

The most satisfactory method for controlling this disease is the planting of resistant varieties. The United States Department of Agriculture claims to have developed two or three strains of great promise in this connection. The Norton seems best at present for general purposes, while Marvel, an early variety, and Norduke, a late variety, also show considerable resistance to this disease.

In the more southern districts of the United States this wilt is very damaging. Although some cases of it have been met with in Canada it does not yet appear to be general, and we venture to hope that our severe climate has something to do with the degree of immunity we seem to have enjoyed up to the present.

VERTICILLIUM WILT (*Verticillium* sp.)

The wilt caused by this fungus is very similar in appearance to the fusarial wilt (fig. 6). Observations made in 1924 and 1925 in the Niagara peninsula would tend to show that this type of wilt is much more prevalent in Ontario than the fusarial wilt. This same fungus causes not only a wilt disease of tomatoes, but also of potatoes, and apparently of raspberries. At any rate a survey made in 1924 has shown that practically every bad attack of wilt (blue stem) on raspberries has been found on soil which had previously been planted to potatoes or tomatoes. This means that considerable wilt has been present in potato and tomato fields in Ontario. We are of the opinion that this disease should be given more attention in the future, as it is fairly general. Several

cases of wilt on potatoes and tomatoes have been observed this year, and isolations from such diseased materials gave cultures of *Verticillium sp.*

CONTROL

The breeding of resistant strains is the most promising method of controlling this type of disease. In the greenhouse, however, such fungi can be eradicated by means of soil sterilization. In the field good sanitary measures, such as the burning of diseased tomato vines, along with a four- to five-year rotation of crops, should generally be sufficient to prevent any bad attack. In a crop-rotation plan it should be remembered that this fungus attacks not only the tomato, but also the potato, egg plant, and apparently the raspberry.

BACTERIAL WILT, BLIGHT (*Bacillus Solanacearum* E. F. Sm.)

The symptoms of this wilt disease are very similar to those of the former, except that the bacterial wilt generally becomes first apparent by the wilting of a single branch or leaf, from which it rapidly spreads throughout the whole plant, whereas, with the fusarial and verticillial diseases, the wilt is more general from the first. Also, stems when cut across show a black discoloration of the sap conducting tissue and a dirty, milky slime is exuded at the cut surface. The bacterial wilt is caused by a bacterium which may gain entrance through wounds not only in the roots, as in the wilts previously described, but also into the stems and leaves by means of insects feeding thereon.

CONTROL

1. Disinfect or sterilize the seed-bed.

2. Practice at least a four- to five-year rotation of crops, taking into consideration that potato, pepper, and egg plant are also attacked by this bacterium.

3. Remove immediately, and destroy all plants in the field that show any symptoms of this wilt.

SCLEROTIAL BLIGHT, WILT (*Sclerotium Rolfsii* Sacc.)

This disease has only been reported once or twice in Canada, but is very general in all the Southern States of the Union, and has been found in greenhouses in Ohio. The fungus, *Sclerotium Rolfsii,* attacks the plant at or near the ground, and the first evidence of the disease is often a white, mouldy growth on the stem. This mouldy growth often produces numerous hard, round bodies, known as sclerotia. These sclerotia are at first white, then brown, and finally black. Soon a wilting of the tips is apparent and, later, the wilting and dying of the whole plant follows.

This fungus also attacks peppers, potatoes, and a number of other cultivated plants. This disease is as yet of no importance in Canada. However, any plants found diseased in this way should be pulled up and burned.

SCLEROTINIA WILT, TIMBER ROT (*Sclerotinia libertiana* Fckl.)

This is a minor disease of tomatoes, but may at times be somewhat troublesome in greenhouses. The writer has observed many cases of this disease during the last three years, although in all cases, the percentage of diseased plants in a house was small.

The disease is generally first manifest by a wilting of the foliage. Upon examination it is found that the stem at or just above the ground is decayed and hollow, the pith having disappeared. Later the white cottony growth of the fungus may be seen on the stem. If the stem is split open, the white

cottony mycelium, and numerous black sclerotia of the fungus may be seen lining the hollow stem. Sclerotia may be found intermixed with white mycelium on the outside of the stem as well.

CONTROL

Since this disease will be troublesome only when the soil is heavily infested with the fungus, and the humidity of the soil and greenhouse is abnormally high, the correct measures of prevention include use of clean, or sterilized soil, good drainage and ventilation.

WESTERN YELLOW TOMATO BLIGHT

Tomato-growers of southern British Columbia have for several years suffered from a disease called "Western Yellow Tomato Blight." Its severity varies with the seasons, in bad years the loss running as high as 30 per cent of the crop. The disease is widespread throughout the Pacific coast region of North America, extending from Mexico to southern British Columbia. In some of these districts, the losses sustained have been as high as ninety per cent of the crop, and in many, it is the chief limiting factor in the growing of tomatoes.

Diseased plants are readily distinguishable since they are rigid, the leaves are stiff and brittle and have a marked tendency to roll and droop slightly; no wilting occurs; the veins are generally purplish in colour and the normal green colouring of the leaf gradually gives place to a sulphur-yellow colouration. The plant ceases to grow, and fruit already formed likewise ceases to enlarge. Eventually the plant turns brown and dies. The disease runs its course in from one to two weeks. Affected plants sometimes show signs of recovery, but rarely do they become normal again. An examination of the root-system shows the fine rootlets to be brown in colour, and decayed. The outer tissue may be easily rubbed off between the fingers, leaving the central woody cylinder. Careful surveys and field observations, made by the U.S. Bureau of Plant Industry, have shown that conditions which favour a high evaporation rate, likewise favour the development of western yellow blight. It has been observed for instance that years which were bad blight years, were also years with a high evaporation rate.

Recently M. B. McKay and T. P. Dykstra[1] have demonstrated that western yellow blight is a " virus " disease since they have been able to induce the disease in healthy tomatoes by transferring thereto, by means of leaf hoppers, the juice from sugar beets affected with the curly top virus disease.

CONTROL

Satisfactory control measures based upon experimental evidence have yet to be formulated. However, since the above relationship between western yellow blight and sugar beet curly-top has been definitely established, growers would be well advised to plan their plantings so that tomatoes and sugar beets may be as far apart as possible.

MOSAIC

The mosaic disease of tomatoes is common everywhere in greenhouse and field crops alike, although generally a higher percentage of mosaic is found in the greenhouse crop. In 1924 and 1925, many fields of tomatoes, particularly around St. Catharines, showed a high percentage of mosaic. The writer observed numerous fields of tomatoes in 1924 showing from a trace to 40 and 50 per cent mosaic, with an average of around 5 and 6 per cent. There is no doubt whatever but that mosaic is a very serious disease in the field as well as in the greenhouse, and that a great lessening in the crop results from bad attacks. In

[1] M. B. McKay & T. P. Dykstra—paper entitled Sugar Beet Curly-top Virus the cause of Western Yellow Tomato Blight, presented at the Philadelphia Meetings of the American Phytopathological Society, 1926.

severe cases plants give from one-quarter to one-half a normal yield. In slightly affected plants there is apparently a normal yield. In one small block of tomatoes in 1924 a combination of leaf spot and mosaic produced a total loss.

Mosaic is apparent on the leaves as a mottling of dark and light green areas. Sometimes the dark areas are raised giving the leaf a rough, puckered appearance. Often a spindly of filiform leaf is associated with mosaic (fig. 4). The disease itself does not kill the leaf tissue, but may so weaken the plant, as a whole, that it falls a prey to drought, sunburning, or fungi that otherwise would have no damaging effect.

It has been shown that the disease is highly infectious and spreads with great rapidity. Insects, such as plant lice (aphids), are perhaps the greatest factor in the spread of this disease. Such cultural operations as pruning, harvesting, transplanting, etc., also aid in this connection.

Tomato mosaic is not transmitted through the seed, and does not persist in the soil or litter from diseased plants.

It has been shown by Gardner and Kendrick[1] that certain solanaceous weeds, such as bittersweet, horse nettle, ground cherry, etc., are subject to the same disease, and that these perennial weeds in certain regions harbour mosaic over winter. This means that such weeds are a yearly, primary source of mosaic and tomatoes planted near them are quite likely to become diseased due to the spreading of the disease from the weeds to the tomato by means of insects. Therefore, such weeds should be destroyed where tomatoes are to be grown.

If mosaic is present in the seed-bed it will be transferred with the transplant to the field. This means a wholesale spread of the disease. It has been shown that some of the worst cases of spread of mosaic were due to infection in the seed-bed.

CONTROL

1. Do not set out affected plants.
2. Do not use plants from seed-beds in which mosaic has developed.
3. Destroy mosaic plants when they are first noticed.
4. Do not touch healthy plants after having touched diseased ones without first washing the hands thoroughly.
5. Destroy all weeds in the seed-bed, plant-bed, or greenhouse.
6. Keep tomato fields free from weeds.
7. Control insect-carriers in the field or plant-bed by spraying with Bordeaux 4:6:40, to which nicotine sulphate and arsenate of lead have been added. Greenhouses may be fumigated with hydrocyanic acid gas (Cyano gas).

STREAK

The "streak" or winter blight of tomatoes is a fairly widespread and troublesome disease of tomatoes grown under glass. During the last few years it has been reported in many sections of Canada. It is also general in the Eastern United States and has long been troublesome in Europe.

The name "streak" is very appropriate as small, dead, streaky spots appear on the leaves, stem and sometimes even on the fruit. The first signs of the disease are a curling of the upper leaves. Affected leaves remain small, take on a sickly appearance, show necrotic spots, die and finally fall. When the fruit is affected it shows black sunken, or raised necrotic spots with a greasy appearance. Such fruits are small, deformed, and unfit for the market (fig. 7). On the stem, brown sunken streaks appear which often coalesce and completely girdle the stem.

[1] "Tomato Mosaic." Bul, 261. Purdue University Agr. Ex. Sta. Lafayette. Ind.

Recent investigations by Gardener[1], Vanterpool[2], and the writer[3] have clearly demonstrated that "streak" belongs to the "filterable virus" group of diseases. This means that it is a contagious disease, similar to tomato mosaic. Therefore from the standpoint of control "streak" must be considered, in the light of our present knowledge, as a mosaic disease. The writer has further demonstrated[3] that the juice from apparently healthy potatoes is able to produce streak symptoms on tomatoes.

CONTROL

Our investigations indicate that "streak" of tomatoes need not be a serious disease in a well managed greenhouse. In any case we have had very satisfactory control of this disease during three successive crops in commercial greenhouses. Our investigations have also clearly demonstrated that streak is not of a simple nature. That is, no single factor is able to consistently bring about the disease, but evidently a combination of factors is necessary. In this connection we have come to the conclusion that greenhouse environment is one of the most important factors.

The following recommendations relating to control, are given:—

1. Since streak is of the "mosaic" type of disease it is essential that the tomato seed-bed, plant-bed, etc., should be distant from old tomato and potato crops.

2. Practice strict sanitary measures in the seed-bed, plant-bed or glass-house; do not allow weeds in close proximity to tomatoes since recent investigations have shown that they (weeds) may harbour mosaic and related diseases (streak?).

3. Set out healthy plants only.

4. The soil for growing of greenhouse tomatoes should be well drained, and contain abundant humus and general fertility so that there will be little need for the addition of commercial fertilizers.

5. Temperature as near 70-75° F. as possible in the day time; not below 50° F. at night.

6. Regular and thorough ventilation is a first essential.

7. Avoid too much nitrate or too heavy and too frequent mulchings. Mulching should be delayed until the second and third trusses of fruit have set. We have had our best results from a light mulching applied when the second truss had set, followed by another heavier mulching, ten to fourteen days later.

8. Acid phosphate is to be recommended.

9. Practice strict adherence to regularity in watering, lessening or increasing the amount according to weather conditions.

10. Avoid all measures which tend to "force" the plants into soft, succulent growth.

11. Above all, endeavour to manipulate greenhouse environment so as to encourage an even, steady, regular growth. Avoid "forcing" and then later "checking" the plants.

BLOSSOM-END ROT

The first symptom occurs on either green or ripening fruit as an irregular, sunken, brownish area at the blossom-end of the fruit (fig. 2). Generally the disease advances rapidly until the greater part of the lower half of the fruit

[1] Gardner, Max W. Jour. Agr. Res. Vol. 30, No. 9, page 871, 1925.
[2] Vanterpool, T. C. Phytopathology. Vol. XVI. No. 5. page 311-331, 1926.
[3] Berkeley, G. H. Scientific Agriculture. Vol VII. No. 6. 210-223, 1927.

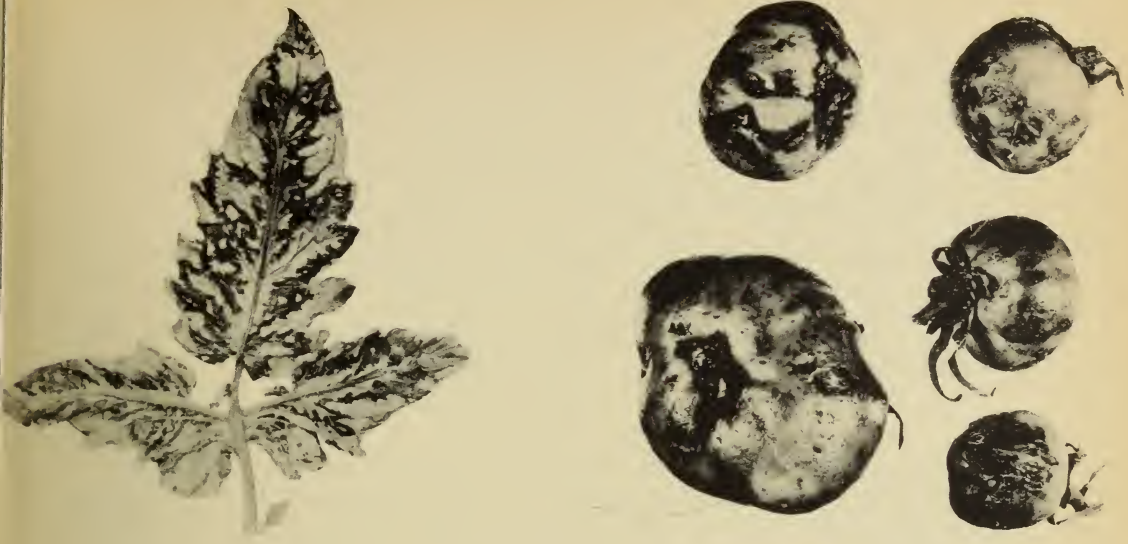

Figure 7

STREAK IN LEAVES AND FRUIT. The brown areas in the leaves are typical of more advanced stages. In earlier stages the brown spots are small.

Figure 8

PHOMA ROT
(After Jamieson.)

shows a black, dry, leathery rot. The cause of the disease has not been fully determined, but it is usually associated with drought conditions or irregularities in the water supply. Excessive moisture followed by drought, or vice versa, favours the disease. It is thought that such conditions bring about sap pressures which rupture the tender tissues around the blossom-end of the fruit, after which fungi, or bacteria, or both, gain an entrance and initiate a definite rot. The black rot fungus is generally prominent in this second stage of the disease. Rapidly growing plants are very susceptible. The writer had under observation two small garden plots in 1924 that showed 20 per cent to 25 per cent end rot due to extra rapid growth in the early growing season. Later in the season after cessation of irrigation the trouble almost entirely disappeared. Plants grown on soil heavily fertilized with manure often show more of this disease than those growing on a soil less rich. This trouble is generally less prevalent on sandy soil than on heavy soils.

CONTROL

Very little can be done in the field to check this disease after it has become established. In the greenhouse, however, a regularity in the water supply should be maintained. In the field, control measures must be based upon the facts mentioned above. That is, everything done to ensure (1) an even steady growth, (2) fairly rich soil conditions, and (3) deep root systems, will aid in preventing the disease. This means, deep preparation of the soil, a fairly rich sandy loam, thorough cultivation, and everything else that will keep the plant in good growing condition.

OEDEMA

An exceptionally severe case of this trouble was observed at Vineland in 1925, where only a 40 to 50 per cent crop was harvested.

It is apparent as numerous small swellings on veins, midribs, petioles and stems. These are at first frosty-white in appearance but later become yellowish-brown in colour, and corky in appearance. These wart-like swellings may occur singly or so close together that they form complete ridges, and variously-shaped, irregular, raised areas. At first the swelling is confined just beneath the epidermis, but finally the epidermis is broken and the brownish warty, corky-like tissue is exposed. Badly affected leaves die, and when greenhouse conditions are favourable for the disease the plant as a whole may die.

This trouble is due to improper greenhouse environment such as overheating, over-watering and lack of ventilation, resulting in the atmosphere above the plants being so moisture-laden that the plants cannot transpire (give off water) sufficiently. In order to avoid, or overcome this trouble, the grower should see that watering and heating are not overdone, and that the atmosphere surrounding the plants is fairly dry. This can best be done by heat and ventilation.

SUNSCALD (Climatic)

When tomatoes have a scanty water supply and the sun is very hot, the exposed surfaces of the fruits may be scalded. It should be noted here that with plenty of water the tissue of the fruit will withstand the sun's heat without injury, but the same tissue is readily killed when the water supply fails.

The injured surface is flattened and the skin becomes dry and papery. Later on these spots may turn dark because of invasion by rot fungi, but in many cases they ripen normally except for the flat, dead area on one side. Such fruits are much disfigured for market, but are not seriously injured for canning purposes, as in most cases proper ripening will take place afterwards if rot does not follow.

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