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Vegetable Diseases in Nebraska

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Tomato bacterial spot

Extension Circular 1801

The University of Nebraska College of Agricultural Extension Service U. S. Department of Agriculture Cooperating
W. H. Brokaw, Director, Lincoln, Nebraska

Where to Find Information in This Circular

This circular has been prepared in three sections for the convenience of the readers.

Section I—Gives detailed descriptions of specific diseases on different vegetables and their control measures. The crops are listed in alphabetical order (see index on page 36.)

Section II—Contains a discussion of sprays, seed treatments, and other control measures.

Section III—In this section, general control measures that should be practiced by every vegetable grower each year in order to obtain maximum production in the garden are given for the different garden crops. Most of the vegetable diseases start from either infected seed beds, or from infected plant remains from previous crops and by practicing these general control measures much of this initial infection can be eliminated.

The Prevention and Control of Vegetable Diseases in Nebraska

Introduction

The loss to vegetable growers through disease is much greater than is usually realized. A disease which kills the plant, as in the case of bacterial wilt of cucumbers, or which destroys the product, as does blossom-end rot of tomato and bacterial ring-rot of potato, causes damage which cannot escape attention. On the other hand, diseases such as leaf-spot of beets and Septoria blight of tomatoes, which reduce the vigor and yield of the plants but do not rot or disfigure the product, often go unnoticed. The leaf-spot diseases oftentimes cause a greater loss than those diseases which completely destroy the product but which are more obvious and more easily recognized.

It is essential, in the control of plant diseases, to apply the control measures at the proper time. Few plant diseases can be cured after they have become established, although it is sometimes possible to check their spread. Vegetable disease control should be started when the seed is sown in the seed bed and continued through the season in the field. Rotation of crops and plowing under old plant refuse, soil and seed disinfection, spraying, dusting and the use of resistant varieties are all necessary for growing disease-free vegetables for the market. When applying sprays and dusts, it must be remembered that they merely protect the plant from further infections and do not stop the development of disease infections that have already taken place.

The Nature and Cause of Plant Disease

Plant diseases are caused by either (1) parasitic organisms such as fungi, bacteria, or nematodes; (2) by viruses; or (3) by non-parasitic agencies such as unfavorable weather, soil, or nutritional conditions. Fungi and bacteria, which cause most of the common garden diseases, might be called the invisible weeds of the garden since they are unwanted microscopic plants. They do not contain green chlorophyll, and therefore, cannot manufacture their own food but must obtain it from material already manufactured by the host plant. This food-getting disturbs the normal development of the plant and results in disease.

1. Parasitic organisms.

Fungi have a vegetative stage composed of fine thread-like strands which correspond to the roots and stems of plants. They propagate themselves commonly by spores which are seed-like organs similar in function to the seeds of higher plants. These spores, or seed-like organs, are too small to be seen by the naked eye and are easily blown and splashed about by wind and rain. They germinate and infect plants most readily when there is plenty of moisture present, such as after rains or heavy dews.

Bacteria are simple one-celled organisms, so small that they can be seen only with the aid of a microscope. They are dependent upon an abundance of moisture for their spread.

Nematodes are tiny, microscopic eelworms. They live in the soil and attack the roots, stems, leaves, and buds of living plants and cause swelling, distortion and breakdown of the tissues.

2. Virus.

The exact nature of viruses is not well understood. They are present in the juice of plants affected with virus diseases and are transmitted from diseased to healthy plants by transferring some of the juice by insects, tools, or other means. They are carried from season to season in tubers, cuttings, bulbs, and sometimes in seeds.

3. Non-parasitic agencies.

Environmental conditions greatly influence the development of disease in plants by affecting the activity of the parasitic organisms and also the vigor of the plant. Moisture, temperature, and soil reaction must be within certain limits for infection to take place and for the disease to develop and spread.

Oftentimes environmental conditions may cause a plant to become unthrifty and to appear diseased. Extreme fluctuations of temperature, moisture, or improper light conditions and numerous soil influences may interfere with the normal growth of plants.

Section I --- Description of Common Vegetable Diseases

ALL OR MOST GARDEN VEGETABLES

Damping-off.[1]—Damped-off seedlings fall over shortly after they come through the soil. Diseased stems show a wet brown to black rot at the soil line. In many instances the seedlings rot before the sprouts get through the ground, resulting in poor stands. It is especially important when seeds are started in flats in greenhouses, hotbeds and cold frames, and is the most universal disease affecting vegetable seedlings.

Damping-off is favored by heavy, wet soils, cloudy weather, and inadequate ventilation. Several fungi are responsible for damping-off. These organisms are normally present in most soils, although damping-off is usually less severe in sand or peat.

Control

Culture.—Heavy and too frequent watering should be avoided and it is best to apply the water in the morning when the sun is shining. Good air circulation, good soil drainage, and as much sunlight as possible should be provided.

Soil Sterilization.—In addition to the above precautions, there are several satisfactory methods of destroying the organisms in the soil. Sterilization by heat or formaldehyde is the most common practice. Directions for using these treatments are found in the discussion of soil sterilization, page 30.

Seed Treatment.—Another satisfactory method of controlling damping-off is by seed treatment. Several chemical materials applied in the form of dusts are Spergon, Semesan, Cuprocide, Metrox, and Zinc Oxide. The directions for use are furnished with the materials. A pint fruit jar makes a suitable container for treating small vegetable seeds.

[1] Caused by *Rhizoctonia sp., Fusarium sp., etc.*

Seed planted on soil and covered with a thin covering of sand or peat moss are seldom affected by damping-off.

Nematodes.—Nematodes are tiny eelworms which enter the plant roots from the soil, causing them to become swollen with large rough spots which look much like warts (Fig. 1). They have been reported from several areas in the state and many become serious in old garden spots. Infested plants may not show any above ground symptoms, except perhaps a slow growth with a tendency to wilt on warm days. On the other hand, the plants may be stunted, yellowed, sickly, or complete failures, depending on the severity of the attack. Most of the damage is done during the late spring and summer as the parasitic nematodes are most active during warm weather. As a result, early spring vegetables which make most of their growth in cool weather, often escape serious injury. In Nebraska nematodes are most likely to be found on carrots, beets, parsnips, cucumbers, melons, beans, tomatoes, and potatoes.

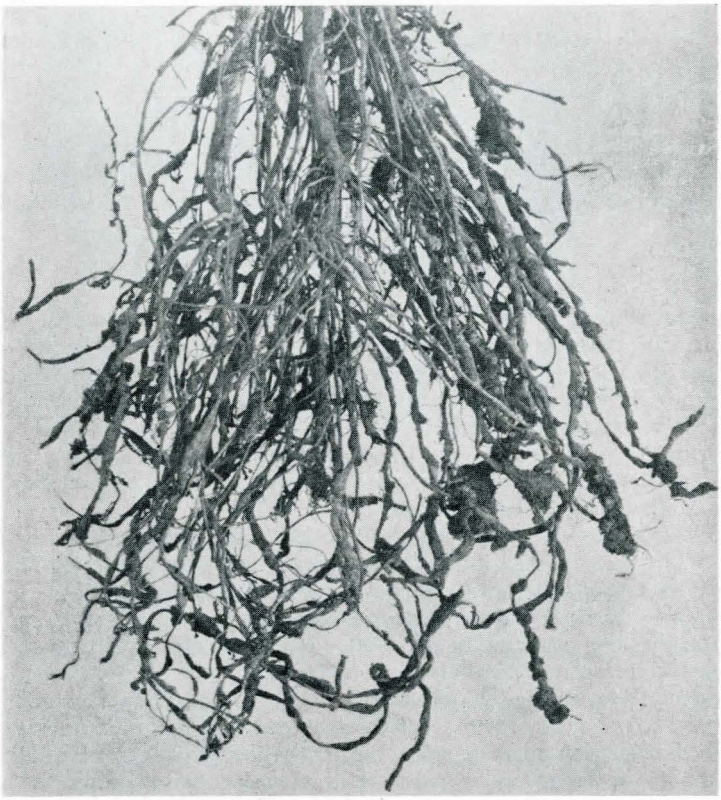

FIG. 1.— Nematode galls on the roots of a legume.

In buying such plants as tomato, eggplant, pepper, and cabbage, only those whose roots are free from warts or galls should be accepted.

The nematodes live in the soil for as long as three years. When soil becomes infested, the garden should be moved to a new location and the old garden planted to a resistant crop, such as one of the small grains. Rotating the crops within the garden will help to reduce the nematode damage. However, in view of the large number of crops attacked, it is difficult to eradicate the nematodes from a small garden.

Complete sterilization of the soil in a small garden with compounds such as chloropicrin holds some promise. This material comes as a liquid and is injected into the soil, after which it evolves as a gas. The treatment is expensive for large gardens, thus where possible, it is advisable to move the location of the garden.

ASPARAGUS

Rust.[1]—Rust is the only disease of importance on asparagus in Nebraska. Red and black pustules or blisters appear on the stalks and leaves. Severe infestations may cause tops to turn yellow and die early. Asparagus rust may spread from old rusted tops left in the field, from escaped plants, or from new plantings, to the shoots developing after the cutting season, or to the new shoots developing the next spring.

Control.—Mary Washington and Martha Washington varieties show some resistance. Wild or escaped plants should be eliminated. Seed beds and young beds should be isolated from producing fields if possible. When rust is present practice clean cutting throughout the producing season and dust several times with sulfur, beginning three weeks after cutting ceases.

BEAN

Bacterial Blights.[2]—The bacterial blights, along with leafhoppers, are limiting factors in bean production in Nebraska. Watersoaked spots surrounded by yellowish halos or irregular, watery, light green patches appear on the leaf (Fig. 2). These spots later turn brown and become dry and brittle, often with a yellowish border. Reddish, watersoaked, sunken spots appear on the green pods (Fig. 3). Stems may show long, reddish-brown cankers. Watersoaked spots appear on the pods and become slightly sunken and brick-red. Seed may show small, yellowish spots.

The bacteria overwinter in seed and possibly old infected plant refuse left in the field. Infected seed may produce stunted and wilted plants. The bacteria may be spread from diseased to healthy plants by splashing rain.

Control.—Use seed produced in arid areas, certified if available, or select seed from healthy plants. Do not work in bean field when leaves are wet. Do not use a sprinkler system for irrigating beans.

Fusarium Root Rot.[3]—The plants are stunted; leaves turn yellow and drop. Plants may have a generally undernourished appearance and produce few pods. Reddish discoloration appears on the tap root which may develop into streaks extending above the ground. A mat of fibrous roots may develop just below the surface of the soil. Cracks appear in the stem in some cases.

The root-rot fungus lives in the soil from year to year. It is most severe

[1] Caused by *Puccinia asparagi.*
[2] Caused by *Phytomonas spp.*
[3] Caused by *Fusarium spp.*

. . . .FIG. 2.—Bacterial blight on bean leaves showing watersoaked spots surrounded by yellowish halos.

on poorly drained soils and important only in those years with a cool, wet spring. Sometimes the plants recover later in the season.

Control.—Practice 5- to 6-year rotation. Plant on well drained soil.

Mosaic.[1]—Leaves become wrinkled and curl downward. Irregular, yellow areas alternate with dark green in the leaves. The plants may be stunted and produce few or no pods. This disease is caused by a seed-borne virus which is spread from plant to plant during the growing season by aphids. Mosaic is an important disease of green and wax beans.

Control.—Plant certified seed or seed produced on healthy plants. Control insects in the field. Resistant varieties of green or garden beans are Idaho Mosaic Resistant Refugee No. 5, U. S. No. 5 Refugee, Wisconsin Refugee, Sensation Refugee 1066 and Sensation Refugee 1071. Great Northern dry beans, University of Idaho Nos. 15, 59, 81, and 123 are also resistant to mosaic.

[1] Caused by a virus.

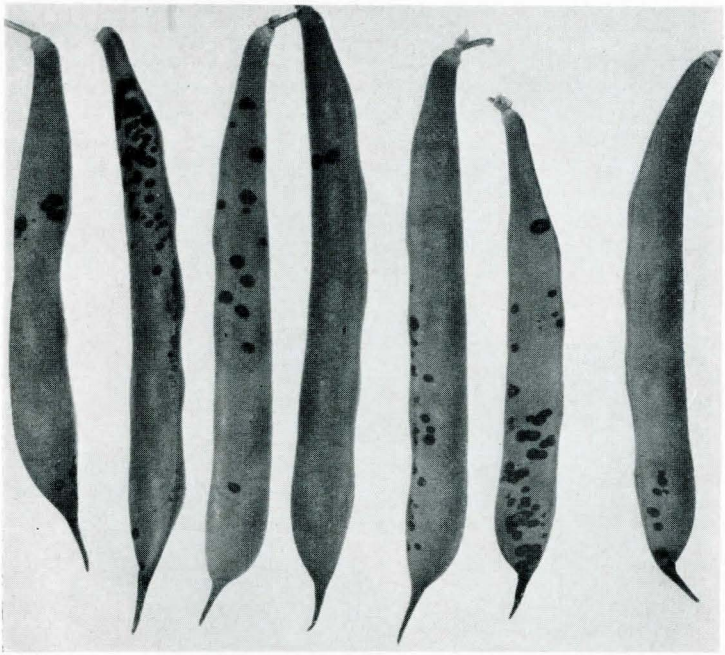

FIG. 3.—Bacterial blight on bean pods showing reddish watersoaked spots.

BEET (Garden)

Leaf Spot.[1]—Small, brown spots with a purple border appear on leaves, leaf petioles, flower pedicels, seed pods and seed but they are most noticeable on the leaves. The spots enlarge to one-eighth inch or more in diameter and become ash-gray in color and are very brittle. The centers may drop out of the spots, giving the leaves a ragged appearance.

Dry weather followed by a damp period favors the disease. The fungus lives from year to year in infected beet refuse in the field. Damage from this disease is usually small.

Control.—Destroy or plow under all beet refuse in the fall. Practice 2- to 3-year rotation. Spray with Bordeaux mixture or dust with fixed copper dust at two-week intervals, if the disease is likely to become serious.

CABBAGE, CAULIFLOWER, TURNIP, AND OTHER CRUCIFERS

Bacterial Soft Rot.[2]—Principally a rot of the storage organs. A soft, slimy, mushy rot develops in the field at the end of the growing season, in storage and in transit following injury, worm damage, or other diseases. It is distinguished from other types of decay by the offensive sulphurous odor. The

[1] Caused by *Cercospora beticola*.
[2] Caused by *Erwinia carotovorus*.

bacteria are often present in the soil and enter the plant storage organs through wounds.

Control.—Roots or heads should be dry before placing in cool storage. Store only those heads that are sound. Prevent injury to roots or heads by careful handling and controlling cabbage worms. Practice rotation.

Black Rot.[1]—Yellowing of leaves beginning at margins, progressing toward midrib, often in a V-shaped area. Veins become dark colored, and darkening progresses into the stem. Stems cut across have a blackened ring of water-conducting vessels. Plants often show a one-sided stunting. Soft rot commonly follows in the storage organs.

This disease is important on cabbage and cauliflower. It over-winters on the seed or infected plant parts and spreads rapidly in the seed bed. It may also be carried from field to field in any plant part, or in infested soil, upon tools, etc., and especially in manure infested by the use of diseased plants as feed.

Control.—Soak cabbage seed 25 minutes, seed of other crucifers 15 minutes, in a solution of one part corrosive sublimate in 1000 parts of water (⅓ oz. or 1 teaspoonful in 2½ gals. of water); wash thoroughly in running water and plant in clean or sterilized soil. Destroy old infected plants and rotate the crops. Seed beds should be placed in a new location each year.

Fusarium Wilt or Yellows of Cabbage.[2]—Yellowing and falling of lower leaves and eventually all of the leaves except those of the head (Fig. 4). This may show prominently upon one side of the head or upon one side of single leaves, resulting in a one-sided dwarfing of the plant. The water-conducting vessels in the stem usually show a brown discoloration instead of the black discoloration which appears with black rot.

FIG. 4.—Fusarium wilt or yellows of cabbage.

[1] Caused by *Phytomonas campestre.*
[2] Caused by *Fusarium conglutinans.*

The fusarium-wilt fungus lives indefinitely in the soil and increases if the old infected plants are left in the field. Since the introduction of resistant varieties, this disease has become of minor importance.

Control.—Plant only resistant varieties, such as Wisconsin Golden Acre, Jersey Queen, Racine Market, Marion Market for early maturity. For mid-season, Globe and Wisconsin Allhead Select. For late cabbage, Wisconsin All Seasons, Wisconsin Ballhead, Wisconsin Hollander No. 8, Red Hollander.

CARROT

Bacterial Soft Rot.[1]—Same as for cabbage.

Leaf Spot and Blight.[2]—Leaves first turn yellow, then brown, and later die. In other cases the only symptoms are small, gray to brown spots on the leaves. In shipment, affected leaves become decayed and slimy.

The fungous organisms causing leaf spot and blight live from season to season on infected plant parts.

Control.—Spray with Bordeaux mixture or dust with a fixed copper dust beginning when plants are six inches tall and repeat at 10-day intervals. When used for bunching, discontinue sprays or dusts 10 days to two weeks before marketing. Destroy old carrot refuse and practice crop rotation. Chantenay variety has some resistance.

CELERY

Bacterial Blight.[3]—Small, brown, translucent spots which are surrounded by a yellow halo are formed on the leaves. The fungus lives from year to year on diseased plant refuse from which it spreads to healthy plants by means of wind, rain, surface water, or in transplanting.

Control.—The three diseases described on celery respond to the same treatments. Crop rotation, using new or sterilized seed beds and destruction of old plant refuse will help to prevent infection. The most successful control is either to dust the plants in the seed bed with 20–80 copper-lime dust or spray with 4–4–50 Bordeaux mixture at weekly intervals beginning when the plants are one inch tall. The plants should be kept growing vigorously and should not be cultivated when the foliage is wet.

Early Blight.[4]—Indefinite spots on stems and leaves which are brownish at first but later become ashen-gray. Stem lesions are in the form of grayish streaks which gradually turn black. The early-blight fungus overwinters on old plant refuse and spreads from them to healthy plants by means of wind and rain. Warm, moist weather favors the development of the disease.

Control.—Same as for Bacterial Blight.

Late Blight.[5]—Small, circular spots containing many black dots appear on the leaves. Stems also show similar but more elongated spots. The disease is of primary importance during the cool weather of early spring. The fungous organism causing this disease overwinters on dead plant refuse from which it spreads to the new plants. It may also overwinter in the seed.

Control.—Same as for Bacterial Blight.

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[1] Caused by *Erwinia carotovorus*.
[2] Caused by *Cercospora* sp. and *Macrosporium* sp.
[3] Caused by *Phytomonas apii*.
[4] Caused by *Cerospora apii*.
[5] Caused by *Septoria apii*.

CUCUMBER, MELON, AND OTHER CUCURBITS

Bacterial Wilt.[1]—Bacterial wilt is the most serious disease of cucumberr muskmelon, pumpkin, and squash. Wilting begins at the tip of the plant and gradually spreads until the entire plant wilts and dies. The juice in the vine becomes sticky and stringy so that when the vine is cut across, the juice may be drawn out like a string when the finger is pressed to the cut surface and slowly withdrawn. The bacteria live over winter in the cucumber beetles which are the only source of infection in the spring.

Control.—Spraying or dusting to control the cucumber beetles controls the disease. For cucumbers and muskmelons, dust with rotenone dust (¾% to 1% rotenone) as soon as the plants break through the ground and repeat often enough to keep the plants well covered. After the vines begin to spread, dust at 10-day intervals with fixed copper-rotenone dust as follows: Fixed copper 1 lb. (see page 31); rotenone dust (¾ to 1%) 8 lbs.

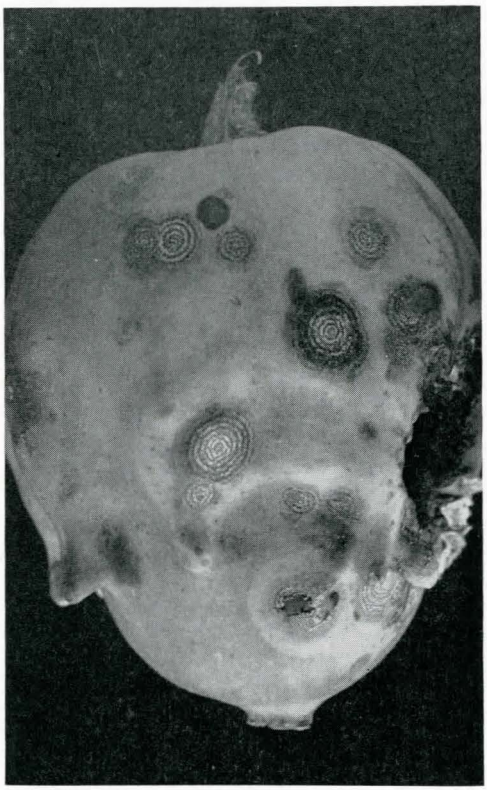

FIG. 5.—Anthracnose on a cucurbit. Note the tiny black fruiting bodies of the fungus in the circular, sunken spots.

[1] Caused by *Erwina tracheiphilus*.

(If rotenone cannot be obtained, dust with a mixture of 1 oz. of fixed copper and 1 oz. of calcium arsenate with a pound of powdered burnt gypsum or land plaster.)

For watermelons, keep vines covered with fixed copper-derris dust. In the latter part of the season spray with Bordeaux.

Anthracnose.[1]—Circular, dark brown, dry-leaf spots develop on the leaves, eventually killing them. On watermelons the spots are black. Dark, elongated spots appear on the stems and petioles. Circular, sunken spots appear on fruits (Fig. 5). These often have a flesh-colored ooze in the center. The attack is most severe on young fruits.

The fungus causing this disease lives from one year to the next on infected plant refuse. It is also carried on the seed.

Anthracnose is of local importance on cucumbers, muskmelons, watermelons, and gourds.

Control.—Immerse the seed 5 to 10 minutes in 1–1000 corrosive sublimate. Wash in running water and dry or plant immediately. Dust with a fixed copper dust as soon as leaf spotting occurs. Bordeaux spray may be used late in the season. Rotate crops. All old vines and fruits should be destroyed at the end of the season.

Downy Mildew.[2]—Yellow, irregular spots appear on the upper surface of the leaves with a downy mildew growth on the under surface. The spots rapidly increase in size, killing the leaf. Nearly all above ground parts of the plant may be attacked.

Moist weather is essential for the development of the disease. The downy mildew fungus overwinters in greenhouses and spreads to fields in the summer. It is a minor disease of cucumbers and muskmelons.

Control.—Repeated applications of 4–2–50 Bordeaux mixture (see page 31) or 20–80 copper-lime dust at 10-day intervals. Cucumbers are sometimes injured by Bordeaux. To prevent danger of injury, apply the spray under high pressure and cover the leaves lightly.

Fusarium Wilt of Watermelons.[3]—This is a major disease of watermelons. Affected plants wilt, followed in a few days by death, sometimes after reaching considerable size. The central portion of the tap root near the ground line is yellow in distinct contrast with the white root tissue of healthy plants. The fungus causing this disease increases in infested soil so that melons cannot be planted continuously in the same place without serious losses.

Muskmelons are occasionally affected.

Control.—Plant the wilt-resistant varieties Improved Kleckly Sweet No. 6, Improved Stone Mountain No. 5, Iowa Belle, Iowa King, Hawkesbury, Leesburg, or Klondike R7. Rotation following sweet clover also reduces danger from wilt.

Mosaic.[4]—Mosaic-infected plants are stunted. The leaves are deformed and mottled with yellow and green. The fruit may show yellow and green mottling and occasionally cucumbers may be nearly white, giving rise to the

[1] Caused by *Colletotrichum lagenarium*.
[2] Caused by *Peronoplasmopara cubensis*.
[3] Caused by *Fusarium bulbigenum* var. *nivcum*.
[4] Caused by a virus.

name "white pickle." Mottled fruits may develop greenish warts with sunken yellowish areas.

The disease is spread in the field by aphids or plant lice. Workmen also spread the virus from diseased to healthy plants during cultural operations. Several weeds, such as wild cucumber, milkweed, ground cherry, and catnip remain infected from year to year and the virus is carried from these hosts to garden cucurbits by aphids.

This is one of the most serious diseases on cucumbers.

Control.—Clean cultivation and removal of all susceptible weeds. Insect control important. Young infected plants should be pulled and destroyed.

Scab.[1]—Watersoaked spots appear on leaves and stems. The stem spots are in the form of small cankers. Sunken spots may appear on green fruits. These spots at first appear as insect stings; later they become dark brown with a viscid, gummy exudate. An olive-green fungous growth often appears on the spots.

The scab fungus lives from season to season on dead vines, from which it spreads to the new plants. Scab occurs occasionally on cucumbers, muskmelons, and squash.

Control.—Destroy old infected refuse and vines. Applications at 10-day intervals of 4–2–50 Bordeaux spray or a fixed copper dust. Practice crop rotation.

EGGPLANT

Anthracnose.[2]—Yellow and later brown spots appear on the leaves. Small, sunken spots occur on fruits and roots.

The fungus causing anthracnose overwinters in diseased plant refuse from which it spreads to new plants.

Control.—Crop rotation and destruction of infected plant refuse. Spraying with 3–3–50 Bordeaux every ten days will help.

Phomopsis Blight and Fruit Rot.[3]—This is the most important disease of eggplant. Seedlings may damp-off at the ground line. Numerous circular, gray to brown spots occur on leaves. Dark stem cankers may cause stunting and wilt. A light-brown, zonated rot dotted with numerous minute black pimples occurs on the fruit and leaf petioles (Fig. 6). This rot is at first soft and mushy but later the fruit becomes a shriveled blacky mummy.

This fungus can live three years in the soil. It is also carried on the seed.

Control.—4-year crop rotation. Destroy infected fruits and trash. Treat the seed in corrosive sublimate solution (⅓ oz. or 1 teaspoonful in 2½ gals. water) for 5 minutes. Rinse in water and dry. It is advisable to first treat a small quantity of seed and test the germination as the germination of old or weak seed may be injured. Spray with 4–4–50 Bordeaux or dust with 20–80 copper-lime dust to prevent the leaf spots.

Gray-mold Fruit Rot.[4]—Fruits may rot on the plant, in storage, or during shipment. Purple fruits become tan to brown in infected areas. Rotten areas are covered with a dense, gray moldy growth. This often begins at the blossom end. The rot develops most rapidly under humid conditions.

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[1] Caused by *Cladosporium cucumerinum*.
[2] Caused by *Colletotrichum solanicolum*.
[3] Caused by *Phomopsis vexans*.
[4] Caused by *Botrytis cinerea*.

Rotten moldy fruits serve as a source of infection.

Control.—Remove withered blossoms at harvest time. Destroy all moldy fruits and keep healthy fruits as dry as possible.

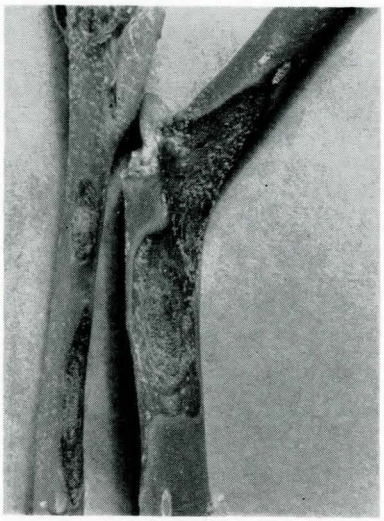

FIG. 6.—Phomopsis blight of eggplant. Note the tiny pimple-like fruiting bodies in the center of the spots.

LETTUCE

Bottom Rot.[1]—Rot begins with bottom leaves on the ground and works up into the head. The blades of the leaves are rotted but the midribs are left standing. Heads continue rotting after harvest but the main stem remains solid. Wet, poorly drained soil favors the disease. This disease is caused by a fungous organism which lives in the soil for several years. It is the most important disease of lettuce.

Control.—Practice long rotations and keep the garden free from refuse of leafy vegetables. Plant on well drained soil. Ceresan (2%) dusted under nearly mature plants at the rate of 20 to 25 lbs. per acre has given good results. Soil sterilization is important in the greenhouse.

Other Diseases.—Downy mildew and gray mold rot often develop in greenhouses and hotbeds where the humidity and the temperature are high. Downy mildew causes light green to yellow areas on the upper surface of the leaf with a white, moldy, fungous growth on the lower surface. Gray mold causes the heads to wilt after which there develops a soft, slimy rot which becomes covered with a dense, gray moldy fungous growth.

Control.—Provide cool temperature and low humidity by proper ventilation in the greenhouse and cold frame. Varieties "Imperial 44," "C," "D," and "F" are resistant to downy mildew.

[1] Caused by *Corticium vagum.*

ONION

Neck Rot.[1]—A soft, watery rot develops in storage, particularly in the white varieties. The disease usually starts at the neck as sunken, dried-out spots and spreads downward. It may also start at wounds. White mycelium of the fungus appears between the scales and sometimes tiny, black, overwintering bodies or sclerotia develop. These sclerotia live through the winter in the soil or on infected bulbs and start the disease the next year. Hot, dry weather stops the development of the disease. Storage rot develops most rapidly from 60° to 64°F.

Control.—Colored varieties are resistant. Cure thoroughly after harvest at 90° to 120°F. for from 48 to 72 hours. Store in a dry, cool place as near 32°F. as possible. Rotate crops.

Smut.[2]—Black, elongated blisters break out on scales and leaves of young plants. Most seedlings die while young although some outgrow the disease. Abnormal twisting of the leaves often occurs. The fungous organism causing smut overwinters in the soil and once the soil is infested, it remains so for many years. Temperatures between 50° and 77° F. favor the disease; above 81°F. no infection occurs. Infection occurs from the soil on only very young seedlings and needs to be guarded against in greenhouses and hotbeds.

Control.—Use healthy seedlings or sets. Where seed is planted, apply formaldehyde solution (1 pint to 50 pints of water) in row ahead of the seed. Fifty pints will treat 4,000 feet of row or about ¼ acre.

Smudge.[3]—Black, smudgy spots appear on the outer scales shortly before harvest. The spots show concentric rings of dark colored dots, which are the fruiting structures of the fungus. These fruiting structures are responsible for the spread of the disease. The disease develops slowly and often the injury is nothing more than the unsightly appearance of the bulbs. Premature sprouting may occur in storage as a result of the disease.

Control.—Colored varieties are resistant. Dry white varieties immediately after harvest.

PEA

Root Rots.[4]—A reddish-brown rot appears at the base of the stem, upper tap root, and sometimes on lateral roots. Diseased plants turn yellow, wither and die. Root rots are caused by several fungous organisms which live in the soil. They are most active at high temperatures in poorly drained soils and are the most serious problem in the production of peas.

Control.—Crop rotation, thorough preparation of the soil, maintenance of high fertility, and good drainage help reduce root rot. Seed treatment with Red Copper Oxide, Spergon, or mercury dusts (Semesan) are beneficial.

Fusarium Wilt.[5]—The leaves turn yellow and curl downward at the margins. Plants are either killed or stunted. The causal organism lives indefinitely in the soil and attacks the plants most vigorously at high temperatures. Several varieties of peas are resistant to wilt.

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[1] Caused by *Botrytis allii.*
[2] Caused by *Urocystis cepulae.*
[3] Caused by *Collectotrichum circinans.*
[4] Caused by *Fusarium* spp., *Pythium* spp., *etc.*
[5] Caused by *Fusarium.orthocera* var. *pisi.*

Control.—Plant resistant varieties—Resistant Alaska, Mardelah, Wisconsin Early Sweet. Practice crop rotation.

Near-wilt.[1]—Symptoms are very similar to those caused by Fusarium wilt. Pea varieties that are resistant to wilt are attacked by near-wilt.

Control.—Rotation and destruction of old infected plant refuse.

Mosaic.[2]—The leaves show mottled green and yellow areas and the plants are stunted. The pods are mottled and deformed. The virus which causes mosaic is spread from diseased to healthy plants by the pea aphid. Several leguminous plants, including those occurring naturally as weeds about pea fields, may carry this disease.

Control.—Control the pea aphid by spraying with nicotine sulfate. Destroy leguminous plants growing as weeds near the peas.

PEPPER

Bacterial Spot.[3]—Bacterial spot has been of minor importance. Small, raised, wart-like, watersoaked spots on leaves and fruits. The yellowish-brown, blister-like spot on the fruit usually breaks open becoming irregularly ridged. The bacteria which cause this disease are carried on the seed from year to year.

Control.—Do not plant peppers following tomatoes. Seed treatments reduce the percentage of germination but immersing the seed for 2½ minutes in a corrosive sublimate solution (⅓ oz. or 1 teaspoonful in 7½ gals. water) as soon as the seed is harvested will control the disease. After treating, wash in running water for 15 minutes.

Blossom-end Rot.[4]—The blossom end of the fruit becomes water-soaked and black then dries out and becomes sunken. Mold fungi may follow and destroy the fruit. Blossom-end rot is caused by several environmental factors, most important of which are extreme fluctuations in moisture and heavy fertilization. In certain years it causes considerable damage.

Control.—Maintain a uniform soil moisture. Use cultural practices which will encourage a deep, widespread root system. Do not over fertilize.

Cercospora Leaf Spot.[5]—Large, round, dark-brown, water-soaked spots with white to gray centers develop on the leaves. Leaves may turn yellow and drop off. The leaf spot is most injurious during wet weather. This fungous disease survives from one year to the next in old infected plants. It is a minor disease.

Control.—Bordeaux spray will control the leaf spot but occasionally may disfigure the fruit.

POTATO

Bacterial Ring-rot.[6]—This is one of the most important diseases of potatoes. Plants do not show the disease until late in the growing season. The margins of the lower leaves first show wilting, followed by wilting of the entire leaf. The edge of the leaf first turns pale green and later becomes

[1] Caused by *Fusarium oxysporium* f. 8.
[2] Caused by a virus.
[3] Caused by *Phytomonas vesicatorium*.
[4] Caused by environmental conditions.
[5] Caused by *Cercospora capsici*.
[6] Caused by *Phytomonas sepidonica*.

brown and is rolled upward; the leaf finally wilts and usually remains attached to the plant. One or two stems of the plant may wilt and die, or the entire plant may be killed.

When plants affected with ring rot are dug, both rotted tubers and tubers which appear to be healthy but which in reality are infected with the bacteria may be found in the same hill. Rotted tubers may show only small, rotted spots in the vascular ring near the stem end. The decayed tissue is usually yellowish-white and of a crumbly, cheesy consistency (Fig. 7). Later the infected portions become brownish and break away from the sound flesh, leaving an outer shell separated from the central region. If infected tubers are squeezed, decayed material will ooze from the infected vascular ring. Occasionally cracks or reddish discolorations will appear on the surface of severely infected tubers. Cracks penetrate only to the vascular ring. Sometimes the tuber may be completely broken down into a slimy, yellowish mass.

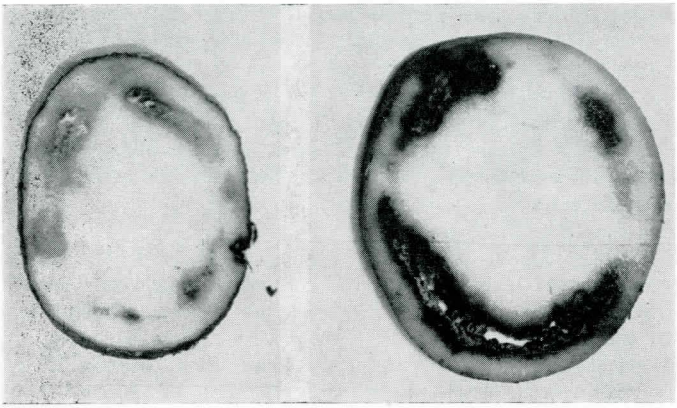

FIG. 7.—Potato tubers infected with bacterial ring-rot showing the yellowish-white, cheesy decayed tissue and the breaking away of the decayed tissue from the sound flesh. (Courtesy of C. H. Metzger.)

Ring rot is caused by a bacterial organism which lives from one year to the next in diseased tubers. The bacteria also may remain alive for some time in cellars, equipment, and up to three or four months in sacks which have come in contact with diseased tubers. When cutting seed for planting, the bacteria may often be carried on the cutting knife for as many as ten successive cuts after cutting a diseased tuber. The disease is not known to be perpetuated in the soil; however, potatoes should not be replanted in a field that produced a crop of ring-rot infected tubers the previous year because of the danger of contamination from old diseased tubers that might have been left in the field. Healthy seed cannot be selected from a lot of potatoes infected with ring rot because very slightly infected tubers can be detected only by microscopic examination.

Control.—For seed production—use only disease-free seed.

For production of potatoes for table use—plant only certified seed. Plant-

ing small, whole tubers may eliminate spread due to cutting and handling freshly cut seed pieces when there is the possibility of the seed being infected with ring rot. However, small, whole tubers that are diseased will produce diseased plants.

If the disease occurs, storage cellars, all containers used for potatoes, planters, diggers, graders, and other equipment should be thoroughly disinfected with a strong solution of hypochlorite (4 lbs. B.K. in 50 gals. water) or formaldehyde (1 to 2 pints in 15 gals. water).

Blackleg.[1]—Blackleg causes a yellowing and wilting of the plant, followed by a soft, black rot of the stem above and below the ground line. The rot follows the stolons to the new tubers and starts a soft, dark rot at the stem end. These tubers may spread the disease in the bin and if used for seed will start the disease the next year. A considerable reduction in stand results in certain years in central and eastern Nebraska. The disease rots the seed piece, then progresses up the stem to a height of several inches above the ground.

The bacteria which cause this disease also live in the soil and in the field they are spread from tuber to tuber by the seed corn maggot. Rhizoctonia injuries on the stem and stolons offer an avenue of entrance for the bacteria. Blackleg is favored by wet, cold weather at planting time and is generally less serious in dry-land areas.

Control.—Plant disease-free seed. Practice crop rotation. Rogue out infected plants and remove from field. Seed treatments for other diseases, such as scab and rhizoctonia, will help control blackleg. Piles of rotted potatoes on the farm should be destroyed.

Early Blight.[2]—Small, dry, brown, circular spots marked with concentric rings develop on the leaves. Complete defoliation may occur with a corresponding reduction in yield. Dark, somewhat sunken, shallow spots may develop on the tubers. The disease is favored by high temperatures and high humidity and usually occurs just after the plants have reached the period of maximum vine growth. Early blight may cause 30 to 40 per cent reduction in yield and in addition there may be a loss due to tuber rots. Tuber infection occurs as a result of contact with infected vines at harvest time. The early blight fungus will also attack tomatoes and eggplants.

Control.—Bordeaux spray should be applied to prevent early infection which usually occurs about blossom time. Under certain conditions Bordeaux spray may interfere with the normal growth of the plants (see discussion of Bordeaux mixture, page 31). Planting after the middle of June reduces the probability of early blight in Western Nebraska.

Fusarium Wilt and Tuber Discoloration.[3]—Fusarium wilt is a disease of major importance in Nebraska, particularly in Western Nebraska. It is caused by three closely related organisms that live in the soil from year to year and attack plants that are growing in infested soil. The symptoms of diseased plants are variable. A dry rot and shredding of the underground stem may occur (Fig. 8) and result in a rosetting of the top and the formation of aerial tubers, or yellowing and early wilting may occur. This often affects only one stem in the hill.

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[1] Caused by *Erwinia carotovorus*.
[2] Caused by *Alternaria solani*.
[3] Caused by *Fusarium* spp.

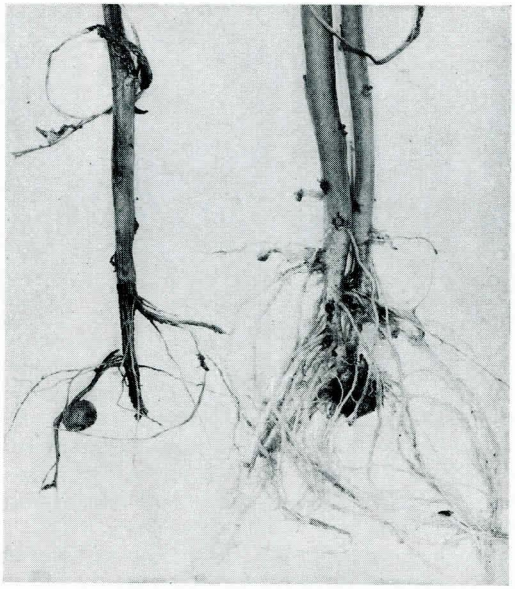


FIG. 8.—The plant on the left shows dry rot and shredding of the underground stem caused by *Fusarium* spp. The plant on the right is healthy. (From Nebraska Extension Circular 1256.)

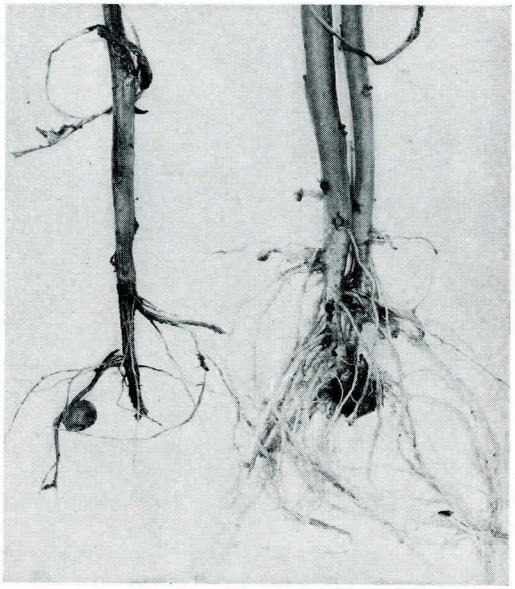
The most typical mid-season or late symptom is a brownish and yellowish mottling of the top leaves with dark, brownish flecks inside of the stem. This may be followed by a complete wilt of the entire plant. Oftentimes the disease develops late in the season so that the plant produces a normal sized crop of potatoes which are all infected with a rot at the stem end. This rot may vary from an internal brownish discoloration to a dark brown rot at the stem end (Fig. 9). The internal brownish discoloration is often in strands which resemble roots penetrating the vascular region of the tuber. Infected tubers are not desirable for seed because they often fail to sprout, resulting in poor stands. The eating quality of such tubers is also reduced because of the brownish discoloration. After plants become infected, the wilt symptoms appear more rapidly under hot, dry conditions. Stem-end rot of the tuber, on the other hand, progresses more rapidly with plenty of soil moisture.

The fungous organisms which cause this disease complex live in the soil and in the seed tubers, with contaminated soil being the more important source of infection.

Control.—Practice a 4- to 6-year rotation under irrigation; 3- to 4-year rotation under dry-land conditions. Plant from June 10 to 20 in Western Nebraska.

Rhizoctonia or Black Scurf.[1]—This is one of the most important diseases of potatoes in central and eastern Nebraska. Small, black specks, sometimes

[1] Caused by *Rhizoctonia solani*.



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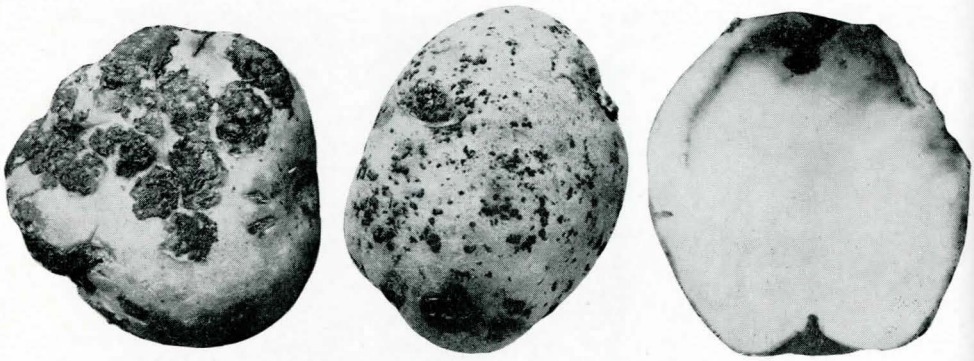

FIG. 9.—Scab, rhizoctonia and fusarium stem-end rot of potato tubers.

reaching ¼ inch in size, appear on the surface of tubers (Fig. 9). When such tubers are used for seed, or when the soil is contaminated with the organism, the young sprouts may be attacked before they reach the surface of the ground, resulting in a reduction in the stand. This is particularly true of early plantings in seasons when the soil is cold and wet.

Later attacks usually produce brown, dead areas on the underground stem, roots, or stolons, sometimes girdling the part attacked (Fig. 10). When the main stem is entirely girdled, a large number of small tubers are sometimes formed at the surface of the ground, or even in the axils of the branches, and a peculiar "rosetting" of the top results.

Rhizoctonia is caused by a fungous organism which lives in the soil and on the seed. It develops most rapidly during cool seasons when there is an abundance of moisture in the soil.

Control.—Plant disease-free seed. Practice 4- to 6-year rotation with legumes preceding potatoes under irrigation, 3- to 4-year rotation under dry-land conditions. Treat the seed with acid mercury (see page 29) or an organic mercury compound, such as Semesan Bel, according to directions. Plant from June 10 to June 20 in Western Nebraska.

Scab.[1]—The tuber is the main part of the plant attacked. Rough, corky, brown spots varying in size from very small spots to areas over half an inch in size develop on the tubers (Fig. 9). These spots sometimes develop into pits into the tuber to a depth of a quarter of an inch. The fungous organism causing scab lives in these scab spots and also lives in the soil. It is most prevalent when soil moisture has been abundant and followed by a packing of the soil and poor soil aeration. Scab occurs in all regions of the state and is of major importance in certain years.

Control.—Plant disease-free seed on clean soil. Practice 4- to 6-year rotation with legumes preceding potatoes under irrigation; 3- to 4-year rotation under dry-land conditions. Treat the seed with hot formaldehyde; dip uncut seed tubers for 3 to 4 minutes in a solution of 1 pint of formaldehyde to each 15 gallons of water kept at 121° to 124°F. After treatment, cover the tubers for an hour, then allow to dry. While drying, the tubers should not be piled

[1] Caused by *Actinomyces scabies*.

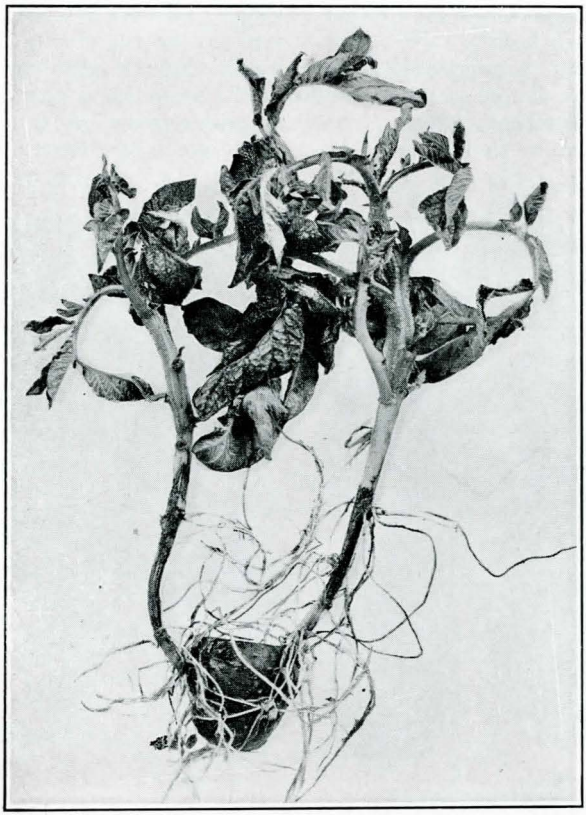

FIG. 10.—Brown dead areas characteristic of Rhizoctonia on the underground stem. (From Nebraska Experiment Station Bulletin 186.)

more than 6 to 8 inches deep, or if in sacks, the sacks should be kept separated. Extra solution, made up at the same strength, may be added to replace lost solution or to cool the solution if the temperature gets too high. Plant June 10 to June 20 in Western Nebraska.

Spindle-tuber, Mosaic, and Other Virus Diseases.[1]—These diseases produce the "running-out" of potatoes which is often attributed to unfavorable environmental conditions or to the continued use of the same strain of seed. They annually cause a considerable reduction in yield when home grown seed is planted. For the individual grower, the practice of obtaining new seed stock when the old is "running-out" is the best method of overcoming this trouble, providing the new seed is disease-free.

Spindle-tuber infected plants are spindly and very erect in growth with smaller than normal leaflets. They are usually slow in coming through the

[1] Caused by viruses.

ground. Affected tubers are elongated, pointed and usually small. They have more eyes than healthy tubers, with a tendency for the eyes to be clustered around the bud end (Fig. 11). Tubers of red varieties tend to lose their color. This disease is carried in the seed tuber and from plant to plant in the field by a large number of insects, including grasshoppers. It is spread from diseased to healthy seed pieces by the cutting knife or by contact of freshly cut seed pieces.

FIG. 11.—Spindle tuber potatoes showing the spindle shaped tubers and the tendency for the eyes to be clustered around the bud end of the tuber.

Mosaic gets its name because of the mottling of the leaves. The healthy green of the leaf alternates with irregulary shaped areas of light or yellowish-green tissue. Often the mottling is accompanied by a wrinkling or ruffling of the leaf surface (Fig. 12), and sometimes this latter symptom is present in the absence of any mottling. The symptoms vary considerably with the variety, climatic conditions, and the severity of the disease and tend to disappear with high temperatures. Tubers show no evidence of being diseased; however, the virus is carried in the tubers and is spread in the field from infected to healthy plants by aphids (plant lice).

Virus diseases do not live from one season to the next in the soil.

Control.—Plant certified or disease-free seed.

Storage Rots.—There are a large number of organisms capable of causing a rot of potato tubers in storage. Most of these organisms enter the tubers through wounds. After entering, they may produce a dry rot with moldlike growths that break through the skin over the sunken rotted areas, or they may

produce a soft, wet rot that progresses rapidly causing a complete decay of the tuber.

Careful handling to avoid wounds and elimination of all rotted or badly wounded tubers before placing in storage is essential for the prevention of storage rots. Since there is always a certain amount of unavoidable wounding

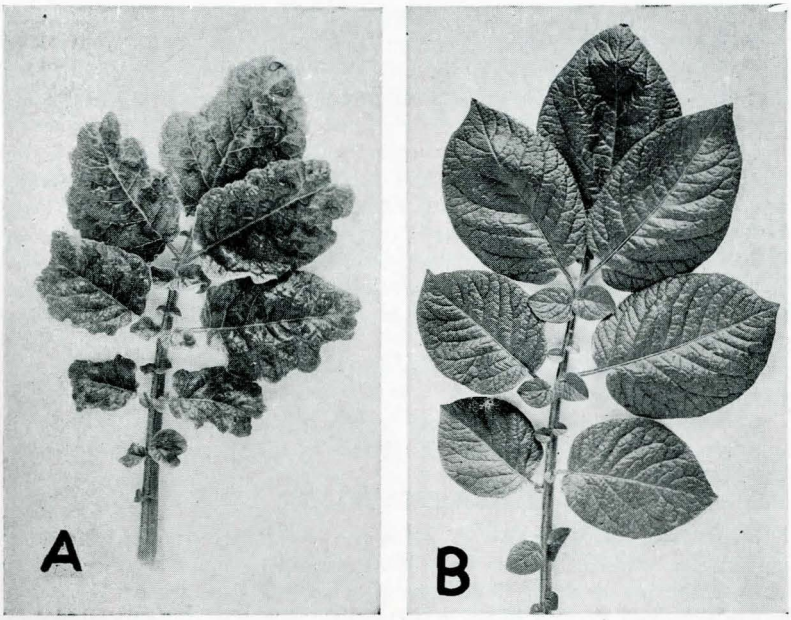

FIG. 12.—A—Leaves from a mosaic plant showing typical wrinkling, ruffling and mottling. B—Healthy leaves. (From Nebraska Extension Circular 1256.)

during the digging and storing operations, conditions favorable for wound healing or suberization should be provided during the first week of storage. Wound healing is a simple process which requires good ventilation, high humidity, and a temperature above 55°F., preferably between 60° and 70°F. After a week of storage under these conditions the temperature should be lowered to about 40°F. if the potatoes are to be kept in storage throughout the winter. Later in the season, seed potatoes for mid-winter planting in the southern states need to be stored at higher temperatures prior to shipping to encourage sprouting.

RADISH

Black Root.[1]—Dark spots develop where the lateral roots emerge from the large, fleshy main root. These spots enlarge until several units form a large, black area on the fleshy radish. The radish is often distorted. This

[1] Caused by *Aphanomyces raphani*.

disease is caused by a fungous organism which lives in the soil from one year to the next. It is important on the icicle type radish.

Control—Rotate crops. Grow Red Globe types.

RHUBARB

Crown Rot.[1]—Sunken, brown spots appear at the base of the leaf-stalk. The spots enlarge rapidly causing the leaf to wilt and die. The rot progresses from stalk to stalk until the entire plant may be killed.

The fungus causing crown rot will live in the soil for several years. The disease can be spread by scattering infected soil or by using infected plants for propagation.

Control.—Dig out and burn diseased plants, being careful not to scatter infected soil. Use only healthy plants or treat roots before division by dipping for ½ hour in either corrosive sublimate, ⅓ oz. or 1 teaspoonful to 2½ gals. of water, or formaldehyde, 1 pint in 30 gals. of water. Rinse in clear water.

Leaf Spot.[2]—Irregularly circular spots varying in size up to one-half inch in diameter appear on the leaves. These spots have a white center surrounded by a red border. Centers of the spots may dry and drop out, giving a shot-hole effect.

The leaf spot is caused by a fungous organism which lives from year to year on old infected plant parts.

Control.—Remove and burn old leaves and stalks in the fall after they have frozen. Spray with Bordeaux mixture in spring when growth starts.

SWEET POTATO

Black Rot.[3]—Diseased sweet potatoes show large, circular, almost black spots on the surface. Under these spots is a rather dry, very black, fungous decay of the potato flesh. This may develop and spread from the potato to the underground portion of the new sprout causing black cankers or spots to develop. These sprouts may be killed, or, if they have reached considerable size before being attacked, they will put out roots from healthy tissue near the surface of the ground and produce a partial crop. The foliage of diseased plants will be yellowed and sickly in appearance. The disease is spread primarily by propagating from infected potatoes. Soil in which diseased potatoes have been produced will remain contaminated for several years.

Control.—Early digging when potatoes are found to be affected. Select clean potatoes for seed at bedding time and then treat them with a solution of 1 part of corrosive sublimate in 1000 parts of water (⅓ oz. or 1 teaspoonful in 2½ gals. of water). Immerse potatoes for 8 minutes, remove, drain off excess solution and place in sprouting beds. If old beds are used, they should be sterilized and clean or sterilized soil used. Practice 3- or 4-year crop rotation in the field.

Dry Rot.[4]—This is primarily a storage disease. A slow, firm, brown rot starts at the stem end of the potato and progresses until the entire potato becomes shrunken, wrinkled, and finally mummified. The flesh beneath the

[1] Caused by *Phytophthora parasitica.*
[2] Caused by *Phyllosticta* sp.
[3] Caused by *Ceratostomella fimbriata.*
[4] Cuased by *Diaporthe batatis.*

skin becomes coal black in color. The surface of the potato is covered with small pimples lying close together. These pimples are the fruiting bodies of the fungus and perpetuate the disease from one year to the next in storage houses.

Control.—Clean the storage house thoroughly before storing.

Scab.[1]—Scab is also called soil rot and pox. Black, watersoaked spots develop on the roots, stems, and potatoes. As these spots enlarge they form pits with rough margins. The potatoes are often deformed. Badly diseased plants are generally stunted and the leaves are pale green or yellow. Once the fungus becomes established in the soil, it remains active for several years.

Control.—Practice a 4- to 6-year rotation. Plant sprouts produced from healthy potatoes.

Scurf.[2]—Scurf is also soil stain or rust. It causes a brown to black discoloration of the skin which may occur in spots, blotches, or uniformly over large areas of the stem and potato. Scurf does not appear to reduce the yield or kill sprouts but it does mar the appearance of the potato and it causes considerable shrinkage in storage. It appears to be worse on alkaline soils and where fresh manure has been applied. Diseased potatoes are primarily responsible for carrying the disease from one year to the next.

Control.—Use plants produced from healthy potatoes. When clean potatoes are not obtainable, treat tubers with corrosive sublimate as for black rot.

TOMATO

Anthracnose.[3]—This is chiefly a disease of the ripe fruits, either upon the vine or after harvest. It appears as sunken, discolored spots with wrinkled surfaces covered with many tiny black specks (Fig. 13). These black specks are the fruiting bodies of the fungous organism causing anthracnose. It occasionally causes considerable loss of fruit in local areas.

Control.—Destroy all old infected fruits and plants at harvest time. Practice rotation.

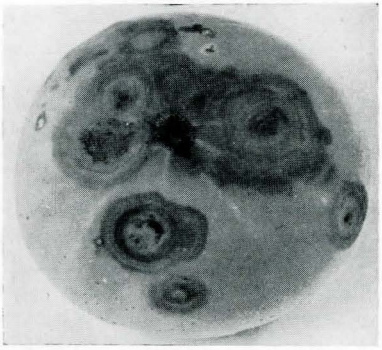

FIG. 13.—Anthracnose on tomato. Note the concentric rings and tiny black fruiting bodies in the spots.

[1] Caused by *Actinomyces ipomea.*
[2] Caused by *Monilochaetes infuscans.*
[3] Caused by *Colletotrichum phomoides.*

Bacterial Canker.[1]—The first evidence of the disease is browning and upward rolling of the leaf margins. Usually the leaves and petioles remain green and are not easily separated from the plant. Small spots or cankers may develop on the stems from which bacteria may be spattered by rain to leaves and fruit, causing leaf spots and fruit spots. Stems cut lengthwise may show a yellowish or light brown streak of decayed tissue of a mealy consistency. Badly diseased plants may be stunted or even killed.

Fruit spots are small with tan centers surrounded by a conspicuous white margin giving rise to the term "birdseye" spot. Seed from infected fruits carry the disease to next year's crop.

Bacterial canker is found in western Nebraska but is uncommon in the eastern part of the state.

Control.—Practice rotation in seed bed and field. Destroy infected plants in the fall. Fermentation of fruits for at least three days at 65° to 70°F. kills the bacteria on the seed. Soaking the seed in acetic acid solution as follows is also effective: Immediately after extraction, the moist seed should be soaked for 24 hours in an 0.8 per cent solution of acetic acid and water at a mean temperature not in excess of 70°F. Dry seed should be soaked for 24 hours in a 0.6 per cent solution of acetic acid in water at a mean temperature not in excess of 70°F.

Bacterial Spot.[2]—Bacterial spot is the most common disease of tomatoes in Nebraska. Small, dark spots with papery centers appear on the upper surfaces of the leaves. On the fruits small, black, raised, scab-like spots develop (Fig. 14). Later these spots may become sunken. Infection takes place only on young, green fruits. The bacteria causing this disease are spread by driving rains. The seed becomes smeared with the bacteria during the extraction from the fruit and such seed produces infected plants. Peppers are also infected by bacterial spot.

Control.—Practice rotation in seed bed and field. Treat the seed for 5 minutes in 1 part of corrosive sublimate in 3000 parts of water (⅓ oz. in 7½ gals. of water). Corrosive sublimate is a deadly poison and must be used with care.

Blossom-end Rot.[3]—This disease annually causes considerable loss throughout the state. A small, watersoaked spot appears at the blossom end of the fruit. It enlarges and becomes sunken. Later it dries and remains firm and leathery unless decay-producing organisms enter the affected region and produce a soft rot. An irregular supply of moisture appears to be the primary cause of the disease.

Control.—Cultural practices that will encourage extensive root development, and a constant moisture supply tend to prevent blossom-end rot.

Fusarium Wilt.[4]—Fusarium wilt occurs in local areas throughout the state. Lower leaves first turn yellow and as the fungus advances the upper leaves turn yellow and drop off. The wilted leaves are easily removed from the plant as contrasted with the firmly attached wilted leaves of bacterial canker. Wilting of the leaves may occur on only one side of the plant. When

[1] Caused by *Phytomonas michiganensis*.
[2] Caused by *Phytomonas vesicatorum*
[3] Caused by irregular moisture supply.
[4] Caused by *Fusarium lycopersici*.

the stem is cut open, the conducting vessels show a brownish discoloration. The wilt fungus may live in the soil indefinitely and attack susceptible varieties

Control.—Practice crop rotation. Pritchard, Marglobe, and Rutgers have some resistance but do not yield as well in most seasons in Nebraska as several

FIG. 14.—Black, scab-like spots characteristic of bacterial spot on tomato fruits.

other varieties. Sterilize seed beds if wilt has been a problem. Southern grown plants are often infected with wilt, thus only certified plants should be used from southern states.

Mosaic.[1]—Mosaic is a common disease of tomatoes. Leaves become mottled with irregularly distributed areas of light and dark green. The light green areas grow more than the dark green, resulting in distorted leaves. Tip leaves may be narrow, distorted, and bunched. Workers may spread the virus by handling and by the use of tobacco since mosaic is very common in tobacco. Wild ground cherries and horsenettles also carry the disease and may serve as a source of infection in the field. Seeds from infected plants rarely carry the disease. Aphids spread the virus from diseased to healthy plants while feeding.

Control.—The virus is transferred from plant to plant by workers and insects. Destroy perennial weeds, particularly groundcherries and horsenettles. Wash hands after handling each diseased plant. Control insects. Infected plants should be destroyed as soon as detected.

[1] Caused by a virus.

Early Blight.[1]—The spots on the leaves are dark brown to black and marked with concentric rings producing a "target spot." The spots enlarge to one-fourth to one-half inch in diameter.

Small, black cankers sometimes girdle the stems causing stunting and death. The early blight fungus may also cause cankers on the green stems and sepals of the tomato fruits and the infection passes on into the fruit producing a dark, dry stem-end rot. This same organism causes early blight of potatoes. Old tomato refuse is a source of infection for next year's crop. Early blight is of minor importance.

Control.—Burn all diseased vines. Transplants showing stem spots and cankers should not be set in the field. Leaf spot and fruit rot may be partially controlled by Bordeaux spray or a fixed copper dust. Do not plant in rotation with potatoes.

Nailhead Spot.[2]—"Target spots" develop on the leaves which are identical with those caused by early blight but tend to be larger. Small, shallow, gray to tan-colored specks develop on the green fruits. These spots enlarge rapidly, become grayish-black and slightly sunken. On mature, colored fruit the spots have a narrow, black border surrounding the grayish central portion. Very often the host tissue immediately surrounding the spot is green in contrast to the pink or red color of ripe fruits. Older spots on ripening fruit almost always penetrate to the seed cavity and if a spot occurs over a locular partition, the fungus penetrates to the core. Secondary organisms may follow, causing a complete rot of the fruit.

The fungus causing nailhead spot survives from one season to another in old tomato stems, foliage, and fruits left in the field at the end of the season. In the field the disease is spread primarily by wind, rain, running water, cultivators and pickers.

This is one of the more important diseases of tomato. Eggplant, potato, and horsenettle are also attacked.

Control.—Same as for Early Blight.

Septoria Blight.[3]—This is a common foliage disease. Small, gray leaf spots with brown borders appear first on the older leaves then proceed to the younger. Numerous small, black specks appear in the center of the spots and serve to distinguish these spots from those caused by early blight and nailhead spot. The fungus also causes black spots on the stem which may unite, producing long, black streaks. Fruit spots rarely occur. The disease is spread from plant to plant by wind and rain, and by persons working among wet plants. The fungus also attacks horsenettle, ground cherry, and jimson weed. These and old diseased plants serve as a source of infection for the following year's crop.

Control.—Burn old diseased vines. The fungus will not survive burying in the soil so plow under all infected material not burned. Practice crop rotation. Spraying and dusting with Bordeaux mixture or a fixed copper fungicide will control this disease.

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[1] Caused by *Macrosporium solani.*
[2] Caused by *Macrosporium tomato.*
[3] Caused by *Septoria lycopersici.*

Section II --- General Control Measures

Certain farm practices that are usually considered only in connection with production may be adapted to serve as very important aids in preventing injury by diseases. Such practices include thorough prepartaion of the seed bed, adequate cultivation and application of fertilizers so the plants are not so susceptible to disease attacks.

Sanitation

Care should be taken at the end of the season to destroy crop remnants in the garden by burning or deep plowing. In addition, the crops should be rotated in the garden so that there will not be an opportunity for a disease on a particular crop one year to live through the winter on old diseased plant tops or in the soil and attack that same crop the next season.

Weeds may also harbor disease-producing organisms and should be destroyed in and around the garden.

Seed Selection and Treatment

Seed selection is very important. Certified seed will pay dividends with those crops for which it is available.

With crops such as tomatoes and cabbage where there is danger from seed-borne diseases, seed treatment is advisable. All seeds which are to be planted in flats, hot beds or cold frames, should either be treated or the soil sterilized to prevent damping-off.

Chemical Dust Treatments.—Seed treatment with Spergon, Cuprocide, Metrox, Semesan, or Zinc Oxide will prevent damping-off. Copper-compounds should not be used with cabbage and other crucifers. They are quite satisfactory for other vegetables.

Corrosive Sublimate.—Some seed-borne diseases, such as bacterial spot of tomatoes and peppers, can only be controlled by treating the seed with a corrosive sublimate solution. Corrosive sublimate can be obtained at drug stores, either as a powder or in tablet form. The solution will corrode metal and should be handled only in non-metallic containers, such as glass, wood, or earthenware. Seed may be tied in cheesecloth or other porous cloth bags and immersed in the solution for the desired time. After treatment the seeds should be washed thoroughly and dried. Corrosive sublimate is a *deadly poison* and extreme care should be exercised to see that it is not taken internally.

Corrosive sublimate is most often used at a strength of 1 part of the chemical to 1,000 parts of water (1–1000) which is equivalent to:

4 ounces to 30 gallons of water
1 ounce to 7½ gallons of water
1 teaspoonful (⅓ oz.) to 2½ gals. (10 quarts) of water
8 tablets (7½ grains) to 1 gal. of water.

The corrosive sublimate powder dissolves slowly in cold water thus it is advisable to add a small amount of salt to the water along with the powder, or to add the powder or tablet to a small quantity of hot water to bring it into solution.

Acid Mercury Dip for Potatoes.—This treatment is effective for the control of rhizoctonia on the seed potatoes. It is a short treatment and simple to use,

although not as simple as the organic mercury treatments, such as Semesan Bel, which are also effective against rhizoctonia.

The acid mercury solution is prepared by dissolving 6 ounces of corrosive sublimate in 1 quart of commercial hydrochloric acid and this solution is then stirred into 25 gallons of water in a wooden barrel or concrete tank (corrosive sublimate will corrode metal containers). The uncut potatoes are placed in this solution for 5 to 7 minutes, or longer (10 to 15 min.) if the potatoes are severely infected. Twenty-five gallons will treat 10 to 50 bushels, after which it should be discarded and a new solution made up.

Acid mercury is poisonous to livestock and human beings and corrosive to metal. The tubers should be treated loose or in crates and should be dried after treatment before cutting.

Hot Water.—Hot water is often used as a seed treatment for members of the cabbage family, especially in the control of black rot. Careful regulation of the temperature and length of the treatment is required. The temperature should be controlled at 122°F. throughout the treatment, otherwise the germination of the seed may be impaired. Cabbage seed should be treated for 25 minutes and the seed of other crucifers, such as cauliflower, kohlrabi, radish, rutabaga, broccoli, brussels sprouts, and turnip for 15 minutes. After treatment the seed should be spread out in thin layers at once to cool and dry. Rapid drying is important to help prevent seed injury. Old, weak seed should not be treated.

Acetic Acid.—The acetic-acid seed soak is advisable for tomatoes in western Nebraska where bacterial canker is an important disease. When treating moist seed, immediately following extraction, it should be soaked for 24 hours in an 0.8 per cent solution of acetic acid in water at a mean temperature not in excess of 70°F. Dry seed should be soaked for 24 hours in a 0.6 per cent solution of acetic acid in water at a mean temperature not in excess of 70°F. The seed should be placed in a loosely tied cheesecloth or other porous cloth bag and agitated in the solution to insure uniform treatment.

Fermentation.—Commercial seed producers can control bacterial canker by prolonging the fermentation period during the seed extraction process from the usual 24 hours to 96 hours at a mean temperature of 70°F. or below. The tomato fruits should be thoroughly crushed at the beginning of the treatment and stirred at least twice a day to insure uniform treatment of all seeds.

Soil Disinfection

Sterilization of small quantities of soil may be accomplished by baking in pans or flats in the oven for at least an hour. If a fairly large quantity of soil is to be sterilized, a medium sized potato should be buried in the center of the soil and the soil left in the oven until the potato is baked.

Sterilization with formaldehyde is the oldest and most used method. One tablespoonful is used for a flat of soil 20 x 14 x 3 inches deep or 2½ tablespoonfuls for 1 bushel of soil. The formaldehyde is diluted 4 to 5 times with water and applied by spraying on the soil while mixing, then the soil is covered for 24 hours, after which it is allowed to air at least 24 hours before planting. After the seeds are sown, the soil should be thoroughly watered. If the soil mixture is high in organic matter, a slight increase in the amount of formaldehyde may be justified.

Spraying and Dusting

Spraying and dusting is relatively inexpensive in the small home garden. Small sprayers and dusters are available and for most diseases the individual has the choice of spraying or dusting. Each method has certain advantages. Spray materials adhere better than dusts to the foliage thus fewer applications are necessary. Sprays can be applied when there is a light wind which makes dusting impractical, and less materials are wasted in spraying.

Dusting, on the other hand, requires less time and labor in application. There is less danger of burning tender foliage and oftentimes better coverage of the leaves is obtained. Dusters are less expensive than sprayers and require less attention to keep them in working order.

Bordeaux Mixture.—Bordeaux mixture is the most widely used spray for the protection of vegetables against fungous diseases. It may be used in different strengths, as indicated by the formulas 3–3–50, 4–4–50, etc. The first figure indicates the number of pounds of copper sulfate (bluestone) used; the second, the number of pounds of fresh hydrated lime; and the third, the number of gallons of water.

Most small gardeners will probably prefer to purchase Bordeaux mixture already prepared in powder form and mix it with the required amount of water. However, if it is desirable to prepare the Bordeaux mixture at home, the required amount of copper sulfate "snow" must be thoroughly dissolved in a small quantity of water in a wooden or earthen vessel. The lime may be dissolved in the remainder of the water, then the copper sulfate solution is poured into the lime solution while stirring constantly. This procedure must be followed carefully as the copper sulfate solution and the solution of lime will not mix unless the chemicals are thoroughly dissolved. Bordeaux mixture should be used the same day it is made.

Bordeaux mixture tends to increase the loss of water from the leaves of certain plants. There should be ample moisture in the soil when it is applied to potatoes to offset the increased transpiration.

Insecticides, except rotenone, may be mixed with Bordeaux and the mixture applied as one spray. Occasionally Bordeaux will injure tender foliage.

Sulfur Dusts and Sprays.—Sulfur dusts and sprays have value for controlling such diseases as powdery mildews, rusts, and certain leaf spots. They also tend to control some insects.

Insecticides such as arsenicals, rotenone, and nicotine sulfate may be combined with sulfur sprays and dusts.

Sulfur for dusting should be finely ground. It is frequently mixed with lime, bentonite, or an insecticide to make it dust better. Nine parts of sulfur to 1 part of these other materials is usually used.

Fixed Copper Dusts and Sprays.—A number of "fixed coppers" are on the market under the trade names of Cuprocide, Tribasic, Copper A Compound, Basicop, and COC-S. The formulae given in this bulletin are based on the compound containing 50 per cent metallic copper. They are preferred over Bordeaux and copper-lime dust for tomatoes and cucurbits as there is less danger of burning.

Copper-Lime Dust.—A 20–80 copper-lime dust (20 parts monohydrated

copper sulfate and 80 parts fresh hydrated lime) is commonly used and can be purchased already mixed. This dust must be applied when the foliage is wet.

RESISTANT VARIETIES

Resistant varieties are the most practical means of controlling vegetable diseases. Unfortunately, they are available for only a few crops. Varieties of cabbage resistant to fusarium wilt or yellows, of beans resistant to mosaic, of onions to smudge and neckrot, of peas to wilt, and varieties of watermelons resistant to wilt, are available. Varieties of tomatoes having some resistance to fusarium wilt and nailhead spot are available but they do not yield as heavily as some of the more recently developed varieties.

Section III --- Disease Control Measures That Should Be Practiced Each Year

(For detailed treatments of specific diseases see Section II)

The following control measures should be practiced each year, especially in gardens where disease has been a problem in the past. The most important step in avoiding loss from disease is preventing the disease from getting a start in the garden. A few simple practices such as using good seed, planting in a clean seed bed, rotating the crops and planting resistant varieties when available will aid greatly in producing disease-free vegetables.

ASPARAGUS

Resistant Varieties.—Mary and Martha Washington resistant to rust.

Seed Treatment.—None.

Spraying and Dusting.—To control rust, dust with sulfur three weeks after cutting ceases.

Cultural Practices.—Eliminate wild or escaped plants. Practice cutting throughout the producing season.

BEAN

Resistant Varieties.—Resistant to mosaic—(dry beans) Great Northern, University of Idaho numbers 15, 59, 81, and 123. (Garden and canning types —green beans) Idaho Refugee, U. S. No. 5 Refugee, Wisconsin Refugee, Sensation Refugee 1066, and Sensation Refugee 1071.

Seed Treatment.—None. Use certified seed or seed produced in arid areas.

Spraying and Dusting.—None.

Cultural Practices.—Practice rotation.

BEET (Garden)

Resistant Varieties.—None.

Seed Treatment.—New Improved Ceresan or Red Copper Oxide.

Spraying and Dusting.—Leaf spot—Bordeaux mixture or fixed copper dust.

Cultural Practices.—Plow under beet refuse in fall. Practice rotation.

CABBAGE AND CAULIFLOWER

Resistant Varieties.—Cauliflower—None. Cabbage—Resistant to yellows—(Early) Wisconsin Golden Acre, Marion Market, Jersey Queen, Racine Market. (Mid-season) Globe, Wisconsin Allhead Select. (Late) Wisconsin All Seasons, Wisconsin Ballhead, Wisconsin Hollander No. 8, and Red Hollander.

Seed Treatment.—Black rot—Immerse cabbage seed for 25 minutes in hot water at 122°F. Dust seed with Semesan or zinc oxide for dampening-off. Do not use copper dusts on crucifer seeds.

Spraying and Dusting.—None.

Cultural Practices.—3- or 4-year rotation, especially with seed bed. Prevent injury to heads and store in cool place.

CARROT

Resistant Varieties.—Chantenay, resistant to leaf blight.

Seed Treatment.—None.

Spraying and Dusting.—Leaf spot—Bordeaux spray or fixed copper dust.

Cultural Practices.—At least 2-year rotation. Destroy old carrot refuse.

CELERY

Resistant Varieties.—None.

Seed Treatment.—None.

Spraying and Dusting.—Blights—Bordeaux spray or copper-lime dust at weekly intervals beginning when plants are 3 inches tall and continue until blanching.

Cultural Practices.—Rotate crops. Use new or sterilized seed bed.

CUCUMBER, MELON, AND OTHER CUCURBITS

Resistant Varieties.—Cucumbers—Resistant to mosaic—Shamrock. Watermelons—Resistant to wilt—Improved Kleckly No. 6, Improved Stone Mountain No. 5, Hawkesbury. Squash—Resistant to wilt—Table Queen.

Seed Treatment.—For anthracnose of cucumbers and melons, immerse seed 10 minutes in 1–1000 corrosive sublimate solution (⅓ ounce or 1 teaspoonful in 2½ gals. water). Corrosive sublimate is a deadly poison and must be used with care. Dust seed with Semesan or Red Copper Oxide for damping-off.

Spraying and Dusting.—For wilt of cucumber and muskmelon, apply rotenone dust followed after vining with fixed-copper-rotenone dust (see bacterial wilt of cucumbers, page 11). For watermelons, keep vines covered with fixed-copper-derris dust as described for cucumbers. In the latter part of the season, spray with Bordeaux.

EGGPLANT

Resistant Varieties.—None.

Seed Treatment.—Phomopsis blight—Soak seed 5 minutes in 1–1000 corrosive sublimate solution (⅓ oz. or 1 teaspoonful in 2½ gals. water).

Spraying and Dusting.—Bordeaux spray or copper-lime dust at 2-week intervals to control Phomopsis blight in the field.

Cultural Practices.—2-year rotation.

LETTUCE

Resistant Varieties.—Resistant to downy mildew—Imperial 44, C, D, and F.

Seed Treatment.—None.

Spraying and Dusting.—Bottom rot—Dust Ceresan (2%) under nearly mature plants.

Cultural Practices.—Rotation. Plant in sterilized soil in the greenhouse.

ONION

Resistant Varieties.—Colored varieties are resistant to smudge and neck rot.

Seed Treatment.—Where smut prevails, apply formaldehyde solution in row before seeds are planted (see page 15).

Spraying and Dusting.—None.

Cultural Practices.—Rotation. Dry bulbs as thoroughly and rapidly as possible at harvest. Store in dry, cool place.

PEA

Resistant Varieties.—Resistant to wilt—Resistant Alaska, Mardelah, Wisconsin Early Sweet.

Seed Treatment.—Spergon, Red Copper Oxide, or Semesan.

Spraying and Dusting.—Nicotine sulphate spray to prevent spread of mosaic by aphids.

Cultural Practices.—Rotation necessary. Maintain high fertility. Avoid poorly drained soil.

PEPPER

Resistant Varieties.—None.

Seed Treatment.—None.

Spraying and Dusting.—None.

Cultural Practices.—Rotation and destruction of pepper and tomato refuse of previous year's crop. Avoid planting peppers and tomatoes near each other.

POTATO

Resistant Varieties.—None.

Seed Treatment.—Use only State Certified Seed. Semesan Bel and acid mercury for Rhizoctonia; hot formaldehyde for scab. See Rhizoctonia and scab of potatoes, pages 19 and 20, for details of treatments.

Spraying and Dusting.—Early blight—Bordeaux mixture.

Cultural Practices.—Practice 2- to 3-year rotation with dry-land farming, 4- to 6-year rotation with legumes preceding potatoes under irrigation. Where bacterial ring-rot has occurred, disinfect storage houses and equipment with hypochlorite or formaldehyde solution. Mid-June planting in western Nebraska to decrease scab, fusarium wilt, and Rhizoctonia.

RADISH

Resistant Varieties.—Red Globe types are resistant to black root.

Seed Treatment.—None.

Spraying and Dusting.—None.

Cultural Practices.—Rotate crops.

RHUBARB

Resistant Varieties.—None.

Seed Treatment.—None.

Spraying and Dusting.—Bordeaux mixture when spring growth starts.

Cultural Practices.—Remove and burn old leaves and stalks in the fall after they have frozen.

SWEET POTATO

Resistant Varieties.—None.

Seed Treatment.—Black rot—Immerse seed potatoes at bedding time for 8 minutes in a 1–1000 solution of corrosive sublimate (⅓ oz. or 1 teaspoonful in 2½ gals. water).

Spraying and Dusting.—None.

Cultural Practices.—3- or 4-year crop rotation.

TOMATO

Resistant Varieties.—Pritchard, Marglobe, and Rutgers have some resistance to Fusarium wilt and nailhead spot. Southern plants are often infected with wilt; however, certified plants can be obtained from some southern states.

Seed Treatment.—For bacterial spot, immerse seed 5 minutes in 1–3000 corrosive sublimate solution (⅓ oz. or 1 teaspoonful in 7½ gals. water). Rinse and dry. For bacterial canker, fermentation method of seed extraction, or acetic acid seed soak (see bacterial canker of tomato, page 26). For damping-off, dust seed with Semesan or sterilize the soil for flats and hotbeds.

Spraying and Dusting.—Spray with Bordeaux or dust with a fixed copper dust for early blight and nailhead spot.

Cultural Practices.—At least a 2-year rotation. Encourage extensive root system and uniform water supply. Destroy diseased plants in the fall.

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