Market Diseases

of

Cabbage, Cauliflower, Turnips, Cucumbers, Melons, and Related Crops

Glen B. Ramsey and M. A. Smith

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Market Quality Research Division

THIS REPORT is one of a group of publications on market diseases of fruits and vegetables. The publications are designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing in order to facilitate inspection of these food products and to prevent losses from such conditions.

Other reports on market diseases of fruits and vegetables issued by the U.S. Department of Agriculture include:

Miscellaneous Publications

98. Potatoes. Revised Jan. 1949.

168. Apples, Pears, Quinces. Revised Nov. 1951.

228. Peaches, Plums, Cherries, and Other Stone Fruits. Revised Feb. 1950.

340. Grapes and Other Small Fruits. July 1939.

440. Asparagus, Onions, Beans, Peas, Carrots, Celery, and Related Vegetables. Sept. 1941.

498. Citrus and Other Subtropical Fruits. June 1943.

Agriculture Handbooks

28. Market Diseases of Tomatoes, Peppers, and Eggplants. June 1952.

155. Market Diseases of Beets, Chicory, Endive, Escarole, Globe Artichokes, Lettuce, Rhubarb, Spinach, and Sweetpotatoes. April 1959.

Miscellaneous Publications 228, 340, and 440 are out of print but may be consulted in libraries.

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CABBAGE, CAULIFLOWER, TURNIPS, CUCUMBERS, MELONS, AND RELATED CROPS

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CRUCIFERS

The various members of the crucifer group supposedly are horticultural varieties which have been developed by cultivation from the wild *Brassica oleracea.* Thus the headless types (kale and collard, etc.) are *B. oleracea* var. viridis L.; the budding type (brussels sprouts), var. *gemmifera* DC.; the floral head types (cauliflower and flowering broccoli), var. *botrytis* L. and var. *italica* Plenck; the enlarged stem type (kohlrabi), var. *caulo-rapa* L.; and the leafy head type (cabbage), var. *capitata* L.

CABBAGE

Cabbage is used for food as salad and as a cooked vegetable, and a considerable amount is fermented and eaten as sauerkraut. Cabbage, like most other cultivated crucifers, belongs to the genus *Brassica.*

The marketability of cabbage for table purposes is affected by many factors, the foremost being crispness, solidity of head, color, and freedom from blemishes and decay. Since field diseases often affect the crispness, solidity, and color of cabbage, they are both a direct and an indirect factor in its marketability.

Lack of crispness may be due to poor growing conditions, to field diseases, to excessive drying out in storage, or to the respiratory activities of the tissues. Excessive loss of crispness because of respiration may result from too high a temperature during transit and storage or from too long a transit or storage period.

Several diseases which seriously affect production may also directly affect the marketability of the heads. Foremost among these is black rot (*Xanthomonas campestris* (Pam.) Dows.). Others are alternaria leaf spot (*Alternaria brassicae* (Berk.) Sacc. and *A. oleracea* Milbrath), bacterial leaf spot (*Pseudomonas maculicola* (McCull.) F. L. Stevens), downy mildew (*Peronospora parasitica* (Fr.)), and *Rhizoctonia* head rot (*Pellicularia filamentosa* (Pat.) Rogers).

[1] Now retired.

There are several diseases which only occasionally cause losses in the field, but which are exceedingly important in the later stages of distribution and in storage. These are bacterial soft rot (*Erwinia carotovora*), gray mold rot (*Botrytis cinerea* (Pers.)), rhizopus soft rot (*Rhizopus stolonifer* (Fr.)), and watery soft rot (*Sclerotinia sclerotiorum* (Lib.) DBy). Often these also cause heavy indirect losses in transit and storage by necessitating heavy trimming.

(See *10*, *11*, *26*, *27*, *46*, *64*, *68*, *89*, *101*, *104*.)[2]

ALTERNARIA LEAF SPOT

Alternaria spp.

Occurrence and Importance

Alternaria leaf spot is a widely distributed disease that occurs on cabbage, cauliflower, broccoli, and most other plants belonging to the mustard family. In wet seasons this leaf spot has been known to reduce the yield of cabbage by more than 50 percent. The market losses are due to decay which develops in transit and storage, to secondary decay for which it opens the way, and to blemishes which render the heads unsightly and necessitate heavy trimming.

Symptoms

The first symptom of alternaria leaf spot is the appearance of small grayish-brown to black spots about $\frac{1}{16}$ inch in diameter (pl. 3, F). They may appear at any time during the life of the cabbage plant. They usually are most conspicuous on the outer, older leaves. The color of the spots depends somewhat on the color of the part of the leaf affected. Old spots may range up to 1 inch or more in diameter. Sometimes the spots produced by *A. brassicae* are marked by light- and dark-brown concentric zones that produce a "target board" appearance. A growth of dark brown to black mold is often present in a humid atmosphere (pl. 1, B). The spots caused by *A. oleracea* are not zonate and usually are not covered by a moldy growth until the leaves turn yellow or are shed. Bacterial soft rot and other secondary decay sometimes follow in these lesions.

Causal Factors

Three species of Alternaria have been reported as causing leaf spot of plants belonging to the mustard family. *A. brassicae* is generally thought to be the cause of most losses, although *A. oleracea* also causes serious damage in some regions. Under moist conditions the spores of these organisms may germinate and cause infection within 24 hours. The spores germinate best between 63 and 70° F. Wounds are not necessary for infection. Although most infections are prominent on the wrapper and older head leaves, the age of the plant apparently has little to do with the infection. High humidity and moderate temperatures favor the spread and development of this disease. Low temperatures (35–45° F.) and low humidity greatly inhibit infection and decay.

Control Measures

Severely spotted heads of cabbage and other plants of this family should be closely trimmed before shipment. Shipments to distant

[2] Italic numbers in parentheses refer to items in the Literature Cited, p. 45.

markets should be refrigerated to 40–45° F. during transit. Cabbage to be held in storage for any great length of time should be kept at 35° F. or slightly below.

(See *89*, *93*.)

BACTERIAL SOFT ROT

Erwinia carotovora (Jones) Holland and other bacteria

Occurrence and Importance

Bacterial soft rot of cabbage and other members of the mustard family often causes serious losses during marketing. This is because bruised and wounded tissues are readily affected, and the causal organism is a secondary invader of tissues killed or weakened by most of the parasitic and some nonparasitic diseases. It often follows black rot, clubroot, downy mildew, or alternaria leaf spot, and causes most of the damage following freezing.

Ordinarily, soft rot is of little importance in the field except as a secondary invader following other diseases. At times dead and dying heads in the field develop soft rot and in cutting the crop for marketing the knives become contaminated, thus leading to infection of subsequent heads. Such heads show stump or butt rot by the time they reach the market (pl. 3, C).

Symptoms

On cabbage and brussels sprouts the first symptoms usually show as watersoaked or greasy spots on the leaves as bruises or as white to grayish, soft areas at the base of the heads. Small lesions have no appreciable odor but extensive decay has a very putrid odor. When this disease follows black rot and other diseases frequently a large proportion of the head is converted into a brownish-black slimy mass.

On the curds of cauliflower the first evidence of infection is small, yellowish, slightly watersoaked specks in the florets (pl. 6, B). As the decay progresses, the affected florets become darker yellow, more watery and somewhat sunken. The most serious type of bacterial soft rot is developed in cauliflower when large yellowish-brown areas resulting from pressure bruises in packing and handling become infected.

Although bacterial soft rot is usually not of much importance in shipments of broccoli it sometimes appears as dark green watersoaked or greasy lesions at bruises on the leaves and flower heads.

Causal Factors

The bacterial soft rots of vegetables are caused by *Erwinia carotovora* or closely related organisms. The bacteria of this group are ever present in vegetable-growing regions, but they are unable to invade plants except through wounds, through lesions produced by other diseases, or through tissues injured by freezing, asphyxiation, or aging. Moist surfaces or injured tissues which lead to bleeding of the plant juices generally provide the water and food necessary for growth and reproduction of the soft rot bacteria. Warm, wet weather favors the development and spread of the disease in the field, and warm, moist conditions favor its development and spread in transit. Temperatures between 69° and 77° F. favor the disease because there is less drying out of tissues. At 91° the organism does

not grow as well as at 69°; at 61° it produces only one-half and at 54° only one-third as much rot as at 69°, while at 46° there is practically no invasion of tissues.

Control Measures

The control of bacterial soft rot in vegetables during transit and marketing involves careful trimming to eliminate other diseases, careful packing and handling to avoid unnecessary wounds, and good refrigeration in transit and while held in stores. Vegetables should be kept at 45° F. or below to effectively check the development of bacterial soft rot.

(See *27.*)

BACTERIAL ZONATE SPOT

Pseudomonas cichorii (Swingle) Stapp

Bacterial zonate spot is primarily a disease of cabbage although other members of the Cruciferae and Cucurbitaceae are susceptible. It was first observed on Florida-grown cabbage in the Chicago market in 1953.

The disease is characterized by round to irregular lesions 1/16 to 1/2 inch in diameter, at first buff to light brown, becoming darker brown with age. The lesions are zoned or targetlike and may occur on any part of the leaf (pl. 3, D). Superficially the lesions resemble those caused by *Alternaria brassicae* on cabbage. Infected areas are firm and pliable but only slightly soft. This is in contrast to the slimy type of decay produced by *Erwinia carotovora.*

The casual organism, *Pseudomonas cichorii* (Swingle) Stapp, enters cabbage through wounds. Lesions may occur on any part of the leaf but there is no evidence that the disease involves the vascular system. Best growth of the pathogen occurs at 75° F. Control measures have not been developed.

(See *73.*)

BLACK LEAF SPECK

Black leaf speck may occur in cabbage, Chinese cabbage, and cauliflower from all sections. It occurs commonly in transit and storage and sometimes in the field. The spots render these products unslightly, thus affecting their marketability.

Black leaf speck is characterized by small, sharply sunken, brown or black specks occurring anywhere on the leaves of cabbage, cauliflower, and Chinese cabbage (pl. 2, A and pl. 9). At times they are found in great abundance, especially on the leaf blades. These specks may occur in a few of the outer head leaves of cabbage, or in leaves throughout the head. Frequently, it is difficult to distinguish them from the early stages of Alternaria spot in cabbage, and from ring spot in cauliflower.

Very little is known about the cause of black leaf speck. However, a similar type of leaf spotting of cabbage is known to be caused by a virus (see Mosaic, p. 9). Its occurrence under refrigeration in transit and storage and in association with decided drops in temperature in the field suggest that this trouble is in some way related to low temperature. Black leaf speck has been produced experimentally by placing cabbage in a well-ventilated room at temperatures near 32° F. for 2 or 3 weeks.

No effective control measures are known.

(See *52.*)

BLACK ROT

Xanthomonas campestris (Pam.) Dows.

Occurrence and Importance

Black rot is often one of the most serious diseases of cabbage, cauliflower, and related vegetables of the mustard family. The disease is a market factor because it produces discolorations in the leaves and stems of affected plants and because it opens the way for secondary infection by bacterial soft rot which often causes serious loss during marketing. When the heads are not affected throughout, some salvage can be effected by trimming off blemished or decayed leaves.

Symptoms

Black rot is a vascular disease. It is not a soft rot, although it may be complicated by soft rot. Often the first symptoms of this disease are yellow and light-brown spots or patches at the margin of the leaves. The veins in affected leaves appear as a black, conspicuous network and in the midrib where the vascular tissue is covered by light fleshy tissue there is a dark shadow running through the center. This black stain often extends into the compact head leaves of cabbage and down the stem (pl. 2, B). Part or all of the vascular ring in the stem may be discolored, but the pith and cortex generally are not involved (pl. 2, A). Even extensively invaded cabbage heads may remain firm. However, on the market the base of the stem and the outer head leaves often become soft due to secondary invasion by bacterial soft rot.

Although black rot in cauliflower usually develops as in cabbage, it sometimes manifests quite different symptoms. In very rainy weather the leaves of cauliflower that are invaded by the black rot bacteria may wilt quickly without showing the usual black discoloration of the veins. When infection of the lower leaves occurs on the under surfaces where waterdrops form, often large watersoaked lesions are produced and the leaves wilt and dry, causing the plant to have a blighted appearance.

In kohlrabi affected with black rot, the staining of the vascular elements often is very pronounced in the enlarged stem without visible external symptoms. In Chinese cabbage numerous small brown spots may occur on the leaf blade, and the vascular tissue also shows discoloration. In rutabagas the roots may not show external symptoms of the disease but on cutting, the brownish-black stained specks in the vascular ring and in the center of the root are very conspicuous (pl. 8, A). In none of these commodities is there a definite odor associated with black rot lesions unless some secondary organism has invaded the affected tissues.

Causal Factors

The bacterium causing black rot may overwinter on the seed, on the mother cabbage heads, in plant debris, or in the soil. Infection often occurs in the cotyledons of the plants in the seed bed. Most infections in cabbage and other plants of this family occur through the water pores, in the margins of the leaves.

The time of the appearance of black rot and the severity of the disease is largely determined by weather conditions. Warm, rainy weather with moderately cool nights is most favorable for infection

and spread of the disease. Hot, dry weather is unfavorable for the development of black rot.

Black rot does not spread or develop appreciably in transit or storage under refrigeration but secondary decay caused by bacterial soft rot sometimes progresses sufficiently to make it seem to have advanced.

Control Measures

Cabbage heads with badly discolored wrapper and outer head leaves and discolored stems should not be packed for shipment. Slightly infected heads may be salvaged by close trimming, but there is always some danger of secondary bacterial soft rot causing trouble during marketing, unless a temperature of 40° to 45° F. or lower is maintained.

(See *15.*)

BORON DEFICIENCY

See Cauliflower, p. 15.

DOWNY MILDEW

Peronospora parasitica (Fr)

Occurrence and Importance

Downy mildew occurs on members of the mustard family from many regions. The disease is of market significance chiefly on cabbage, cauliflower, radishes, and turnips. In the seed beds and in the field it causes death of young plants during cool, wet weather and blemishes many plants that survive so that their market value is reduced. Downy mildew is sometimes a very destructive disease of radishes and cabbage on the market and in storage.

Symptoms

The first symptoms of leaf infection are small, pale, greenish-yellow angular spots. As the spots enlarge, a fine white downy mildew becomes evident on the underside of the leaves. As long as the weather remains wet, new spots continue to appear and the older ones enlarge and become yellowish brown. When severely spotted, the older leaves are shed, but the newer leaves become infected as long as the weather is favorable. This leads to spotting of the outside leaves, which sometimes detracts from the market value (pl. 3, E).

When the fungus enters the stalk at the base of the old headleaves of cabbage, a grayish-black discoloration of the stalk occurs (pl. 4, B). In some storage lots of cabbage this discoloration has been found extending up through the stalk to the innermost bud leaves. The discolored pith and parenchyma tissues are practically as firm as the healthy tissues. There is no odor and no surface growth of mold visible. However, secondary infections by Rhizopus, Alternaria, and bacteria sometimes produce rot in the discolored areas.

Heads of cauliflower may also show the same grayish-black discoloration of the stalk and thickened branches of the flower head as in cabbage (pl. 4, A).

When maturing turnips are heavily infected with downy mildew, the fungus sometimes follows down the leaves into the crown of the root. Freshly invaded root tissues show brown mottling or streaks extending from the crown into the root. Affected turnips in storage sometimes have most of the central part of the root blackened by this

fungus. This discoloration resembles that caused by boron deficiency, but in general it is blacker and not so watery. As in other instances of invasion of fleshy parts of vegetables, no soft rot is produced, and in topped turnips there is no external evidence of infection.

Affected radishes show brown to black discolorations of the epidermis generally about halfway down the side of the roots. The discoloration has no particular pattern. Sometimes there is an elongated streak, but usually the discoloration is blotchy and frequently spread around the circumference of the roots (pl. 7, A). Internal flesh of the roots is firm and grayish brown to black (pl. 7, B).

Causal Factors

The causal fungus *Peronospora parasitica* overwinters in the form of resting spores (oospores) in debris of affected plants of the previous year in the soil and as perennial mycelium in wild and cultivated plants of the mustard family. Infection spreads rapidly during wet weather but dry, warm weather stops sporulation and spread of the disease. Sporulation may occur on infected leaves and roots in storage or in transit. The spores germinate abundantly at 46° to about 65° F. and may cause new infections. Infections become visible in 3 days at about 70°. There is a rapid development of disease in infected tissues at 75°.

Control Measures

Cabbage and cauliflower heads and radish and turnip roots showing grayish-black discolorations of the fleshy tissues should be sorted out at the packing shed. Transit and storage temperatures below 40° F. should retard the development of this disease.

(See *32*, *62*, *63*.)

FREEZING INJURY

Heavy losses of cabbage occur annually as a result of freezing, both in the field and after harvest. Cabbage tissue has one of the highest freezing points (31° F.) found among vegetables. Although cabbage tissues differ from those of many other vegetables, in that they can tolerate some formation of ice and thawing without apparent injury, there is a limit below which they are likely to be injured. Sometimes frozen cabbage will thaw out without injury and sometimes it will not. In the former case the tissues are merely frozen, while in the latter they have been killed. However, there is no way of telling by examination of a frozen head of cabbage whether it will show injury when thawed out. Immediately after thawing, the frozen areas appear watersoaked due to suffusion with water liberated by the thawing ice in the intercellular spaces. If the cells are still alive, some of the water will go back into them and the only effect in the tissue is a slight wilting or shriveling due to the excessive loss of water. Tissues responding in this way become flaccid, pithy, or spongy and tough, and lose their characteristic flavor. Some of them can withstand freezing several times before the effect becomes pronounced; others develop it the first time. If the cells are not alive, the water does not reenter them and is either lost rapidly into the air, with attendant drying out of the tissues, or it remains and the tissues become a leaking, disorganized mass, which is attacked by saprophytic fungi and bacteria. Whether or not ice formation in the tissues is attended by permanent injury and death

seems to depend upon how low the temperature is, the rate at which it falls, the duration of the freezing temperature, and the condition of the plant tissues.

Frozen leafy tissues and even such storage tissues as turnips and rutabagas lose their natural luster and take on a glassy appearance. Immediately upon thawing they become watersoaked. The leafy green tissues in the watersoaked area also have a dirty or muddy green color. In colorless or fleshy parts like cauliflower heads there is no discoloration at first. Later the more sensitive tissues, especially the fibrovascular bundles, may become yellowish brown and finally black. Fleshy roots such as turnips, radishes, rutabagas, and horseradish often show no discolorations, except in the vascular tissues.

In cabbage the outer leaves seem to be more resistant to killing by freezing than the inner leaves and the stem. Generally they thaw out without injury. After prolonged exposure to freezing temperatures, the inner tissues, especially the pith of the stem, usually are killed and soon become affected with bacterial soft rot.

Control is obtained by avoiding exposure of the products to freezing temperatures for a long enough period to cause their death.

(See *104.*)

GRAY MOLD ROT

Botrytis cinerea Pers.

Cabbage, cauliflower, broccoli, turnip, and rutabagas are the chief members of the mustard family that are attacked by the gray mold rot fungus. This organism is widely distributed and occasionally causes serious damage to crops grown in very humid regions. This disease may cause damage to the growing crops, but it is usually more important as a transit and storage disease. The marketable vegetable produce is contaminated by spores during harvesting and packing operations. The spores germinate readily in moist packages of vegetables. Once infection has occurred appreciable rot may develop even under standard refrigeration practices.

On green leafy tissues of cabbage, cauliflower, and brussels sprouts greenish brown, watersoaked areas are produced. Usually a fine white mold is apparent on the surface of the larger spots. In more advanced stages, the decayed areas become grayish brown and the surface mold becomes brown also when clusters of spores begin to form (pl. 3, B). In fleshy tissues such as cauliflower curd, turnip, and rutabaga roots, the affected portions are gray to light brown and are fairly moist. Gray mold rot is a moist type of decay but not so wet or leaky as is produced by Rhizopus soft rot, or watery soft rot. The diseased tissues have no odor except that of the juices of the plant itself. However, produce which is warm usually becomes infected by bacterial soft rot which produces a disagreeable odor.

Since the gray mold rot fungus is able to make noticeable progress even in temperatures of 35 to 40° F., decay is commonly found in refrigerated shipments and in cold storage. Best control of this decay can be obtained by carefully sorting out all produce showing decay at the packaging shed and keeping the commodity as cold as possible during transit, storage, and marketing. Produce showing infection will continue to develop decay even at 32°, but at a slower rate.

MOSAIC

There are many kinds of mosaic disease on cabbage and other members of the mustard family. Most members of the mustard family are more or less affected during the growing season, sometimes with serious loss. Affected plants are seldom seen on the market because the conspicuously mottled and discolored produce is not shipped. Occasionally cabbage is found on the market with numerous internal black specks that are characteristic of one kind of mosaic. There is no decay but the appearance of the heads greatly reduces their market value. (See Black Leaf Speck, p. 4.)
(See *44*, *52*, *60*, *84*.)

RHIZOCTONIA HEAD AND ROOT ROTS

Rhizoctonia solani Kuehn (*Pellicularia filamentosa* (Pat.) Rogers)

Occurrence and Importance

Various crop plants belonging to the mustard family are subject to attacks by the common soil fungus *Rhizoctonia*. Head rot of cabbage and root rot of turnips and radishes are the most important of the resulting market diseases. Under favorable conditions one or more of the various types of disease induced by this fungus may occur in any of the vegetable-growing sections of the country.

Symptoms

The lesions induced by *Rhizoctonia* may usually be recognized by the moderately coarse, cream-colored to brown surface mycelium and the irregularly shaped chocolate-brown sclerotia of the fungus. The affected tissues are light brown and semiwatery at first and change to dark brown or brownish black as the fungus extends deeper and the tissues dry. Toward midseason the cabbage plants that escaped serious previous infection may show dark lesions on the stem and lower leaves, bottom rot, or later dark-brown sunken lesions on the stem, midribs, and blades of the compact head leaves. This latter phase, known as head rot, is especially damaging to cabbages ready for market, because of the ability of the fungus to continue development during transit and while in storage. Heads so affected are also subject to bacterial infections that induce rapidly developing, foul-smelling decay.

The root rots of turnips, rutabagas, and radishes caused by Rhizoctonia are sometimes important in the field, but in many instances most damage is done in storage. The fungus may enter through the leaf scars or injuries at the crown, or through infected rootlets. The lesions are usually round and light brown. As the fungus grows deeper into the tissues the affected area becomes dark brown and slightly sunken and the internal tissues become semiwatery or spongy as water is lost by evaporation. Frequently the spots in storage turnips are made up of concentric rings of light- and dark-brown tissues. Brown surface mycelium and sclerotia of the causal fungus may or may not be present.

Causal Factors

The sterile form of the fungus (*Rhizoctonia solani*) is by far the most important cause of this disease. This stage of the fungus is ever present in the soil of most vegetable-growing districts, whereas

the spore-forming stage (*Pellicularia filamentosa*) is rarely seen. Under humid conditions the fine creamy-white mycelium and minute granular spores may be found on stems and the under sides of lower leaves of cabbages and other plants, but the spores do not survive long in dry air, and it is doubtful if they ever are important disseminating agents.

The Rhizoctonia stage of the fungus is pathogenic to a great number of plants, and it withstands adverse weather remarkably well. It is able to survive in soils at freezing temperatures and below and is not killed at 100° F. The hard, compact masses of mycelium (sclerotia) may be expected to maintain the life of the fungus in practically any climate.

Several strains of this fungus are recognized, some being able to attack one plant, some another. The strain that causes bottom rot and head rot of cabbage will grow in culture at 48° to 91° F., but the minimum temperature for infection of cabbage is near 53°, the optimum 77° to 80°, and the maximum 88° to 90°.

For growth in culture the strain of *Rhizoctonia* that causes rot of turnips has its minimum at about 35° F., optimum 73°, and maximum 89° to 94°. The minimum temperature for infection of turnips is about 35°, the optimum 66° to 77°, and the maximum between 84° and 90°.

Except for very low or extremely high temperatures the most important limiting factors in determining infection and decay by *Rhizoctonia* are soil moisture and humidity. Since this fungus does not require wounds for producing infection it may attack practically any part of a plant with which it comes in contact, providing there is enough moisture to permit it to grow on the surface tissues long enough to gain entrance into them. Once the hyphae have invaded the tissues they will continue to develop and cause decay regardless of external moisture, although high humidity always favors rapid development of decay. In storage, high humidity favors infection and decay; low humidity limits both.

Control Measures

Cabbage, turnips, rutabagas, or radishes that show severe Rhizoctonia infection should not be shipped or stored. Slightly affected products may be stored for a month without excessive loss, if the temperature is held at 32° to 34° and the humidity is kept as low as possible without causing wilting.

(See *26*, *89*.)

RHIZOPUS SOFT ROT

Rhizopus stolonifer Fr.

The members of the mustard family are often subject to infection and decay by *Rhizopus*. This fungus is ever present in the air and soil, and consequently there is always more or less danger from infection if conditions are favorable. Excessively wounded or bruised stock is especially susceptible to infection if warm, humid conditions prevail. This disease is of little or no consequence in the field or on leafy crops such as mustard and kale, but sometimes considerable loss occurs in the more fleshy vegetables such as cabbage, brussels sprouts, cauliflower, turnips, and rutabagas on account of decay developing during transit and marketing. The chief predisposing factors are wounds and high temperature.

The decay in succulent tissues is light brown, soft, and watery; in root crops the rot is moderately soft and moist, but it lacks the disagreeable but characteristic odor of the bacterial soft rots that sometimes present a similar appearance. Usually in cabbages, cauliflower, brussels sprouts, and turnips the coarse, stringy mycelium bearing white and black sporangia make the diagnosis of this disease fairly easy (pl. 5, C).

Rhizopus does not affect cabbage, cauliflower, or root crops stored near 32° F. The minimum temperature for the development of Rhizopus rot is about 44°, the optimum between 77° and 82°, and the maximum about 90°.

(See *34*, *94*.)

SUNSCALD

In cabbage, scald usually occurs only on leaves that are exposed on the top of the head. The first symptom is a watersoaked or blistered, irregularly shaped area, which promptly dries out and becomes a bleached, papery, or parchmentlike island surrounded by healthy tissue.

The scalded area either remains parched and bleached or is invaded by bacteria that cause soft rot and such fungi as *Rhizopus* sp. and *Alternaria* sp.

Affected leaves should be removed before the cabbage is shipped or stored.

THRIPS INJURY (EDEMA)

Thrips tabaci Lind.

Cabbage on the market in some seasons shows considerable damage by thrips. These small insects, just visible to the naked eye, feed upon the leaves and cause blemishes that sometimes greatly injure the appearance of the heads. These insects puncture and rasp off the epidermis and suck the juice from the injured tissue. Where extensive feeding has occurred the surface of the leaves presents a yellowish-brown scarified appearance when the injured tissues begin to dry (pl. 5, A). In many instances these insects work up through open spaces between the head leaves and in feeding there cause injuries that apparently stimulate proliferation of the epidermal cells so that an edema type of growth is developed (pl. 5, B). These superficial pustules of white or yellowish cells are usually $\frac{1}{16}$ to $\frac{1}{8}$-inch in diameter. Thrips appear to be constantly associated with this edema type of development between the basal head leaves as well as with the scarified rusty patches on the outer leaves.

TIPBURN

Tipburn of cabbage is most common in the Northern States. It frequently causes much damage to cabbage grown in soil deficient in potash and comparatively high in nitrogen. In seasons of severe drought, death and discoloration of the leaf margins (a type of tipburn) sometimes occur.

Cabbage showing tipburn is greatly discounted on the market because of appearance and the loss entailed in preparing it for table use. Affected stock, whether in the field, in transit, or in storage, is also subject to invasion by decay-producing organisms, such as bacteria, Alternaria, Rhizopus, and Botrytis.

Characteristic symptoms of this disease are yellowing, browning, and gradual drying of the leaf margins. Frequently the outer head leaves are the only ones affected and these may be trimmed off before the cabbages are marketed, but in some instances the tips of the leaves a fourth of the way through the head may show yellowish or grayish-brown discoloration.

Control of tipburn has been obtained by application of potash fertilizers to some soils; to others a heavy dressing of stable manure has been found beneficial.

(See *55*.)

WATERY SOFT ROT (Sclerotinia Rot)

Sclerotinia sclerotiorum (Lib.) DBy.

Occurrence and Importance

Among the most serious diseases of vegetables are those caused by soil organisms. Watery soft rot is caused by a soil fungus which is more or less common in all regions that grow vegetables, and is especially destructive because it can attack a wide variety of crops.

Symptoms

A characteristic soft, watery decay is produced and affected tissues are often covered with a white cottony mold (pl. 1, A). In transit, storage, and on the market badly decayed products actually leak, but there is no disagreeable odor like that produced by many other diseases. In dry air the water frequently evaporates as fast as it is liberated and the tissues dry down into a mummy or into parchment-like remnants. Succulent tissues in moist air generally are completely liquefied, so that a pool of juice with the characteristic odor of the plant tissues is all that remains. The color of the lesions varies widely with various hosts and individuals. When the lesions are moist they appear watersoaked, with little change in color. Frequently the borders of the lesions are pink and the inner portions are yellow or light brown.

The disease generally occurs in the basal part of plants or in the parts near or lying on the soil. However, the fungus is not limited to these parts; it can attack the floral parts 3 to 4 feet above the ground.

In storage and in transit the fungus frequently makes a vigorous and compact growth that spreads from one individual to another and enmeshes them in its mycelium.

The fungus itself furnishes a good means for identifying the disease for it usually develops a luxuriant, white, cottony mass of mycelium which is so characteristic that the disease sometimes is known as cottony rot. Even more characteristic are the large resting bodies or sclerotia, which form when the fungus begins to dry out or when the food supply begins to wane. These are white at first and later turn black. Large sclerotia are often formed on affected cabbage, rutabagas, and turnips in storage.

Causal Factors

The disease is caused by a fungus, *Sclerotinia sclerotiorum*. It persists in the sclerotial stage in the soil and becomes active when moisture and temperature conditions are favorable. Cabbage be-

comes infected by mycelium that grows from the sclerotia or by spores that are produced in apothecia and shot into the air.

Watery soft rot may develop in transit or storage in stock which appeared sound when harvested but which came from a field infested with the fungus. Plants taken from fields free from *Sclerotinia* will not develop the rot unless they come in contact with other diseased plants or soil contaminated with the fungus. A few infected cabbages in a package may be sufficient to cause complete decay of the entire contents. Although the fungus does not need wounds for entry, wounded tissues become infected more readily than others.

Severity of the rot increases rapidly with rising temperatures until the optimum temperature for growth is reached between 70° and 78° F. At 88° to 90°, there is practically no growth. Under the most favorable temperature and moisture conditions, the first symptoms may appear within 6 to 48 hours after infection, and the tissue may be completely destroyed in 3 to 5 days.

After infection has taken place the rate of development of the lesions is less dependent upon moisture than upon temperature. If the stock comes from an infested field and is put into storage or shipped, or if it is put into contact with stock already affected, severe losses may occur even at temperatures between 32° and 45° F. Low temperatures will, however, slow up the development and spread of the rot.

Control Measures

Affected products should not be packed or stored.

Although low temperatures do not completely control the disease, they retard its development so much that precooling and good transit refrigeration are highly desirable.

(See *19*, *61*.)

CHINESE CABBAGE

The Chinese cabbage or petsai (*Brassica pekinensis*) is a member of the mustard family and is related to the common cabbage. It does not form compact heads, but a more or less open, soft mass of leaves. The factors governing the marketability of Chinese cabbage are essentially the same as those of the common cabbage. The most important market diseases are bacterial soft rot, black rot, and black leaf speck (pl. 9).

(See Cabbage, p. 1.)

BRUSSELS SPROUTS

Brussels sprouts are the buds of a member of the mustard family (*Brassica oleracea* var. *gemmifera*). Desirability of the buds depends primarily upon crispness, tenderness, and freedom from blemishes and decay. Essentially the same diseases that affect cabbage and other cruciferae affect this plant in the field and the buds after harvest. The most important market and transit diseases are bacterial soft rot, alternaria rot, Rhizopus rot (pl. 5, C), and black rot. Ring spot (pl. 5, D) also affects brussels sprouts.

(See Cabbage, p. 1, and Cauliflower, p. 14.)

BROCCOLI

The term broccoli refers to the green, loosely formed floral heads and associated tender leaves and stems of the plant *Brassica oleracea* (var. *italica* Plenck). This plant is subject to many of the diseases found on cauliflower. The most important market and transit diseases are bacterial spot (pl. 3, A), bacterial soft rot, gray mold rot (pl. 3, B), and watery soft rot.

(See Cauliflower, p. 14.)

(See *40*, *72*.)

CAULIFLOWER

The cauliflower is the malformed condensed flower head with short fleshy branches of a plant (*Brassica oleracea* L., var. *botrytis*) very closely related to the cabbage. By breeding and selection, strains have been developed which produce firm, smooth, white, well-rounded flower heads or curds, and these are greatly in demand on the market.

In the best cauliflower, the outer leaves or jackets are green, the enclosed head is creamy white to white, and the bud clusters are crowded closely together forming an even, firm head. Good heads will remain compact for a short time in the field, and under proper conditions will carry well in transit, maintaining good marketable condition for some time.

Since the market demands green jackets, any disease that spots the leaves or that causes premature yellowing or dropping is important.

Cauliflower is subject to the same diseases that affect cabbage and other members of the Cruciferae. Some of these diseases are especially important. Those that either blemish or decay the curd are more important than those primarily affecting the leaves. The most important diseases are: bacterial soft rot, black rot, bacterial leaf spot, downy mildew, brown rot, gray mold rot, ring spot, and watery soft rot.

BACTERIAL LEAF SPOT

Pseudomonas maculicola (McCull.) F. L. Stevens

Occurrence and Importance

Bacterial leaf spot is a minor disease of cauliflower, cabbage, and broccoli found occasionally in the field and on the market. It is prevalent on cauliflower and broccoli grown in the San Francisco Bay district in California, but it has also been reported from Virginia, Florida, and New York. The disease disfigures the leaves of cabbage, the stems and florets of broccoli, and the leaves and curds of cauliflower, thus reducing their market value.

Symptoms

On cauliflower the disease is characterized by abundant specking, spotting and blotching of the green leaves, on and between the veins, as well as on the flowerheads. Lesions on the leaves appear as very small, watersoaked spots, of variable size, with dark specks in the center. The spots often coalesce, thus becoming irregular in shape, giving the leaf a ragged appearance. Severely affected leaves turn yellow and fall prematurely.

Lesions on the curds appear as small gray to brown spots on the epidermis and deeper tissues of the buds and branches. The affected tissues are firm at first but later may become soft if invaded by secondary organisms.

The disease on broccoli is characterized by purplish gray to black lesions varying in size from mere pin points to circular or oblong spots 1/32 inch in diameter on stems, petioles, florets, and leaves. Infections on stems sometimes coalesce to form lesions 1/4 inch in length (pl. 3, A).

Causal Factors

The causal organism *Pseudomonas maculicola* enters through stomata. Infection is most abundant on the lower leaf surfaces. It has been observed that the disease is more likely to occur on cauliflower curds that are slightly overmature and on those showing slight injuries. The disease does not occur during hot weather. The optimum temperature for the organism in culture is 75° to 77° F., minimum is 32°, and maximum is 84°. Infection becomes visible in about 3 days on leaves and in 7 to 9 days on stems and flower heads.

Development of the disease in storage and transit should be retarded by temperatures near 32° F.

(See *47*, *72*.)

BACTERIAL SOFT ROT

See Cabbage, p. 3, and plate 6, B.

BORON DEFICIENCY

Boron deficiency can cause browning or bitter brown rot on most cultivated crucifers, but cabbage, cauliflower, rutabaga, and turnip are particularly sensitive. This trouble has caused considerable loss to cauliflower in Maine, New York, Wisconsin, and Florida and other areas where it is grown.

In cabbage showing boron deficiency a brown necrosis develops in the fleshy pith of stem and core. The first noticeable symptom of the deficiency in cauliflower is a slight brownish discoloration of the curd. Blisters and cracks may appear on midribs of leaves and brown necrotic areas develop in the pith of stems. In advanced stages, the discolored pith shrinks and cracks and the stems become hollow. Although the head may become brown, it remains firm unless bacteria or other secondary decay-producing organisms enter.

Symptoms of boron deficiency or brown heart in rutabaga and turnip are similar. Severely affected plants are dwarfed and have curled, rugose leaves. In advanced stages watersoaked or brown spots and cracks appear in the interior of roots. These internal brown discolorations sometimes completely destroy the market value of rutabagas.

Boron deficiency of broccoli is characterized by curling, rolling, and discoloration of the leaves. Severely affected plants have cracked petioles, corky growths on the stems and petioles, and brown buds in the heads or flower clusters. Discolored flower buds are bitter and spotted heads are not salable.

Ten to 20 pounds of borax per acre is usually sufficient to correct the disease in cabbage, cauliflower, and radish.

The disease does not increase after harvest.

(See *10*, *11*, *20*, *21*, *26*, *30*, *49*, *85*.)

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BROWN ROT

Alternaria brassicae (Berk.) Sacc.

Occurrence and Importance

Brown rot is caused by the same organism that causes black leaf spot or black mold on other members of the cabbage family. The lesions on curds of cauliflower, however, are known as brown rot. The importance of the disease is due to its effects upon the curd in transit and in storage.

Symptoms

The symptoms of the disease are essentially the same as those found on cabbage and other members of the Brassicae. On the curd the fungus causes a browning of individual buds or groups of buds (pl. 6, A). Lesions at first are light brown, later darkening to chestnut brown and finally becoming olivaceous in color. Under humid conditions a slight amount of grayish-brown mold may develop over the larger lesions. Infected curds may show numerous spots or at other times large blotches. The lesions may be dry and firm or wet and soft so they may be confused with the lesions caused by bacterial leaf spot or by soft rot organisms.

Causal Factors

The causal fungus, *Alternaria brassicae*, winters over in the soil and in the debris of the infected plants of the previous season. The spores of the fungus live over winter on the seed. From these sources the seedlings become infected, and on them are produced the spores that serve as inoculum for other plants.

At 35° F. and at relative humidities varying from 74 to 100 percent, lesions are formed in 5 to 7 days but do not penetrate deeply into the curd. At 60° they form in 3 days and penetrate into the curd. The optimum temperature for development of the disease is about 77° F. Cauliflower, when harvested, may appear to be free of brown rot but visible lesions may develop during transit. Upon arrival at the market such cauliflower may show considerable decay.

Control Measures

Low temperatures in refrigerator cars and trucks may not entirely stop the development of the disease but they do materially retard it. Packaged heads should be precooled at shipping point and shipped in refrigerator cars or trucks held at 40° F. or lower during transit. (See *64*, *91*.)

DOWNY MILDEW

See Cabbage, p. 6, and plate 4, A.

RING SPOT

Mycosphaerella brassicicola (Fr.) Lindau

Occurrence and Importance

Ring spot may affect various plants belonging to the mustard family but is seldom of economic importance except on cauliflower grown in California and Oregon. Cabbage, brussels sprouts (pl. 5,

D), kale, and rutabagas are sometimes spotted by this disease. Radishes and white turnips have not been found affected.

Badly spotted and yellowed leaves injure the marketability of affected stock even though the heads are suitable for use.

Symptoms

Practically all parts of the plant are susceptible to infection. The young spots are small and circular with dark centers surrounded by greenish-yellow watersoaked borders. As the spots enlarge, they usually maintain their circular outline and have light-brown to grayish-brown centers surrounded by narrow olive-green or olive-gray borders. The black pycnidia and perithecia may appear in concentric rings toward the outer part of the central region or be scattered promiscuously over it.

Causal Factors

The causal organism *Mycosphaerella brassicicola* lives over from season to season on the old leaves, stems, and seed pods of affected plants and may live for some time in the soil. Moderately low temperatures and high humidity favor development of the disease. The lesions are usually about a month old before the small fruiting bodies of the fungus have developed sufficiently to make a definite diagnosis of ring spot.

Control Measures

Experimental evidence tends to show that few, if any, new lesions will form if cauliflower is held at 32° F.

(See *92.*)

COLLARDS AND KALE

Collards and kale are horticultural varieties of a nonheading type of cabbage plant (*Brassica oleraceae* var. *viridis.*). Both are subject to many diseases that occur on cabbage and other members of the mustard family. Bacterial soft rot (*Erwinia carotovora*) is the most important disease in transit and on the market. Yellows (*Fusarium conglutinans* Wr.) is a market factor at times because of the foliage discoloration associated with it.

CRESS

The name "cress" is used for several species of crucifers that are used in salads and for garnishing. The leaves of the common garden cress (*Lepidium sativum*) and water cress (*Radicula nasturtium aquaticum*) are most often found upon the market. The marketability of cress depends upon the color, tenderness, crispness, and freedom from blemishes and decay of the foliage. Few diseases affect this group of plants while they are young enough to be marketed as cress. Bacterial soft rot may cause some damage in badly wounded or bruised stock during transit and marketing.

HORSERADISH

Horseradish is the fleshy, white taproot of *Armoracia rusticana* Gaertn., a member of the mustard family. The marketability of this

product depends chiefly upon the size and smoothness of roots and freedom from growth cracks.

Horseradish is subject to a number of field diseases that reduce the vitality of the plant and in cases of severe foliage infection indirectly influence the marketability of the roots. The virus diseases, mosaic and curly top, and fungus and bacterial root rots which may occur either in the field or in storage pits may cause serious losses.

Mosaic and curly top are the two most important virus diseases affecting horseradish. Infected roots are usually much smaller than normal roots and are always brittle. Such roots show pronounced discoloration in the vicinity of the vascular strands. As the disease progresses the discoloration darkens until in most cases it is black by the time the plant is dead. The roots of infected plants are unsuitable for sets and are unsalable on the market.

(See *38*, *59*.)

BACTERIAL ROOT ROTS

Bacteria spp.

Several types of root rots attributed to *E. carotovora* and other bacterial organisms have been reported from New Jersey. Over 60 distinct species of bacteria have been isolated from horseradish in Illinois. Some of the species caused discoloration, some soft rot, and some dry rot. Observations showed that the bacteria present were often able to bring about decay whenever they gain entrance through various types of injury.

(See *38*.)

PENICILLIUM ROOT ROT

Penicillium hirsutum Dierckx

A root rot caused by *Penicillium hirsutum* occurs on horseradish stored in pits. Losses of stored sets have been reported to be as high as 40 percent. The decay caused by this fungus is somewhat similar to that caused by *Rhizoctonia* except that the fungus sporulates abundantly, coating the diseased surface with greenish-blue spore masses and rendering them unsuitable for planting or the market.

RHIZOCTONIA ROOT ROT

Rhizoctonia solani Kuehn

Rhizoctonia root rot has been reported on horseradish in New York, New Jersey, Connecticut, Illinois, and Michigan. Root tissue infected with Rhizoctonia rot is light yellow to grayish tan in color and rather dry. Infected tissue separates readily from the advancing edge of the rot. As the infection progresses brownish-black sclerotial bodies produced by the fungus may be seen scattered in the creamy-white mold on the surface of the roots.

(See *66*.)

KOHLRABI

Kohlrabi is the swollen, fleshy stem of *Brassica oleracea* var. *caulorapa*, a member of the mustard family. The stem usually is marketed with the leaves attached. The most important factors determining its marketability are tenderness, absence of woodiness, and

freedom from blemishes and decay. The plant is subject to many diseases that attack cabbage but few of these are direct market factors. Bacterial soft rot (p. 3) is the most important disease.

MUSTARD

The mustard plant (*Brassica* spp.) is grown commercially for two purposes: for the seeds which yield oil and are used as a condiment, and for the leaves, which are used for greens. The marketability of mustard for greens depends upon good green color of the leaves and freedom from blemishes and decay.

The mustards are not often seriously affected by disease, although they are susceptible to most of the diseases which attack other crucifers. The marketability of mustard is most generally affected by such diseases as bacterial soft rot, alternaria leaf spot, and white rust.

RADISH

The radish is the fleshy taproot and hypocotyl of *Raphanus sativus*, a member of the mustard family. Although only the root is eaten, radishes may be marketed in bunches with the tops attached. Consequently the appearance and condition of the tops as well as of the roots are market factors. The main market requisites for the root are tenderness, crispness, and freedom from pungent taste, blemishes, and decay.

BLACK SPOT OF RADISH

(Cause Unknown)

Prepackaged radishes from Florida and Texas often show small, sunken discolored spots with well-defined margins. These spots are grayish brown to black with centers of lighter shade (pl. 7, C). When internal tissues are affected they are generally black and in various stages of disintegration. As a rule, examinations fail to reveal the presence of any organisms until the spots have reached an advanced stage when many kinds of bacteria, considered to be secondary organisms, appear. This type of radish discoloration has been shown to be inhibited at temperatures below 50° F. It may be retarded by precooling and cold storage.

(See *16*, *74*, *75*, *76*.)

DOWNY MILDEW

See Cabbage, p. 6, and pl. 7, A and B.

WHITE RUST

Albugo candida (Chev.) O. Kuntze

White rust is found throughout the world wherever plants of the mustard family grow. In rare instances it may become of economic importance in the field, greenhouse, or seedbeds, especially in radish seedbeds. The disease is of no importance on the market except on mustard greens or on radishes marketed with the tops. The white pustules containing powdery spores damage the appearance of severely infected leaves.

(See *83*.)

RUTABAGA AND TURNIP

The turnip is the fleshy taproot and hypocotyl of *Brassica rapa*, another member of the mustard family. The rutabaga is *Brassica napo-brassica*. Several horticultural varieties are grown, but in all of them tenderness, crispness, and freedom from blemishes and decay are important factors in their marketability.

Young turnips are marketed prepackaged with tops removed and with tops attached as a bunch vegetable; the late turnip crop and rutabagas are topped and stored like other root vegetables. Freedom from blemishes and decay are direct market factors.

ALTERNARIA ROOT ROT AND LEAF SPOT

Alternaria brassicae (Berk.) Sacc.

The leaf spots of crucifers caused by various species of Alternaria are in general very much alike. *A. herculea*, however, has been found to cause a serious decay of turnip roots in the field and in storage when seasonal conditions are favorable. The fungus may enter the root through the crown, or infection may take place when spores and mycelium come in contact with uninjured surfaces of the root. Bruised and scarred roots are especially susceptible to infection.

Lesions produced on the roots are usually circular, dark brown, and firm (pl. 8, C). Frequently concentric rings of light and dark-brown tissues give them a characteristic appearance. Gray to grayish-brown surface mycelium may form over the decayed areas in humid storage or pits. Although the dark brown decay may penetrate deeply into the roots, the decayed tissues remain firm and are not moist or ill smelling as in the case of bacterial soft rot.

Turnips and rutabagas intended for storage should be carefully selected for freedom of decay and injuries.

(See *14*, *93*.)

ANTHRACNOSE

Colletotrichum higginsianum Sacc.

This disease occurs on many crucifers but is seldom of economic importance. Turnips, radishes, cabbage, Chinese cabbage, and collards are the most susceptible crops.

In stored turnips, this fungus sometimes causes grayish to light-tan spots with regular depressed margins. Bacterial soft rot usually follows in these spots and a light-brown, wet decay encircles the original lesion. Under humid conditions the spores and mycelium are able to cause infection of uninjured turnip roots. Consequently this fungus and the associated bacteria common to most soils are capable of causing considerable damage to storage turnips under favorable moisture and temperature conditions.

No control measures have been developed.

(See *35*.)

BLACK ROT

See Cabbage, p. 5, and pl. 8, A.

BROWN HEART

See Cauliflower, Boron Deficiency, p. 15.

CLUBROOT

***Plasmodiophora brassicae* Wor.**

Clubroot occurs on nearly all cultivated crucifers as well as on many wild species of this family. The malformations that characterize the disease are found only in the parts below ground, with indirect secondary systemic symptoms. Clubroot is a direct factor in marketing root crops, such as turnip, rutabaga, and radish.

Although the disease occurs in many regions, it is rarely observed on the market because the deformed roots are easily sorted out at packing time.

The outstanding symptom of clubroot is enlargement of the main or lateral roots or both. At first the club-shaped enlargements are dirty gray or pale yellow, smooth, and firm; later they become dark colored. Infected roots are unmarketable.

The causal organism is *Plasmodiophora brassicae*, a soil inhabiting slime mold. It hibernates in the debris of affected crops or in weeds of the previous season. For satisfactory control measures in the field local authorities should be consulted.

DOWNY MILDEW

See Cabbage, p. 6.

GRAY MOLD ROT

See Cabbage, p. 8.

RHIZOCTONIA

See Cabbage, p. 9.

WATERY SOFT ROT

See Cabbage, p. 12, and pl. 8, B.

CUCURBITS

CUCUMBER

Cucumbers are harvested while green. Their desirability depends chiefly upon their crispness, firmness, shape, and color. The size and shape of the cucumber fruits vary greatly with different varieties. For fancy pickles, the pickling varieties are grown and the fruits are harvested when they reach a length of about 2 inches. The larger varieties are grown for slicing, for salads, and for keg or barrel pickles. There is only a limited market for ripe cucumbers. In general, white or yellowish fruits are looked upon with disfavor, although occasionally white pickles have been placed upon the market with success.

Certain cucumber diseases occur on both the vines and the fruit and thus are of direct and indirect effect on the market. The most important diseases of this type are anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. & Halst.), bacterial spot (angular leaf spot) (*Pseudomonas lachrymans* E. F. Sm. & M. K. Bryan), cottony leak

(*Pythium aphanidermatum* (Edson) Fitz.), black rot (*Mycosphaerella citrullina* (C. O. Sm.) Gross), scab (*Cladosporium cucumerinum* (Ell. & Arth.)), sclerotinia fruit and stem rot (*Sclerotinia sclerotiorum* (Lib.) DBy.), sclerotium rot and blight (*Pellicularia rolfsii* (Curzi) West), and mosaic, a virus disease.

A number of diseases occur only on the fruits. These are bacterial soft rot (*Erwinia* spp.), blue mold rot (*Penicillium* spp.), diplodia rot (*Diplodia* sp., p. 31), fusarium rot (*Fusarium* spp.), gray mold rot (*Botrytis* sp.), pink mold rot (*Cephalothecium roseum* Cda.), rhizopus soft rot (*Rhizopus* spp.), low-temperature breakdown, and sunscald.

(See *4, 27, 28, 83, 87, 101, 104.*)

ANTHRACNOSE

Colletotrichum lagenarium (Pass.) Ell. & Hals.

Occurrence and Importance

Anthracnose affects the vines, causing reduced yields due to foliage and stem injury, and malformed fruit. It also occurs on fruits in the field and in transit, disfiguring them and causing decay, either directly or indirectly by opening the way for secondary organisms.

Losses are most severe on field crops grown for slicing, or on cucumbers grown under glass. Damage also tends to be heavy in fruits that are shipped long distances because of the additional time for the development of lesions in transit.

Symptoms

On fruits the first symptoms are the appearance of more or less circular, sunken, watersoaked areas. As the lesions enlarge, the fungus sporulates abundantly, producing orange-pink slimy spore masses; later the lesions turn black (pl. 11, C). On mature fruits the black lesions may show white centers on which old acervuli appear as conspicuous black dots. The tissues underneath are dry and the sunken epidermis often cracks, exposing the tissues to invasion by soft rot organisms.

Causal Factors

The causal fungus *Colletotrichum lagenarium* overwinters in plant debris of the previous season and on seed from diseased fruit. Usually the disease does not become general in a field until late in the season.

The most favorable temperatures for spore germination are between 71° and 80° F. Since the fungus can penetrate the rind of mature fruit, new lesions develop as long as temperature and moisture conditions are favorable for spore germination. Anthracnose spots become visible about 5 days after infection. (See Watermelon Anthracnose, p. 38.)

(See *4, 8, 31, 36.*)

BACTERIAL SOFT ROT

See Muskmelon, Bactrial Soft Rot, p. 28.

BACTERIAL SPOT (Angular Leaf Spot)

Pseudomonas lachrymans (E. F. Sm. & M. K. Bryan) Carsner

Occurrence and Importance

Bacterial spot of cucumber occurs on both leaves and fruits in most humid and semihumid regions. The name "angular leaf spot" has been applied to the disease as it appears on the leaves. None of the horticultural varieties now grown is known to be resistant to this disease. It does not occur on the watermelon or muskmelon, but occurs on honeydew melons and squash. Reduction of leaf surface by severe infection often leads to a reduction in yield. This is the principal source of loss to the pickle industry, although considerable loss may result from rotting of small fruits on the vines. When cucumbers are grown for slicing, there is opportunity for development of the lesions on grown fruit.

Symptoms

The fruit lesions, which are at first evident as minute, circular, watersoaked areas, later become conspicuous because the centers sink and assume a chalky-white color as a result of the drying out and cracking of affected tissues (pl. 10, B and C). Often a gummy exudate is formed on the lesions before the spots become dry. The lesions are usually blemishes confined to the outer tissues of the fruits. Frequently, however, as fruits begin to mature, brown lesions develop in the fleshy tissue beneath the rind, and the discoloration continues along the vascular system to the seeds. Bacterial soft rot commonly follows.

Causal Factors

The disease is caused by a bacterial organism, *Pseudomonas lachrymans*. The organism is carried on or in the seeds and consequently seedling infection often is the first evidence of the disease in the field. These bacteria may get on fruit in the field or during packaging. Since at least 6 days are required for the development of visible lesions on fruit after artificial inoculation, fruits showing young lesions upon arrival at the market may have appeared sound when picked.

Control Measures

Secure disease-free seed and rotate crops. Refrigerate shipments to 45 or 50° F. and market promptly.

(See *9*, *70*, *81*, *88*, *102*.)

BLACK ROT (Gummy Stem Blight)

Mycosphaerella citrullina (C. O. Sm.) Gross

Black rot is an important decay in cucumber shipments from Florida, other Southern States, and Cuba. Inconspicuous watersoaked spots on which patches of white, cottony mycelium are growing mark the first appearance of the disease on the fruit (pl. 11, A). Later these areas gradually darken and eventually black fruiting bodies of the fungus (both pycnidia and perithecia) may be seen (pl. 11, B). Although the decay may continue to develop during transit, there are no indications that new lesions appear after the

cucumbers are harvested. Initial infections that are not observed at packing time apparently account for the decay found on the market. (See Watermelon Black Rot.)

(See *12*, *13*, *100*.)

COTTONY LEAK

Pythium aphanidermatum (Edson) Fitz.

Occurrence and Importance

Cottony leak has been reported from only a few localities in the Southeastern States. Infection of cucumber and squash fruits take place in the field, and decay develops and spreads very rapidly during transit. The fungus is spread by contact, and visible wounds are apparently not necessary to enable it to penetrate the fruits. The fungus also causes damping-off and a vine canker during excessively wet seasons.

Symptoms

The first symptoms on the fruits are soft, dark green, watersoaked lesions; later, as the mycelium penetrates the tissues of the fruit, water is liberated in large quantities. In the moderately humid atmosphere of containers during transit, a very luxuriant, white, cottony mycelium is produced, which sometimes completely covers the fruit (pl. 11, D). When juice from decaying cucumbers leaks down upon those below, the mycelium becomes flattened and forms a matted layer over the surface of the fruits.

Causal Factors

The causal fungus, *Pythium aphanidermatum*, is a soil inhabitant. It causes greatest damage in wet soils. This fungus produces no aerial spores, but depends upon propagation by mycelium and by spores that swim about in water during the rainy season. Fruits that come in contact with the infected soil or that become spattered with rain and soil containing spores or mycelium of *Pythium* are consequently liable to infection.

Control Measures

This disease may be reduced by providing good drainage. No cucumbers that show evidence of decay should be shipped.

(See *24*.)

LOW TEMPERATURE BREAKDOWN

Cucumbers held for one week or longer at temperatures of 32° to 40° F. are subject to low-temperature breakdown soon after they are removed from storage. This injury is recognized by the presence of numerous sunken spots over the surface of the fruits (pl. 10, A), the total area of which may cover half to three-quarters of the cucumber surface. Frequently the tissues immediately at the base of the spines are first affected; likewise those about the lenticels appear to be involved in most cases. The sunken areas soon become spotted with molds and affected with shallow decays caused by species of *Fusarium* and other fungi.

If the cucumbers are held at 50° F. and 75 to 95 percent relative humidity, little or no breakdown develops, but they tend to ripen rather rapidly, the color changing from green to yellow, and there

may be some shriveling and surface pitting. Chilling at lower temperatures depends on how low the temperature is and the length of exposure. Slight injury occurs in 4 days at 32° and 8 days at 41°. Severe injury occurs after 12 days at 32° and 16 days at 41°.

(See *25*, *51*.)

MOSAIC

Mosaic is a serious disease in the production of cucumber, muskmelon, squash and pumpkin. Infected vines are mottled, stunted and often killed and the yield of fruit reduced. The cucumber fruit is mottled, misshaped, warty, and stunted. It is usually unfit for sale although, occasionally, slightly affected fruit may be found on the market. Summer Straightneck squash are often mottled green and yellow, but other kinds of squash, pumpkin and muskmelon fruits show little evidence of disease except for reduction in size and poor quality.

Mosaic is caused by a number of viruses that occur in the growing plants and are transmitted by insects and by handling the plants during cultivation and picking.

The disease does not spread after harvest. Diseased fruits are not attractive and should not be packed for marketing.

(See *23*.)

SCAB

Cladosporium cucumerinum Ell. & Arth.

Scab, an important disease of cucumbers, also occurs on pumpkin, squash, and muskmelon. On cucumbers it is of chief importance on the greenhouse crop and on the pickle crop in the North Central States.

The cause of the disease is a fungus, *Cladosporium cucumerinum*. It overwinters on plant debris in the soil. It occurs on the leaves and stems but it is on the fruits that the chief injury occurs. Small, grayish, slightly sunken spots mark the first appearance of the disease there. Frequently a gummy exudate forms on the lesions and later turns dark. Under dry conditions the lesions may remain as more or less superficial blemishes; under humid conditions, however, the fungus causes a shallow decay. In later stages the decayed tissues become covered with a dark olive-green layer composed of the mycelium and spores of the causal fungus.

The disease is favored by cool, moist weather, inasmuch as the pathogen grows best at about 70° F. and develops slowly at 95°. It is particularly severe under humid conditions. Lesions apparent at the time of shipping may continue to develop during transit, but no new lesions develop.

Control Measures

The planting of resistant varieties is most effective in controlling this disease.

(See *22*, *82*, *86*.)

SOIL ROT

Rhizoctonia (*Pellicularia filamentosa* (Pat.) Rogers)

Soil rot of cucumber fruits was first reported in the 1949 crop in North Carolina. Very small cucumbers showed yellowish-brown superficial discoloration whereas the larger fruits had a rather firm,

dark, watersoaked decay. Under humid conditions a dense mold covered the infected fruits within 24 hours. In inoculation tests at 76° to 87° F. the first symptoms of infection were evident in 24 hours and the fruits were almost completely rotted in 72 hours. This decay progressed most rapidly at about 82° F. or above.

Since this fungus is in the soil and may attack several other vegetable crops it is difficult to control this disease. Temperatures near 50° F. should retard its development during transit and marketing. (See *28*.)

MUSKMELON

The muskmelon, *Cucumis melo* L., is one of the many species belonging to the gourd family, the Cucurbitaceae. There are several botanical varieties within the species. Although some of the forms are not actually musk-scented, all members of the species are referred to as muskmelons. The term "cantaloup" commercially is used synonymously with muskmelon. Although not botanically correct, cantaloup will be used in this publication to denote the small green-skinned, netted melons that are the most important single type of muskmelon found on the American market. Other types of muskmelon in the approximate order of their importance are: honeydew melon, honeyball melon, persian melon, casaba melon, spanish melon, and santa claus melon.

The market value of these fruits depends upon their flavor and freedom from blemishes and decay. The flavor depends primarily upon the variety and the stage of maturity at which the fruit is harvested. In order to reach the market in an acceptable condition the melons must be picked while still firm, yet if they are removed from the vine too soon they lack flavor.

(See *3*, *50*, *51*, *57*, *87*, *95*, *96*, *98*.)

ALTERNARIA ROT

Alternaria tenuis Nees

Occurrence and Importance

Alternaria fruit rot is of general occurrence in the market and in storage on all types of muskmelons. It may occur in melons from any region. Much of the mold at the stem scar and elsewhere on cantaloups is Alternaria. When the rot occurs on honeydew and honeyball melons, it seriously detracts from their appearance even when only small areas of the melon surface are involved. Decay by other rot-producing organisms frequently follows alternaria rot.

Symptoms

On honeydew and honeyball melons, alternaria rot causes circular or oval brown to black sunken lesions, some of which may be as large as 2½ inches in diameter. The edges of the lesions are fairly regular and definite and occasionally are slightly watersoaked. Frequently there are alternating bands of lighter and darker colors on the surface of the lesions that form a pattern of concentric rings. The lesions become darker as they grow older and finally become definitely black. The lesions usually are covered by a deep grayish-olive colored fluffy mat of the fungus, or by scant mycelial growth covered by a black, thin, velvety layer of sporulating hyphae (pl. 13, A).

The decay is often largely confined to the rind. Sometimes, the decay is moist and progresses well into the flesh. In both cases the boundaries are sharply delineated and the decayed tissues can be easily lifted out. The color of the diseased tissue varies from grayish white to nearly black.

The internal symptoms on cantaloups are similar to those on honeydew melons. The external ones are more or less definite lesions covered with dark sporulating fungus mycelium. They resemble the late stages of cladosporium rot (p. 30) and often cannot be distinguished from the latter without microscopic examination.

Causal Factors

This disease may be caused by several strains or species of alternaria. Some studies indicate that *Alternaria tenuis* Nees is one species that causes rot in melons.

Optimum growth in culture of alternaria isolates from muskmelons occurs at 75° to 85° F. Only slight growth occurs at 37°. The optimum temperature for development of decay in inoculated honeydew melons was 75° to 80°. Although no decay develops at 37° in 10 days, lesions slightly over ¼ inch in diameter were produced in 4 weeks.

Alternaria rot frequently follows sun scald injury, low-temperature breakdown, and skin breaks and cracks.

Control Measures

Alternaria rot is best controlled by the grading out of melons that have been injured by sunburn, by careful handling to avoid skin breaks and cracks, and refrigeration (35° to 40° F. for cantaloups and 45° to 50° for honeydews) in transit.

(See *95*, *96*.)

ANTHRACNOSE

Colletotrichum lagenarium Ell. & Hals.

Occurrence and Importance

This disease is seldom seen on muskmelons of any kind on the market. However, an occasional shipment of honeydew melons may be affected. When this occurs, the affected melons are unsalable or at least lower in market value. Besides affecting the appearance of the fruit, the flesh bordering the decayed spots has a disagreeable taste.

Symptoms

Anthracnose causes circular or oval spots that are about ¼ to ¾ inch in diameter. They are shallow at first, but soon become sharply sunken. Salmon-colored or pink spore masses often arranged in concentric rings are produced in abundance over the surface of the larger lesions (pl. 12). Later the lesions become dark colored and the decay penetrates deeply into the flesh. Other decay frequently starts in the anthracnose lesions.

Causal Factors

Anthracnose is caused by the fungus *Colletotrichum lagenarium*. It causes a serious disease of the vines and foliage of muskmelons and other cucurbits in the field and when conditions are favorable

the fruit becomes infected. In Colorado it was found that honeydew melons became infected by washing in water that was contaminated with spores from diseased melons. Some experimental work indicates that wounding is necessary for infection to take place. Melons that become infected in the field may appear sound when harvested but be badly infected within 5 days if conditions are favorable for development of the disease.

The optimum temperature for germination of the spores and growth of the fungus is generally considered to be about 75° F., but good growth takes place between 65° and 85°. Growth drops off rapidly at temperatures above 85° and there is none at 95° or higher. Growth in 6 days at 55° is less than half as great as that at 65° and none occurs at 45°. Only a trace of growth occurs in 2 weeks at 45°.

Control Measures

Avoid shipping melons from fields affected with anthracnose. Refrigerate promptly and keep transit temperatures between 45° and 50° F. to prevent development of anthracnose of honeydew melons in transit. Use water containing 1,500 p.p.m. chlorine in the wash tank to prevent infection during washing.

(See *42*, *43*, *95*.)

BACTERIAL SOFT ROT

Erwinia spp.

Occurrence and Importance

Bacterial soft rot is found only occasionally on domestic muskmelons, as a stem end rot and following injuries, but it causes considerable loss every year on shipments of honeydew melons from Chile. Cucumbers, squash, and pumpkins are also seriously damaged by this disease.

Symptoms

The early symptoms of this decay are watersoaking and a pronounced softening of the flesh about the point of infection. As the decay advances, the infected fruits become soft and mushy. Eventually they become hollow shells filled with liquefied, broken down tissues. The skin may remain unbroken at first, but finally tears and collapses as the watery disintegrated tissues and seeds spill out. The decay is usually accompanied by an offensive odor.

Causal Factors

Bacterial soft rot of muskmelons has been attributed to *Erwinia aroideae* (Towns.) Holland, and *E. carotovora* (L. R. Jones) Holland. The optimum temperature for decay development by soft rot producing bacteria isolated from Chilean honeydew melons is between 80° and 85° F. At this temperature infected melons are almost completely rotted in 3 days. Decay is restricted at 90° and only a trace occurs at 98°. The rate of decay falls off rapidly at temperatures below 80°. Only a trace of decay occurs in 2 weeks at 45°.

Control Measures

Careful handling to prevent injuries and refrigeration at 35° to 40° F. will help prevent development of soft rot of cantaloups during transit and marketing.

(See *95.*)

BACTERIAL SPOT

Pseudomonas lachrymans (E. F. Sm. & M. K. Bryan) Carsner

Occurrence and Importance

This disease on honeydew melons was first observed at Chicago in 1940 in a shipment from Colorado. It was found again at Chicago in 1944 in a car from Colorado in which 40 percent of the melons were affected over 10 to 75 percent of their surface area. In 1945 it was also found on melons from Arizona.

Symptoms

This disease causes slightly sunken, circular to oblong, water-soaked, greenish-tan spots that are ⅛ to ¼ inch in diameter (pl. 13, B). Some of the spots coalesce to form large brown or black areas. The bacteria apparently pass through the stomata into the parenchyma cells underneath. Bacterial spot becomes visible 5 to 8 days after inoculation.

Causal Factors

Bacterial spot is caused by *Pseudomonas lachrymans*, the same organism that causes angular leaf spot of cucumbers. (See p. 23.) The optimum temperature for growth of the organism in culture is 77° to 80° F., the minimum about 35° and the maximum 95°.

Control Measures

Control measures used with the growing crop should reduce the chances of infection. Transit temperatures of 45° to 50° F. should retard development of the disease in honeydew melons enroute to the market.

(See *71.*)

BLUE MOLD ROT

Penicillium spp.

Occurrence and Importance

Blue mold rot is often found on cantaloups and honeyball and honeydew melons on the market but ordinarily it does not cause appreciable loss. It is usually found on honeydew melons that have been held in cold storage or on the track for some time. The disease gives the flesh a musty odor and taste.

Symptoms

The lesions caused by blue mold are usually restricted, well-defined spots, circular to oval and ½ to 2 inches in diameter. The surface of the spots is somewhat darker than the normal rind and slightly depressed. Underneath, the diseased tissues are sharply delineated from the healthy tissues. Spore masses that are bluish or greenish in color develop abundantly along skin cracks that are found over the lesions and over the inner surfaces of cavities in the flesh.

Causal Factors

The blue mold rot that is most commonly observed is caused by slow-growing species of Penicillium. Occasionally rapid-growing species have been observed. The optimum temperature for growth of the slow-growing species in culture is between 65° and 75° F. No growth occurs in 6 days at 32° or 90°.

Control Measures

Blue mold rot can be controlled best by refrigeration at 45° to 50° F. and by prompt movement of melons in transit and after arrival at the terminal markets.

(See *95.*)

CHARCOAL ROT

Macrophomina phaseoili (Maub.) Ashby

Occurrence and Importance

Charcoal rot is frequently found in shipments of honeydew melons from South America, but is seldom found on domestic melons.

Symptoms

In the early stages charcoal rot causes a gray or purplish-gray watersoaked spot. It enlarges rapidly and may eventually cover the whole melon. As the decay advances, a thin wrinkled crust of black, tightly packed, minute sclerotia is formed over the surface of the lesion. The crust is easily peeled off to expose the watersoaked, but more or less normal colored, infected flesh beneath. The infected areas are soft and spongy, and unless invaded by soft rot organisms they dry out to form black wrinkled mummies. The flesh of diseased melons has a pungent sour odor and taste.

Causal Factors

Charcoal rot is caused by *Macrophomina phaseoli* (*Sclerotium bataticola*), a fungus that has long been known as the cause of charcoal rot of sweetpotatoes. Growth of the fungus in culture and development of decay are most rapid at about 90° F. The maximum temperature is about 110° and the minimum about 50°. Lesions 3 inches in diameter were developed in 5 days at 85° F., but no decay developed in 2 weeks at either 45° or 50°. Wounding is necessary for infection.

Control Measures

Transit temperatures below 50° F. and careful handling to avoid injuries should give effective control of charcoal rot.

(See *95.*)

CLADOSPORIUM ROT

Cladosporium cucumerinum Ell. & Arth.

Occurrence and Importance

Cladosporium rot, also called green mold rot, occurs frequently on cantaloups and honeyball and honeydew melons on the market. It seriously detracts from the appearance of the melons and decreases the selling price. This disease is especially important on melons that have been held for some time in the car or in cold storage.

Symptoms

Cladosporium rot commonly affects cantaloups at the stem scar and causes the so-called slip rot. It also occurs at cracks and other points over the surface. The surface of the affected areas is covered by a thin superficial layer of mold that is deep olive green in color at first and later turns black (pl. 16, A). The netting is frayed and dirty looking, when partially covered with mold. The edges of the lesion are indefinite and irregular. The diseased rind is fairly firm and moist and the tissues 1/16 to 3/16 inch beneath are soft and spongy.

Honeyball melons also are affected by Cladosporium rot at the stem scar and elsewhere on the surface. It occurs especially along the shallow irregular surface cracks. The mold spots that are scattered over the surface of the melon may have indefinite fimbriated edges or definite lesions as occur on honeydew melons.

The cladosporium rot lesions on honeydew melons vary from small specks to spots 1 inch or more in diameter that sometimes coalesce and form larger diseased areas. The individual spots are circular to oval and have fairly regular and distinct margins. The lesions are smooth, shiny, and black but are frequently surrounded by a narrow, light buff-colored band. Under humid conditions a heavily sporulating mat of green or greenish-black mold develops over the affected areas. Decay is confined chiefly to the rind or tissues immediately beneath the rind. The affected tissues may dry out and become papery, if not invaded by secondary organisms.

Causal Factors

This disease is caused by the fungus *Cladosporium cucumerinum*. The optimum temperature for growth in culture is about 70° F. No growth occurs at 90° in 6 days. The minimum temperature for growth is near 35°. Cladosporium rot occurred on cantaloups after 1 week of storage at 40° to 42° and after 2 weeks at 32° to 34°. Severe spotting has developed on honeydew melons after 2 weeks' storage at 40° to 42°. Growth of this fungus is favored by condensation of moisture on the melons.

Control Measures

Cladosporium rot appears to be of greatest importance in poorly refrigerated shipments and in lots that are not handled promptly at the market.

Avoiding delays in handling the melons and refrigeration at 40° F. or lower will reduce the amount of cladosporium rot.

(See *95*.)

DIPLODIA ROT

Diplodia natalensis Pole-Evans

Diplodia rot has been reported as a field decay of cantaloup and cucumber fruits in Texas. Diplodia stem end rot has long been recognized as a serious decay of watermelons (see Watermelon Stem End Rot).

Under market conditions diplodia rot is found only on honeydew melons from South America. It is characterized by a bleaching of the skin and the development of buff-colored lesions that may occur anywhere over the surface of the melons, but rarely at the stem end. Usually there is only one lesion on a melon, but by enlargement this

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may eventually cover most of the melon surface. In later stages the lesion becomes black in the center, the dark color finally spreading outward over most of the lesion. The decayed tissues are spongy and somewhat softened and have a pungent sour odor and taste, but the melon retains its normal shape. In later stages the decay, occurring as it does under the same conditions as those in which charcoal rot is found, may be mistaken for the latter. It is distinguishable, however, by the development of a greenish-black stroma beneath the epidermis which later turns black. The coarse black fruiting bodies of the causal organism develop in profusion over it and rupture the epidermis which peels back and curls up.

The causal organism and the decay produced by it develop most rapidly between 85° and 90° F. The maximum temperature lies near 100°, and the minimum between 45° and 50°.

The disease can be held in check during transit by temperatures of 50° F. or lower. As a further measure of control all mechanical injury should be avoided during picking and packing. (See *95.*)

FUSARIUM ROT

Fusarium spp.

Occurrence and Importance

Fusarium rot is one of the most common diseases of muskmelons on the market. It is found on cantaloups, honeyball, honeydew, persian, spanish, casaba, and other melons. It is of most importance on fully ripe melons. Although on domestic melons the lesions may occur anywhere over the surface, on honeydew melons from South America the disease is found chiefly as a stem-end decay.

Symptoms

On green-skinned varieties of melons, fusarium rot frequently occurs as small scattered lesions of varying size and shape, with numerous small lesions commonly coalescing to form large diseased areas. The most conspicuous external and internal symptom is the development of the white or pinkish-white mycelium of the causal organism. Upon cutting the melon open the diseased tissues are delineated spongy bodies that can easily be lifted out intact from the healthy flesh. They may either be confined to the outer tissues of the melon immediately beneath the rind or they may extend to the seed cavity (pl. 14).

On the white-skinned varieties the lesions are brown at first and form more sharply defined spots than on the green-skinned varieties. They likewise later become covered with white or pinkish-white mold. The internal symptoms are similar to those on the green-skinned varieties. Occasionally the purplish-red discoloration produced by *Fusarium scirpi* var. *acuminatum* (and certain other species) is evident even before cutting the melon. The decay produced by this species is further characterized by the extremely bitter taste of the infected tissues.

Causal Factors

The symptoms produced by the various species are strikingly similar with the following exceptions: *Fusarium scirpi* Lamb. & Fautr. var. *acuminatum* (Ell. & Ev.) Wr. produces a purplish-red discolo-

ration of the diseased flesh, which has a very bitter taste; *F. culmorum* (W.G. Sm.) Sacc., *F. graminium* Cda, and *F. moniliforme* Sheld. var. *subglutinans* Wr. & Reink. produce some reddish discoloration but do not produce the bitter flavor.

The temperature relations of the various species are also similar, most of them having optimum temperatures of either 75° or 80° F. The average diameter of lesions did not exceed 5/8 inch after 1 week at 65°, or 3/8 inch after 3 weeks at 45°. Only a trace of decay occurred after 2 weeks at 35°.

Control Measures

The most important methods for controlling fusarium rot are the avoidance of wounds during picking and packing, good refrigeration in transit, and prompt handling of the melons after their arrival on the market.

(See *95.*)

LOW TEMPERATURE BREAKDOWN

Muskmelons, particularly honeydew melons, stored for 2 weeks or longer at 32° to 34° F. (or, under certain conditions, even at higher temperatures), before shipment or after their arrival on the eastern markets, frequently become affected with low temperature breakdown. There may be no evidence of injury to the melons at the time of their removal from the car or there may be an irregular watersoaking of the rind. After the melons have been removed from storage and held at room temperatures for a day the typical symptoms develop. The injury is first manifested by watersoaking of the rind which may be restricted to limited areas of irregular size and shape, or it may extend over half or more of the melon surface. The juices of the melon exude and the skin becomes sticky. There is a gradual softening of the melon although the tissues retain their general form and structure. The affected rind may eventually become drab gray or somewhat brown.

Low-temperature breakdown is usually quickly followed by various decays including chiefly alternaria rot (pl. 11, F), blue mold rot, cladosporium rot, and fusarium rot. Melons stored for any considerable length of time may be subject to this type of injury.

Transit temperatures of 45° to 50° F. are recommended for honeydew melons.

(See *96.*)

PHYTOPHTHORA ROT

Phytophthora spp.

Occurrence and Importance

Phytophthora rot of honeydew melons is frequently responsible for appreciable losses in the shipments from South America. Ordinarily it is of minor importance on domestic muskmelons, occurring chiefly on a few individuals scattered through occasional carlots originating in Colorado and California. On several occasions, however, the disease has been responsible for the loss of practically the entire contents of the car.

Symptoms

The decay may occur in the form of one or several slightly sunken spots of practically normal color except for a limiting border of

reddish brown. Generally, however, it is recognized by the presence of an irregular bleached area of the rind that is not sunken nor well defined in extent. As the lesion enlarges the affected flesh becomes slightly softer and more spongy than normal. This and the slight bleaching are the only external evidence of the disease. The affected area of the melon later becomes somewhat water-soaked under pressure. The epidermis loosens, forms blisters, and is easily torn away. As the lesion enlarges, covering most of the surface, the fruit shrivels, the rind wrinkles and folds, and the melon flattens out somewhat under its own weight. Under humid conditions a wet appressed dirty white felty mycelial growth covers the lesion (pl. 15, A). Diseased flesh, although practically normal in color, is slightly sour. When affected flesh is pressed between the fingers the juice is squeezed out, leaving a felty residue of fungus mycelium which has formed in abundance.

Causal Factors

It has not been determined whether more than one species of *Phytophthora* is responsible for this decay. Artificial inoculations with several different species have produced identical symptoms. The temperature relations of the isolates obtained from widely different sources were very similar. All grew most rapidly and produced decay most abundantly at 80° to 85° F. The maximum temperature was between 95° and 100° and the minimum somewhat below 50°. The fungus is soil borne and infects the melons while they are still attached to the vines. The exact conditions under which extensive infection occurs in the field have not been determined.

Control Measures

Until more is known regarding the conditions favoring infection the only control measure that can be recommended is that of maintaining transit temperatures of 50° F. or lower.

(See *77*, *95*, *97*.)

PINK MOLD ROT

Cephalothecium roseum Cda.

Pink mold rot caused by the fungus *Cephalothecium roseum* is found on the market occasionally on cantaloups and spanish melons and more frequently on honeydew melons. It is an important decay only in shipments of honeydew melons from South America. The decay is also occasionally seen on cucumbers.

The earliest symptom of pink mold rot on honeydew melons is a brown discoloration of the rind. Lesions vary from small spots 1 inch in diameter to large areas covering one-third of the melon surface. Frequently these occur at the stem end (pl. 15, B); later the lesion becomes covered with the mycelium and the abundant pink spore masses of the causal fungus. The decay at times resembles some of the fusarium rots but can easily be distinguished from them by the extremely bitter taste of the affected flesh.

The causal organism grows most rapidly at a temperature of about 70° F. The highest temperature at which growth is made is somewhat above 95°; the lowest somewhat above 40°. Control measures therefore include good refrigeration in transit.

(See *95*.)

RHIZOPUS SOFT ROT

Rhizopus stolonifer (Fr.) Ehr., and other *Rhizopus* spp.

Occurrence and Importance

Rhizopus soft rot is common on all types of muskmelons, cucumbers, squash, and pumpkins found on the market. It is also found on watermelons (pl. 22, B). It is a rapidly developing and destructive decay. The earliest symptoms are softening and pronounced watersoaking of the flesh. As the lesions enlarge the affected flesh is readily flattened by the weight of the melon or pushed in by adjacent melons in the container. Nevertheless, it holds together, and the affected flesh is never completely disintegrated and soupy as is that of melons affected with bacterial soft rot. The skin may be torn or remain unbroken for some time. There is often no external evidence of the causal organism, although frequently a slight development of mycelium may occur here and there on the lesion. Internally the decay is recognized by the soft watersoaked flesh that is sharply delimited from the healthy tissue and can usually be removed intact (pl. 16, B). It has a slightly sour odor and taste. The coarse mycelium of the causal organism can be demonstrated by gently pulling apart the diseased tissue.

The decay on cumbers, squash (pl. 19), pumpkins, and watermelons is similar to the decay of muskmelons.

Causal Factors

Rhizopus stolonifer has generally been assumed to be the cause of the decay of cucurbits and other vegetables. However, it has been shown by artificial inoculation that a number of different species of *Rhizopus* are capable of producing a decay of cantaloups, cucumbers, squash, and watermelons. Studies of a large number of isolates from muskmelons indicate that about half of them belong to the medium-temperature group typified by *R. stolonifer* and the other half to the high-temperature group. *R. arrhizus* has been reported from pumpkin.

The spores of *Rhizopus* are widely distributed in the soil, water, and air; consequently infection may occur at any time. Wounds of some sort appear to be essential for the entrance of the organism. The loss is usually greater on the riper melons. The temperature requirements differ considerably with the different species. For *Rhizopus stolonifer* and others of the medium-temperature group, growth on artificial media is greatest at 70° to 85° F. Those isolated from decaying honeydew melons grew most rapidly in culture and caused decay in melons most rapidly at 80° F. Those species of the high-temperature group are most active at 85° to 95° F.

Control Measures

The chief methods of controlling rhizopus soft rot are the avoidance of bruising and injuring melons during picking and packing. The use of refrigeration (40° F. or lower) in transit is recommended for cantaloups. Prompt handling of the products upon their arrival at the terminal markets is also desirable.

(See *94*, *95*.)

PUMPKINS

The pumpkin is the large, globular, or oblong fruit of the pumpkin plant (*Cucurbita pepo* L.). The marketability of pumpkins depends upon their color, maturity, and freedom from decay.

Fusarium rot and rhizopus soft rot are about the only important transit and market diseases of pumpkins. These and other diseases that occasionally occur are similar to those of squash (see Squash, p. 36).

(See *1*, *2*, *78*, *79*.)

SQUASH

The term squash is loosely applied to the fruit of various members of the gourd family, but is not limited to any one species. The summer squashes are fruits of *Cucurbita pepo* and the winter squashes are fruits of other species (*C. maxima Duch.*). The summer squashes are eaten while the rind is still soft; consequently, more careful handling is required for those fruits than for the varieties not harvested until the rinds have become mature and hard. The marketability of all varieties depends upon freedom from bruising and disease.

Among the market diseases of the summer types of squash the following are sometimes of considerable importance: bacterial soft rot (*Erwinia* spp.), blossom end rot (*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.), cottony leak (*Pythium* spp.), fusarium rot (*Fusarium* spp.) (pl. 11, *E*), phytophthora rot (*Phytophthora* spp.), and rhizopus soft rot (*Rhizopus stolonifer*) (pl. 19).

The winter or storage types of squash suffer most loss from alternaria rot (*Alternaria tenuis* Auct.), black rot (*Mycosphaerella citrullina* (C. O. Sm.) Gross), fusarium rot (*Fusarium* spp.), rhizopus soft rot (*Rhizopus* spp.), and scab (*Cladosporium cucumerinum* (Ell. & Arth.)). Sometimes gray mold rot (*Botrytis cinerea* (Pers.)), and watery soft rot (*Sclerotinia sclerotiorum* (Lib.) DBy.) cause serious damage.

There are some serious discolorations of the rinds of squash, the cause of which has never been determined. No decay is associated with these blemishes. The so-called pox, zonate spots, and spiderweb discolorations apparently do not harbor any organisms that can be cultured.

(See *7*, *18*, *33*, *48*, *53*, *58*, *105*.)

ALTERNARIA ROT

Alternaria tenuis Auct.

Alternaria rot is a major disease of squash in cool, damp storages. It is especially serious in lots of squash that have been injured by low temperature, although no freezing has occurred (pl. 17, B). Inconspicuous field infections or spores on the fruit may germinate and cause spots ¼ to 1 inch in diameter during storage. At first the lesions are somewhat tan and smooth, but under humid storage conditions a greenish-black mold appears over the surface (pl. 17, B). In hardshell varieties the fungus penetrates in the flesh, pro-

ducing pockets of decay ½ inch or more deep. These decay pockets (pl. 18, B) are yellowish to black and are fairly dry and spongy. (See *33*.)

BACTERIAL SOFT ROT

See Muskmelon, Bacterial soft rot, p. 28.

BLACK ROT (GUMMY STEM BLIGHT)

Mycosphaerella citrullina (C. O. Sm.) Gross

Black rot is the cause of extensive damage to storage lots of squash. Infections of the fruit occur in the field at the stem end and sides of the fruits. At first the lesions produced are water-soaked and greenish brown in the acorn types, but soon become firm and black as fruiting bodies (pycnidia) are formed in great numbers (pl. 17, A and 18, A). Hard, dry, black lesions dotted with minute black pycnidia characterize this disease on storage squash. (See Black Rot of cucumbers, p. 23, and melons, p. 39.) (See *33*.)

BLOSSOM END ROT

Choanephora cucurbitarum (Berk. & Rav.) Thaxt.

Occurrence and Importance

This disease seems to be of importance only upon the squash, but it has been observed on the flowers of cucumber, althea, scarlet hibiscus, okra, cotton, and a few other plants. Blighting of the squash blossoms and subsequent decay of the fruits take considerable toll in the market garden districts. Although a fruit rot is produced in the field, apparently few affected fruits are shipped to market.

Symptoms

The attack on the flowers is usually evident the second day after they open. The fading blossoms are covered with a dense growth of immature, white spore-bearing structures of the fungus that change to brown and finally purplish black at maturity. From the flower the mycelium works down into the newly forming fruits and causes decay. When larger fruits become affected at the blossom end, a rapidly progressing, soft, wet rot is produced. Half of a moderate-sized fruit may rot within 15 to 20 hours. A profusion of black sporangia develops on the decaying fruit, giving it a very characteristic appearance.

Causal Factors

The causal fungus, *Choanephora cucurbitarum*, looks like *Rhizopus* when fruiting, but the absence of coarse, whiskerlike mycelium serves to distinguish it from that fungus. The spores are disseminated by insects, rain, and wind. Thick-walled spores (zygospores) on the surface or within decaying plant tissue enable the fungus to withstand drought and extremes of temperature. The fungus causes greatest damage in seasons of high humidity and excessive rainfall.

Control Measures

Infected fruit should not be packed for shipment. (See *103*.)

COTTONY LEAK

See pl. 11, D, and Cucumber Cottony Leak, p. 24.

FUSARIUM ROT

See pl. 11, E, and Fusarium rot of muskmelon, p. 32.

PHYTOPHTHORA ROT

See pl. 18, C, and Watermelon Phytophthora Rot, p. 41.

RHIZOPUS ROT

See Muskmelons, p. 35, and pl. 19.

SCAB

See Cucumber Scab, p. 25.

WATERMELON

The watermelon (*Citrullus vulgaris* Schrad.) is a member of the gourd family (*Cucurbitaceae*). Its marketability depends upon size, shape, color, and freedom from blemishes and decay.

Like other plants belonging to the gourd family some diseases of watermelons occur both on the vines and the fruits. These are anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. & Hals.), black rot (*Mycosphaerella citrullina* (C.O. Sm.) Gross.), sclerotium rot (*Pellicularia rolfsii* (Curzi.) West), and soil rot (*Pellicularia filamentosa* (Pat.) Rogers).

The following diseases occur primarily on the fruits either in the field or after they are harvested and consequently are diseases of importance in transit and on the terminal markets: Bacterial soft rot (p. 28), blossom end rot, charcoal rot (*Macrophomina phaseoli* (Maub.) Ashby), fusarium rot (*Fusarium* spp.), pythium rot (*Pythium* spp.), phytophthora rot (*Phytophthora* spp.), rhizopus soft rot (pl. 22, B), and stem end rot (*Diplodia* sp.).

(See *5*, *46*, *56*, *94*.)

ANTHRACNOSE

Colletotrichum lagenarium (Pass.) Ell. & Hals.

Occurrence and Importance

Anthracnose is often the most serious of all field diseases of the watermelon and is more important on that crop than on either cucumber or muskmelon. This is in part due to the fact that the fruits must remain in the field a long time and that individual fruits have great value. The disease occurs on the vines and the immature fruits, causing reduced yield, and on the mature fruits, disfiguring them and causing rot.

Symptoms

On older fruit, the disease is recognized by the presence of slightly elevated pimples with yellow translucent centers. On mature fruit the nailhead type of lesion is very common (pl. 21, B). These are small, circular, raised welts on the rind, which are dark green. As

they increase in size the centers turn brown and become sunken, and under moist conditions the pink acervuli of the fungus are formed in which sticky masses of pink spores are produced (pl. 20, A). As the lesion enlarges the surface cracks, exposing either the rotted tissue or a cavity underneath. The fungus causes a rather slowly advancing dry rot of the rind and finally penetrates the pulp. Frequently a halo of lesions develops around the bottom surface that is in contact with the soil. These lesions often become black and corky. It is this kind of infection which leads to rotting in the field. Under extremely dry, hot conditions, during the melon harvest, the lesions may remain in the blister or nailhead stage.

The disease develops and spreads in transit, since the fungus is able to lie dormant in the melon rind and to develop visible lesions when moisture and temperature conditions become favorable.

The causal fungus is the same as that on cucumbers and muskmelons (see pp. 22 and 27).

Control Measures

Control measures of local authorities should be followed, since the seriousness of this disease varies with climatic conditions and the varieties grown. Watermelons suspected of being infected should not be shipped.

(See *45*, *65*.)

BLACK ROT

Mycosphaerella citrullina (C. O. Sm.) Gross

Occurrence and Importance

In recent years black rot of watermelons has been a serious disease on the market. Most serious trouble has been encountered in shipments of melons from Florida and Iowa. In some cars more than 50 percent of the melons have been infected. Buyers refuse to purchase melons showing black rot, even in the early stages, unless they are given a large discount.

Symptoms

Melons arriving on the market show definitely outlined greenish-tan to black spots ½ inch to 2½ inches in diameter (pl. 20, *B*). Lesions have black centers in which small black specks indicate the development of fruiting bodies (pycnidia). There is usually little if any surface mold. The spots remain smooth and moderately firm until they get quite large. The larger lesions often show brownish-black concentric zones. The decay eventually penetrates the rind and involves the flesh of the melon. Secondary infections by bacteria and yeasts sometimes cause a soft, foul-smelling decay.

Causal Factors

Black rot of melons, cucumbers, and squash is caused by the fungus *Mycosphaerella citrullina*. It causes most damage in the Southern States but has been found as far north as Wisconsin. The minimum temperature for growth of this fungus in culture is about 45° F., the optimum 80°, and the maximum near 95°. In cucumbers and melons a rapid decay develops at 55° to 85°. High humidity or wet weather favors infections and development of decay.

Black rot may develop on any part of a watermelon. Many early lesions do not show evidence of injury to the rind but inconspicuous scratches or sand pitting may furnish the chief mode of entrance of the fungus.

Control Measures

Careful handling to avoid wounds and close inspection at loading to eliminate all spotted melons should help in reducing decay in transit. Since watermelons are not shipped by refrigeration, there is little opportunity to check black rot at temperatures of 45° to 50° F.

(See *17*, *65*.)

BLOSSOM END ROT

Blossom end rot is usually not of much importance in the market but in some seasons it causes serious blemishes, that open the way for secondary infection by several kinds of organisms. It is generally considered a physiological disease caused by faulty nutrition associated with irregular moisture supply and high temperature. Pythium rot, black rot, and fusarium rot as well as others commonly follow blossom end rot so closely that it is difficult to determine the original cause of the trouble.

Blossom end rot on the market appears as dark green or brown, definitely delimited areas, 1 to 3 inches in diameter, about the point of the blossom attachment. The affected area is smooth, leathery, and firm unless softened by the invasion of secondary molds or bacteria.

Affected watermelons should not be shipped to market.

BRUISING (MECHANICAL INJURY)

Watermelons frequently show friction bruises, slight watersoaking, and discoloration of the rind due to mechanical injuries while in transit. These injuries are most prominent on melons in contact with the floor or walls of the car. When the straw or other bedding is wet and dirty, friction against the floor causes serious discoloration, sometimes called floor scald. Dark greenish-brown spots also occur on the ends of melons where they come in contact with each other or with the end of the car when the loads are shifted. The blossom ends of watermelons are often depressed and the adjacent flesh damaged. The latter two types of bruising occur commonly in melons loaded lengthwise.

CHARCOAL ROT

Macrophomina phaseoli (Maub.) Ashby

Charcoal rot has been observed only rarely on the market on watermelons grown in Missouri. Decay originates on the ground side or at the stems of the melon. A light brown, fairly firm rot is produced internally as well as externally. As a stem end rot it resembles that caused by Diplodia, except it is lighter in color and there is no surface mold or fruiting bodies evident. The skin of the affected portion of the rind slips off readily under slight pressure. Very small black specks (sclerotia) may be visible in the decaying rind or internal flesh. (See Muskmelon Charcoal Rot, p. 30.)

The causal fungus is in the soil. It causes most severe infection in wet, warm seasons. Good soil drainage may offer some measure of control. Melons infected with charcoal rot should not be shipped. (See *95.*)

FUSARIUM ROT

Fusarium spp.

Fusarium rot of watermelons rarely causes as much damage as it does in other types of melons (see Muskmelon, p. 32). However, watermelons from Mexico occasionally suffer loss from this disease (pl. 24, A). Infections usually occur at the stem or blossom end although the ground sides of melons are sometimes invaded. Fine white, cream-colored, or pink surface mold generally characterizes this disease. The invaded rind and flesh is yellow to tan and moderately dry. With age these tissues become spongy.

Infection takes place in injuries, or follows in lesions caused by other diseases.

No effective method of control of this decay has been developed. (See *95.*)

INTERNAL RIND SPOT

An internal spot of the rind of watermelons has been observed on the markets at various times since 1924 when it was first noted in melons from Georgia. Since that time it has been found in watermelons from practically all melon-growing regions. Usually the percentage of melons affected is rather low, but this is difficult to determine since the melons must be cut to see the spots.

The brown, irregular, rustlike spots vary in size from mere specks to almost ½ inch in diameter (pl. 24, B). These spots of brown tissue are fairly firm and corky, and there is no soft decay associated with them. Sometimes the external surface of the rind shows some mottling and occasionally small pimples are also present (see Pimples, p. 42).

The exact cause of this trouble remains to be determined. At first it seemed to be associated with drought in the field, but more recent investigations suggest the possibility of virus infections being responsible.

PHYTOPHTHORA ROT

Phytophthora spp.

Occurrence and Importance

Phytophthora rot of watermelons grown in Arizona, California, and Mexico has caused serious loss in transit and on the market for several years. The amount of decay varies greatly with the weather at point of origin of the shipment. Some carlots have shown a loss of over 300 melons on account of this disease. Watermelons grown in the Southeast are seldom damaged by this disease.

Symptoms

The first signs of infection are small, irregular, somewhat water-soaked spots that later vary from grayish green to brown, depending on the variety of melon. On light-colored melons the lesion is usually browner than on deep-green melons. At times there is

slight, brown zonation apparent. The affected rind is moderately firm and does not become sunken until the lesion is very large (pl. 21, A). Under humid conditions a white, somewhat cottony mold or a feltlike scum covers the surface of the larger lesions (pl. 24, C). At points of contact between melons in the load this mold is sometimes quite conspicuous (pl. 24, E). The larger lesions with greenish-brown color of the rind often penetrate 2 to 4 inches into the fleshy pulp of the interior. The red flesh is somewhat watersoaked and bleached but there is no other discoloration. In advanced stages the white mold of the causal organism is evident over and around the seeds (pl. 24, D).

Causal Factors

Several species of Phytophthora may cause rot of watermelons. The most common are *P. capsici* (Leonian), *P. parasitica* (Dast.), and *P. cactorum* (Lib. & Cohn) Schroet. Each of these grow well at 80° to 90° F. but little growth occurs below 50°.

Inoculation experiments with watermelons have shown that infection may develop without wounds as well as in injuries. At 70° F. wound inoculations developed light brown lesions 2 to 3 inches in diameter in 5 days; at 54°, the lesions were ½ to 2 inches in diameter. Contact inoculations without wounds produced lesions ⅝ inch in diameter at 70° and about ⅜ inch in diameter at 54° within 5 days.

Early field infections that pass unobserved at shipping time apparently account for much of the decay found on the market, although new infections by contact frequently cause decay in additional melons during transit and marketing. Wet seasons or heavily irrigated soil provide most favorable conditions for phytophthora infections in the field.

Control Measures

Watermelon shipments are not refrigerated, so low temperatures cannot be used to control this decay. Careful inspection to eliminate infected melons at loading time should reduce the amount of decay during transit and marketing.

(See *6*, *39*, *41*, *54*, *80*, *99*.)

WATERMELON PIMPLES

Watermelons on the market often show more or less serious blemishes due to large numbers of pimples scattered over the rind. For the most part these pimples are small, ranging from 1/16 to ⅛ inch in diameter. They are firm and in general suggest insect stings or early stages of anthracnose. However, no decay originates at these pimples. Apparently watermelon fruit pimples may be caused by more than one agent. In Mississippi small spots of powdery mildew on the surface of watermelons give rise to pimples of various sizes. Texas and Oklahoma watermelons have a type of pimpling shown to be due to the tobacco ringspot virus.

(See *37*, *67*, *69*.)

PYTHIUM ROT

Pythium spp.

Pythium rot has been observed only in excessively moist situations in the southern and midwestern watermelon-growing sections. The

disease is of minor importance on the market. Although the symptoms vary somewhat with the different species of *Pythium* involved, in general it may be said that they appear first as watersoaked spots that soon turn light brown, bluish brown, or chocolate brown. The decay progresses rapidly and the flesh becomes flaccid. In some cases when the epidermis is rubbed off the decayed tissues have a marshy odor. Under humid conditions some white surface mycelium appears. At times this decay appears similar to phytophthora rot (see p. 41).

(See *78.*

RHIZOPUS ROT

See Muskmelons, p. 35 and pl. 22, *B.*

SCLEROTIUM ROT

Sclerotium rolfsii Sacc. (*Pellicularia rolfsii* (Curzi) West)

Sclerotium rot of melons grown in the United States is seldom important on the market. However, Mexican watermelons on the Chicago market in 1959 showed this decay affecting 30 percent of the melons in several carlots.

This disease sometimes causes serious fruit rot in Florida and Texas. In practically all fruit infections, the fungus enters on the under side, usually through wounds. Sometimes infections occur on the sides and ends of melons where no injuries are apparent. A small, watery, light-yellow discoloration of the rind is the first evidence of disease. Discoloration and decay progress rapidly; in several cases the rind cracks open and the fine, silky white mycelium grows out in flat, fanlike radiations over the surface of the melon. Small white, spherical sclerotia soon form in this mycelium and within a few days they appear as brown bodies resembling mustard seeds.

No satisfactory control is known.

SOIL ROT

Rhizoctonia solani Kuehn (*Pellicularia filamentosa* (Pat.) Rogers)

Soil rot of watermelons is seldom of much importance on the market. In wet seasons it is found occasionally on the ground side of the melon. The first signs of this disease are small yellow or tan spots. These later become brown as they enlarge. The affected areas are fairly firm and sharply separated from the healthy tissue. The cream-colored mold (Rhizoctonia stage) of this fungus is seldom seen on the lesions. The larger lesions may penetrate through the rind but the red flesh is rarely decayed.

(See *56.*)

SPECKLE

Watermelons grown in Florida and Texas sometimes show numerous small, pale-yellow to orange-yellow spots in the rind that detract from the appearance of the melons. These spots are superficial and usually vary in size from $\frac{1}{16}$ to $\frac{1}{4}$ inch in diameter. The discolored rind is smooth and firm. No decay is produced in these spots and no organism seems to be associated with the discolored area. The cause of the trouble is not known.

(See *56.*)

STEM END ROT

Diplodia natalensis Pole-Evans

Occurrence and Importance

Stem end rot at times has caused greater loss in transit than any other decay that affects watermelons. Although it also occurs on melon fruits in the field, it is of minor importance there. The pathogen does not attack fruit except through wounds or through lesions produced by other organisms.

Symptoms

The first symptoms of the disease are a browning and shriveling of the stem, so that it feels hollow when pressed. Decay sets in at the point of attachment of the stem to the fruit and consists of softening and watersoaking of the tissues (pl. 22, A). As it progresses into the melon the affected tissues become brown and shriveled. In advanced decay the shriveling becomes pronounced and there is an abundant development of black pycnidia and dark-gray mycelium (pl. 23). The infections usually occur at the stem end, but they may also occur at wounds, and in the field, at the blossom end of the melon.

Causal Factors

The causal agent, *Diplodia natalensis*, is a fungus identical with or a close relative of a species of *Diplodia* that attacks many other plants, including cucumber, squash, and muskmelon fruits. It is abundant on ripe or decaying vegetation in or near watermelon fields. From these sources the spores of the fungus reach the cut ends of the stems of cull melons or the blossom ends of imperfect melons. In a short time it produces spores which serve to infect sound melons through the wound made in cutting the stem, through other wounds or bruises, through anthracnose lesions, rabbit injury, and punctures made by the pickle worm. Infection can also take place in transit from spores lodged in the bedding or produced on infected melons. The cut stem is the ideal place of entry for the causal organisms, because the sap which exudes serves to catch the wind-borne spores and provides a good food supply for the fungus.

The decay progresses rapidly. At temperatures between 75° and 90° F., the fungus will grow through a stem ¾ inch long and decay the fruit to a line about 1½ inches distant from the base of the stem in 90 hours. It is not surprising, therefore, that melons appearing sound at the time of loading may show severe rot after being in transit 4 to 5 days.

Control Measures

In harvesting, all decayed melons should be avoided. If a diseased one is cut into, the knife should be sterilized in a 2-percent formaldehyde solution. The melons should be cut with the longest possible stems.

When the melons are placed in the car or truck, the stems should be recut, and disinfecting paste should be applied to the cut surface. The disinfectant should contain 6 percent of bluestone as a fungicide. (See *56*, *90*.)

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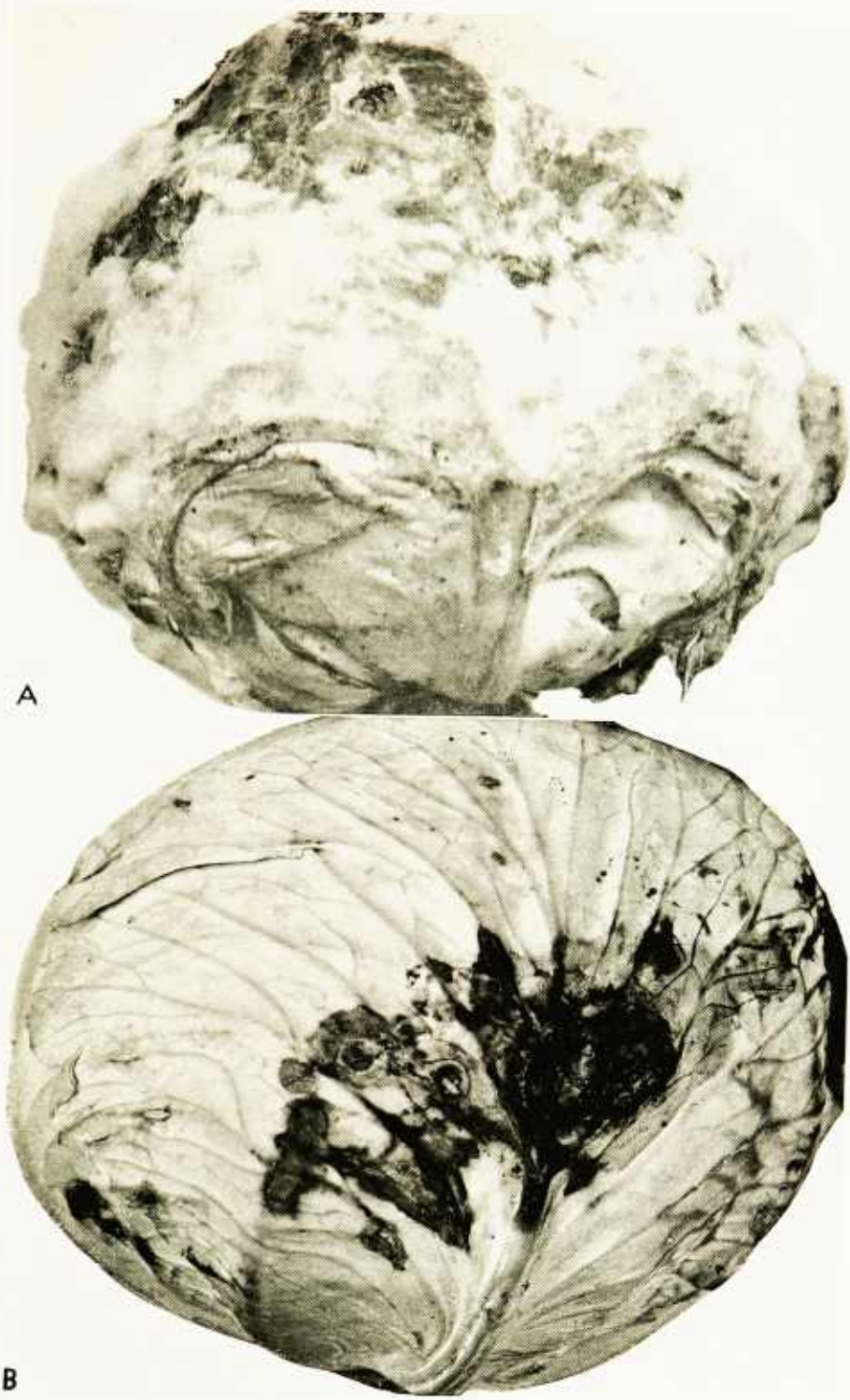

PLATE 1.—Cabbage disease: A, Watery soft rot; B, alternaria rot.

PLATE 2.—Cabbage disease: A, Black rot of stem and black leaf speck on leaves; B, black rot at stem and midrib.

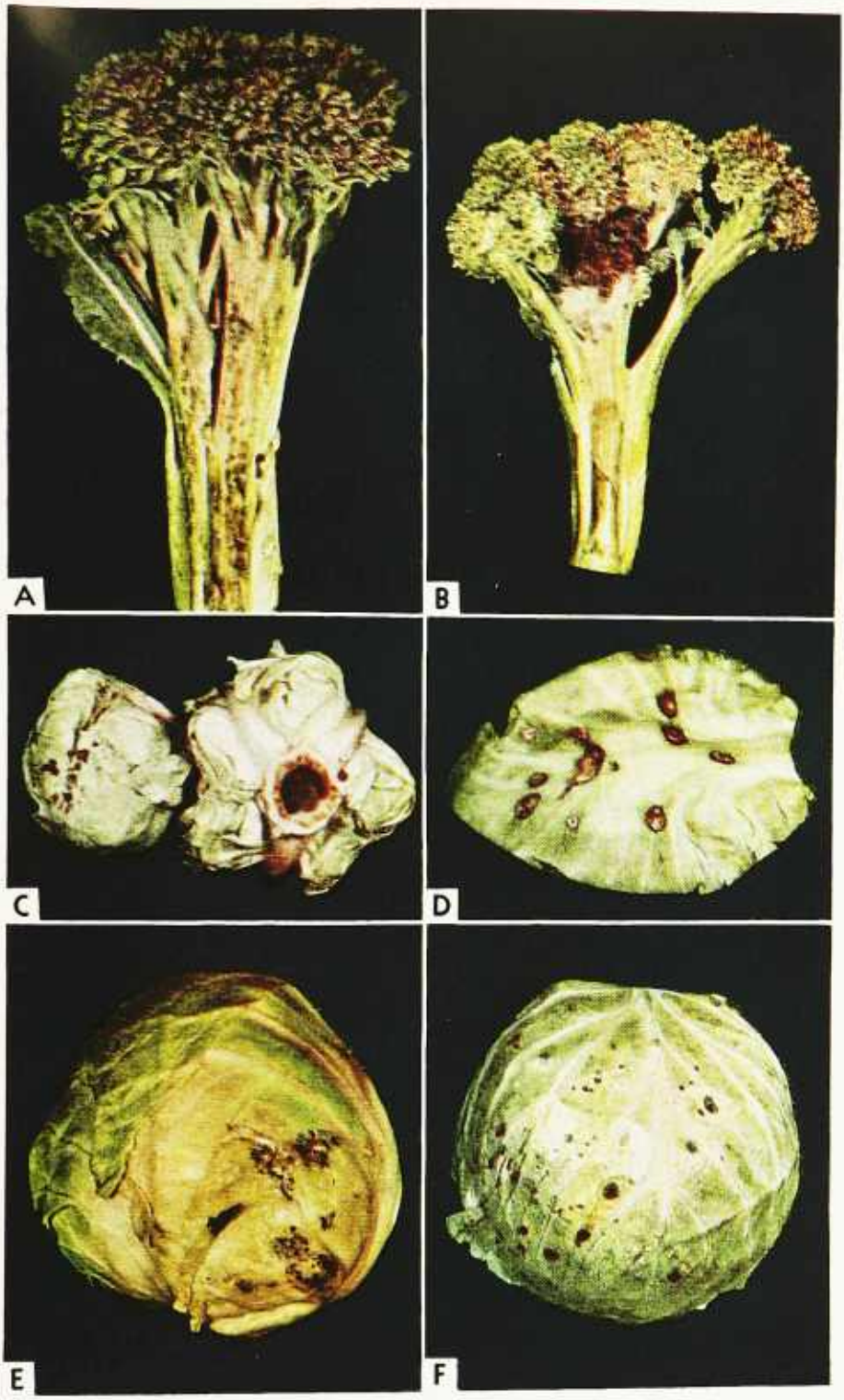

PLATE 3.—Broccoli and cabbage diseases: A, Broccoli bacterial spot; B, broccoli gray mold rot; C, cabbage bacterial soft rot; D, cabbage zonate spot; E, cabbage downy mildew; F, alternaria leaf spot.

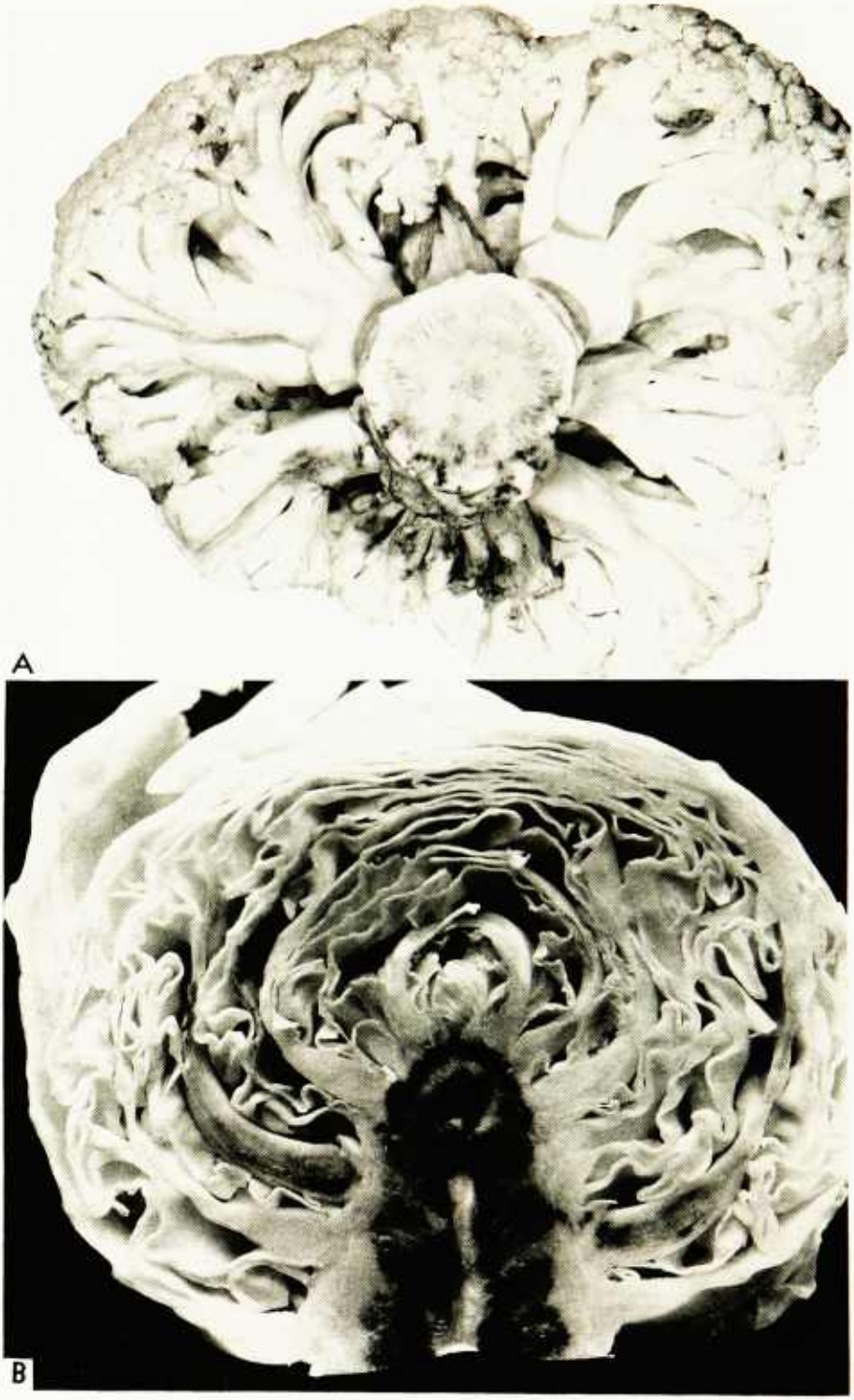

PLATE 4.—Cauliflower and cabbage diseases: A, Cauliflower downy mildew; B, cabbage downy mildew.

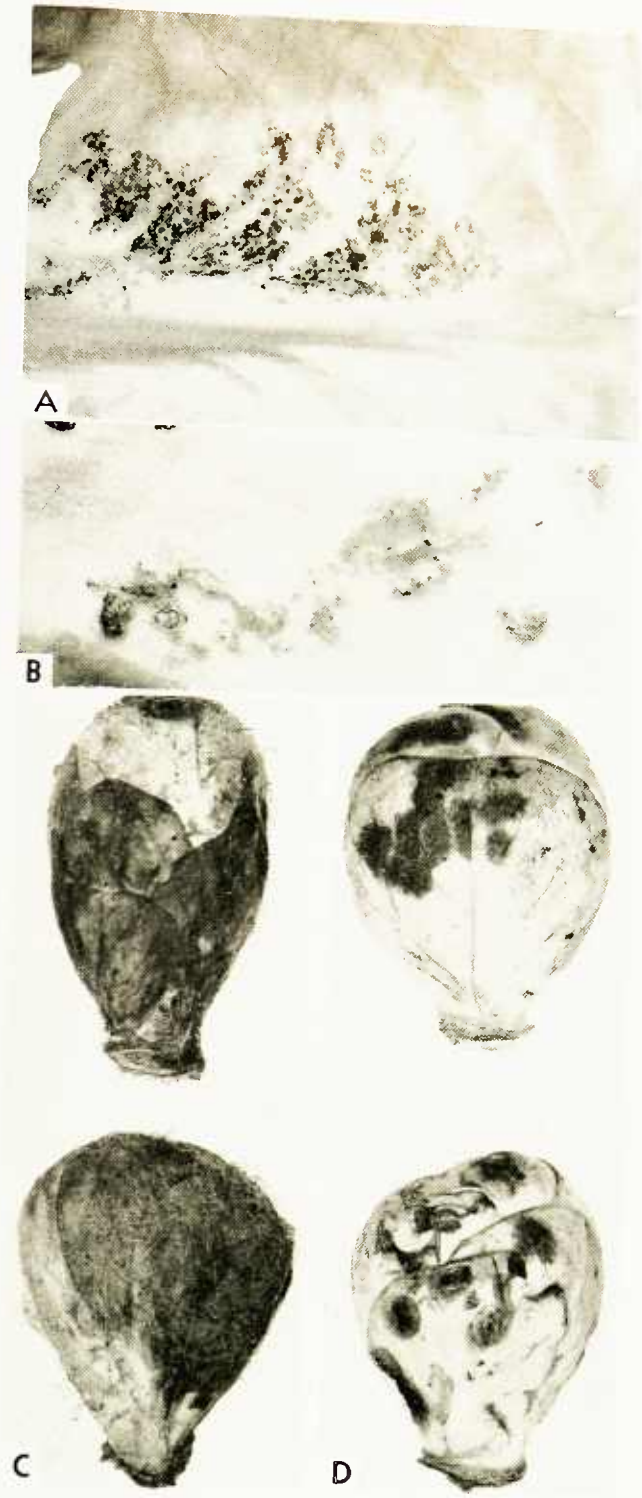

PLATE 5.—Cabbage and brussels sprout diseases: A and B, Cabbage thrips injury; C, brussels sprout rhizopus rot; D, brussels sprout ring spot.

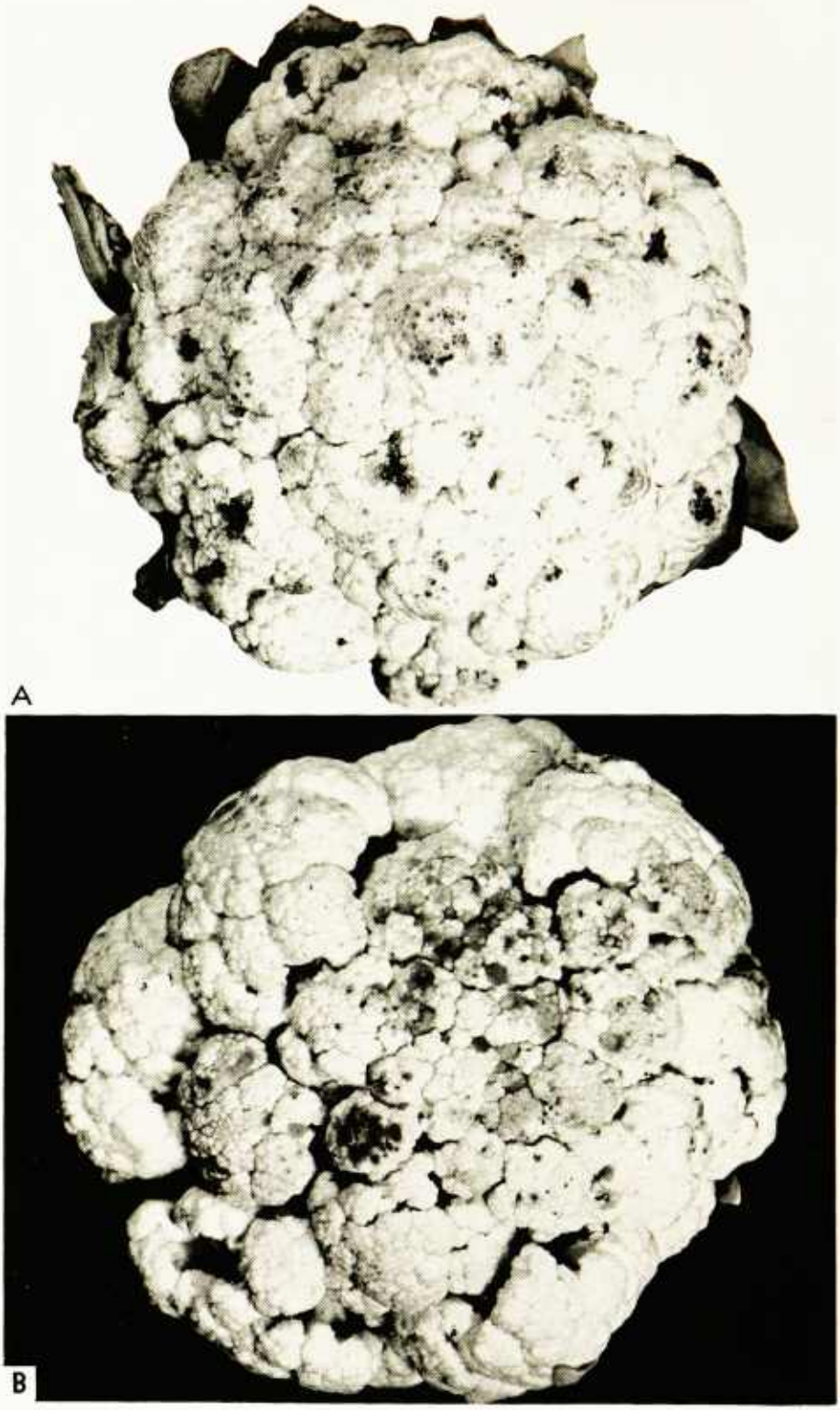

PLATE 6.—Cauliflower disease: A, Brown rot (Alternaria); B, bacterial soft rot.

A

B

C

PLATE 7.—Radish disease: A and B, Downy mildew; C, black spot.

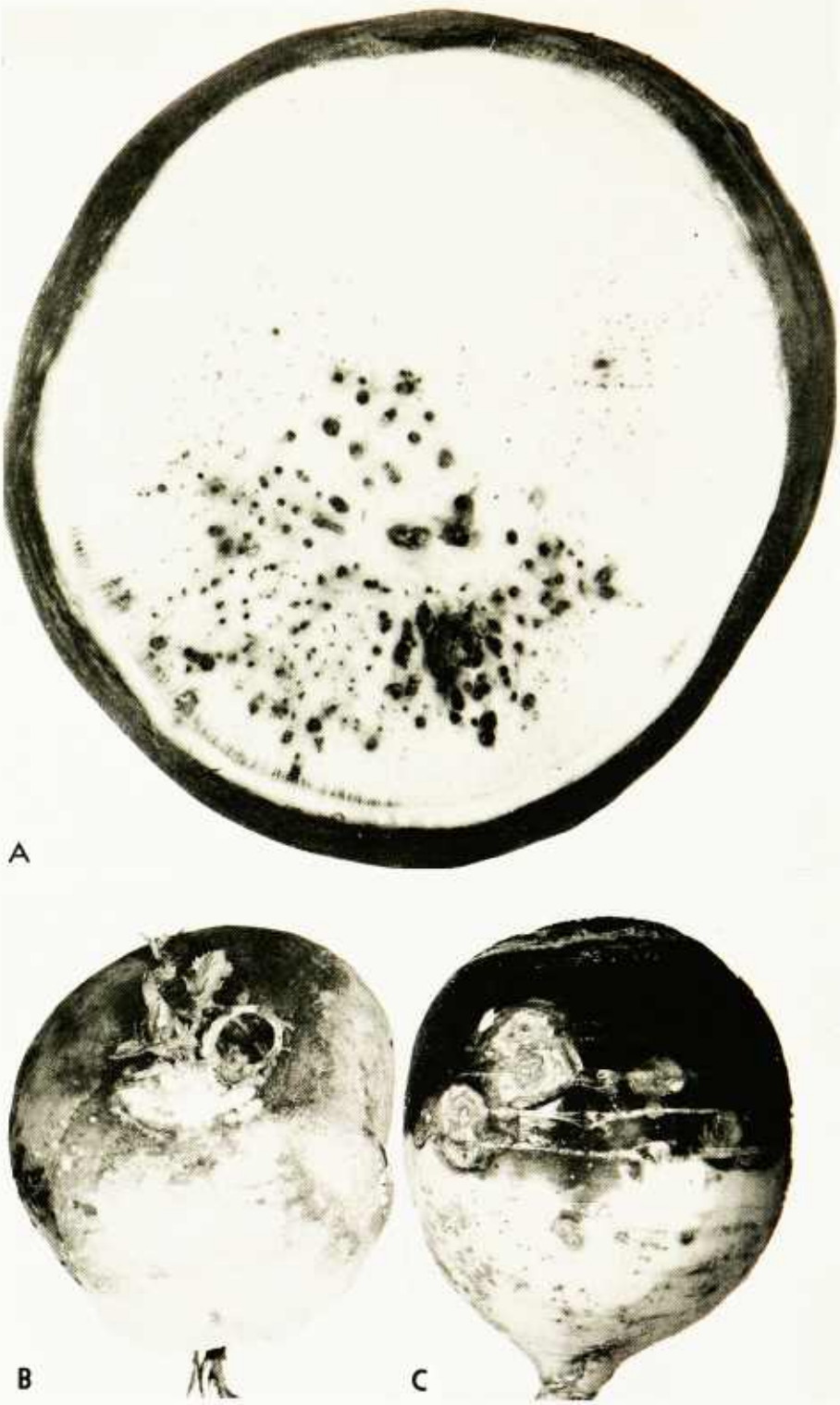

PLATE 8.—Rutabaga and turnip diseases: A, Black rot; B, watery soft rot; C, alternaria rot.

PLATE 9.—Chinese cabbage disease: Black leaf speck.

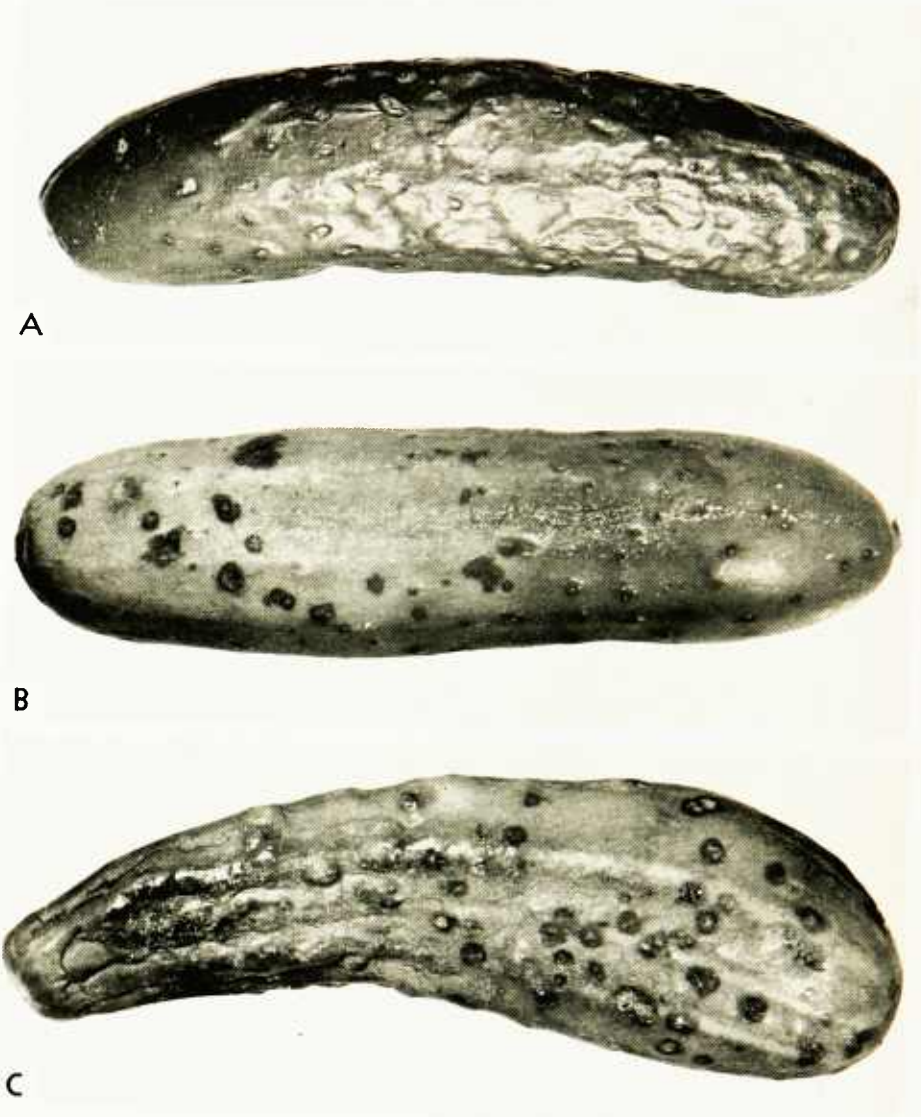

PLATE 10.—Cucumber injury and disease: A, Low temperature breakdown; B and C, bacterial spot.

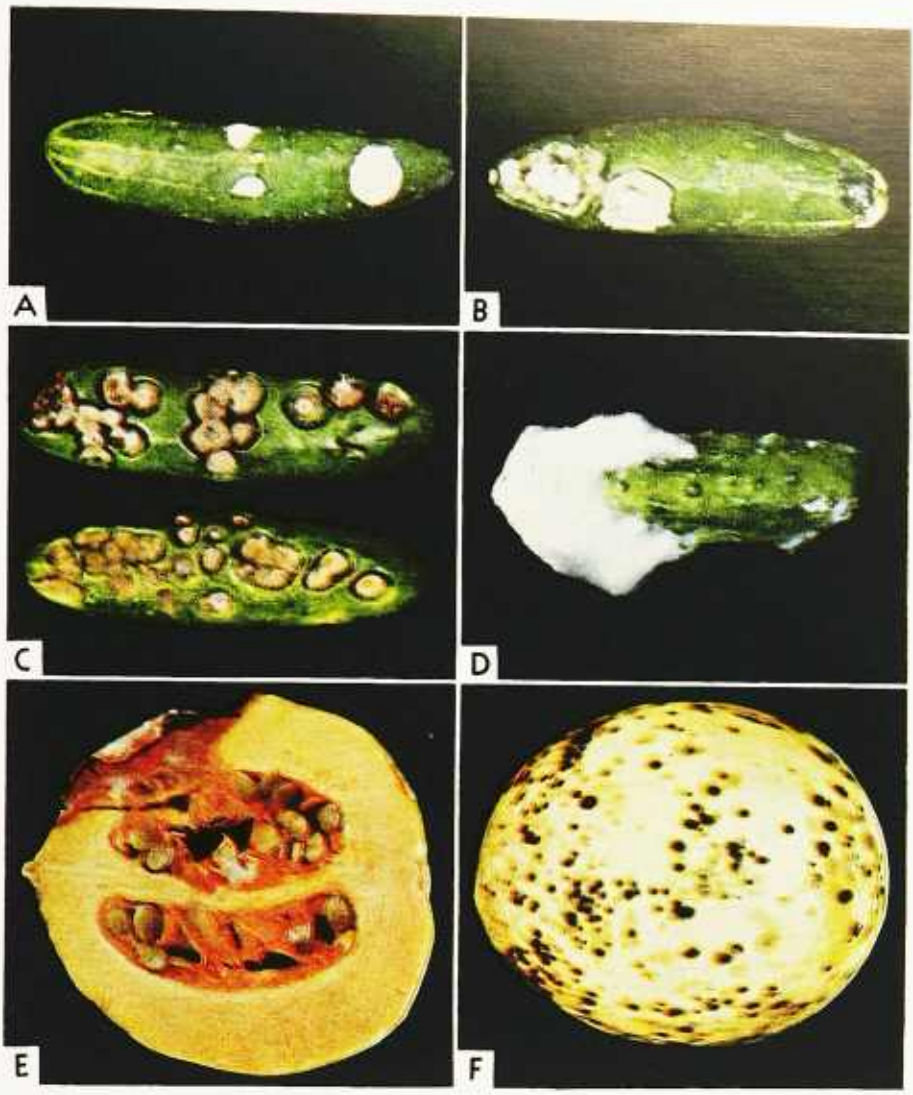

PLATE 11.—Cucumber, squash, and honeydew melon diseases: A and B, Cucumber black rot; C, cucumber anthracnose; D, cucumber cottony leak; E, squash fusarium rot; F, honeydew melon alternaria rot following chilling injury.

PLATE 12.—Honeydew melon disease: Anthracnose.

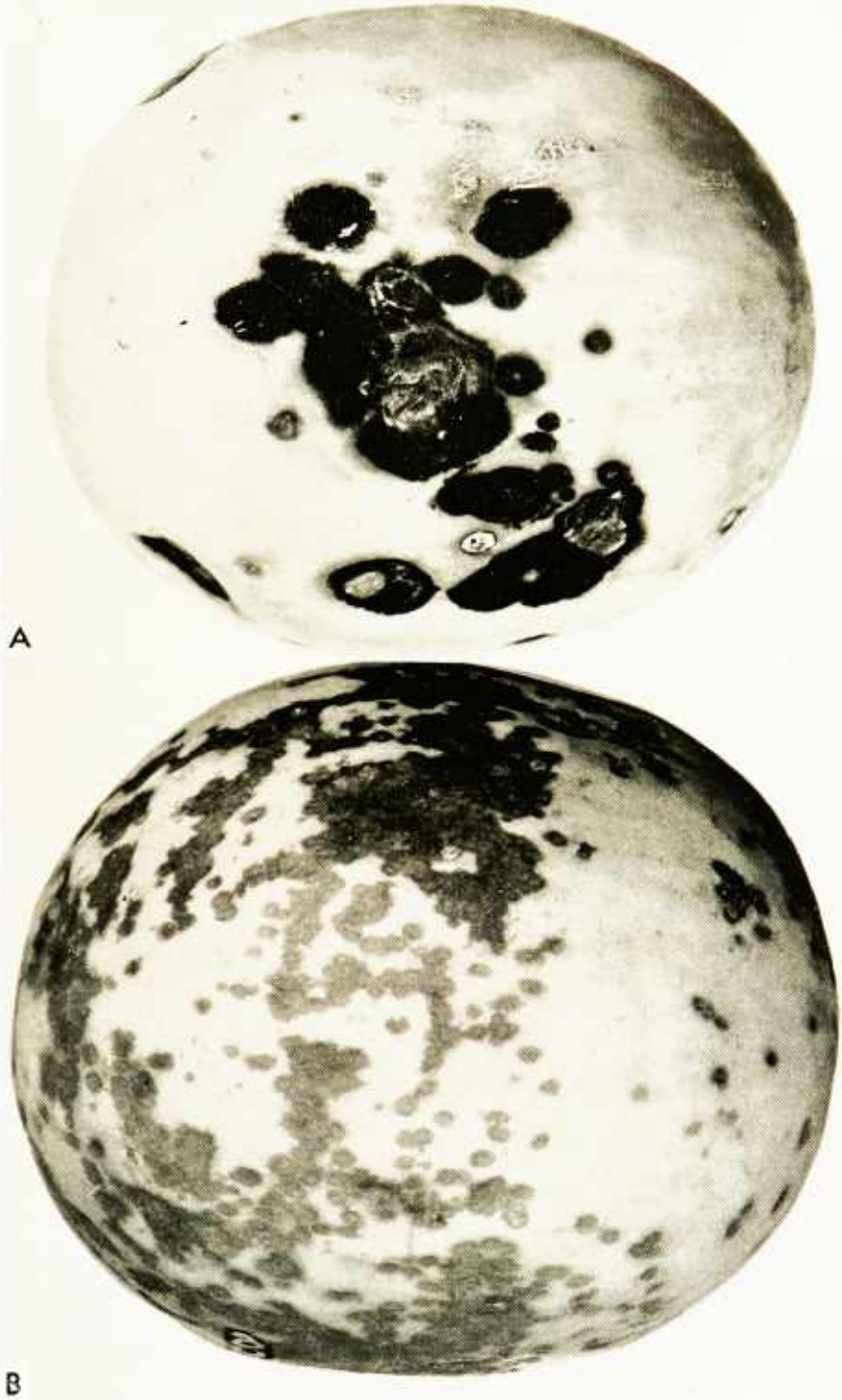

PLATE 13.—Honeydew melon disease: A, Alternaria rot; B, bacterial spot.

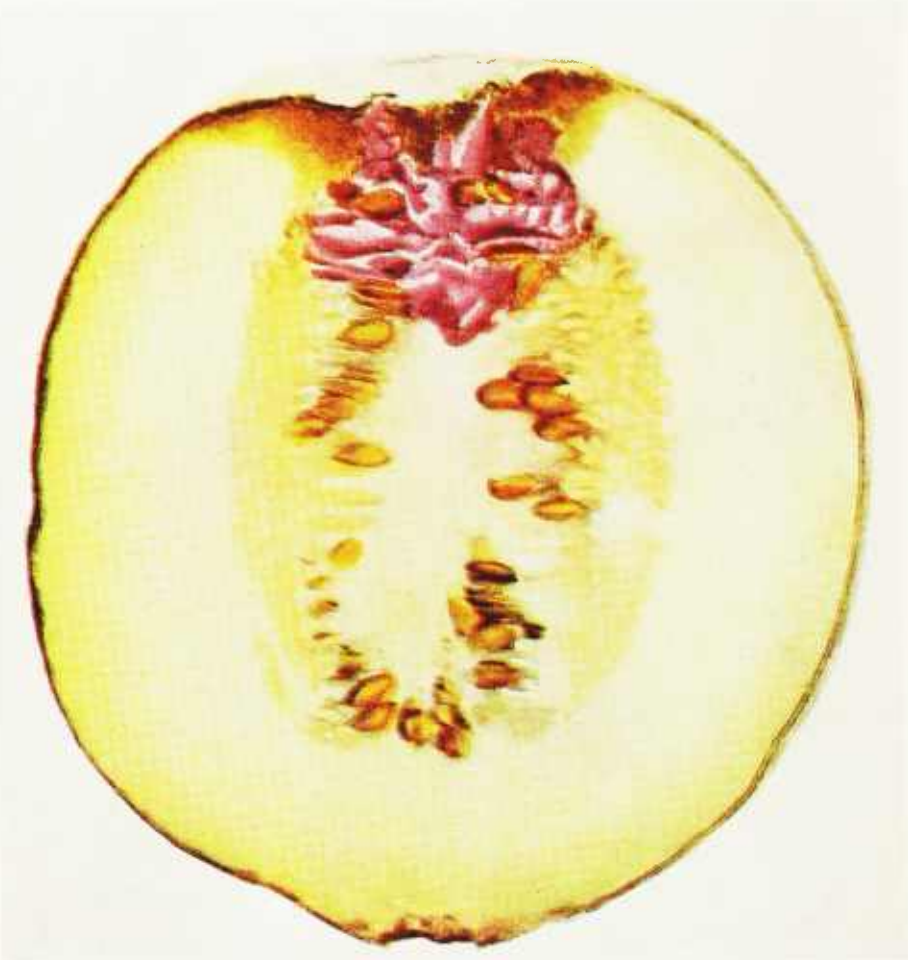

PLATE 14.—Honeydew melon disease: Fusarium rot.

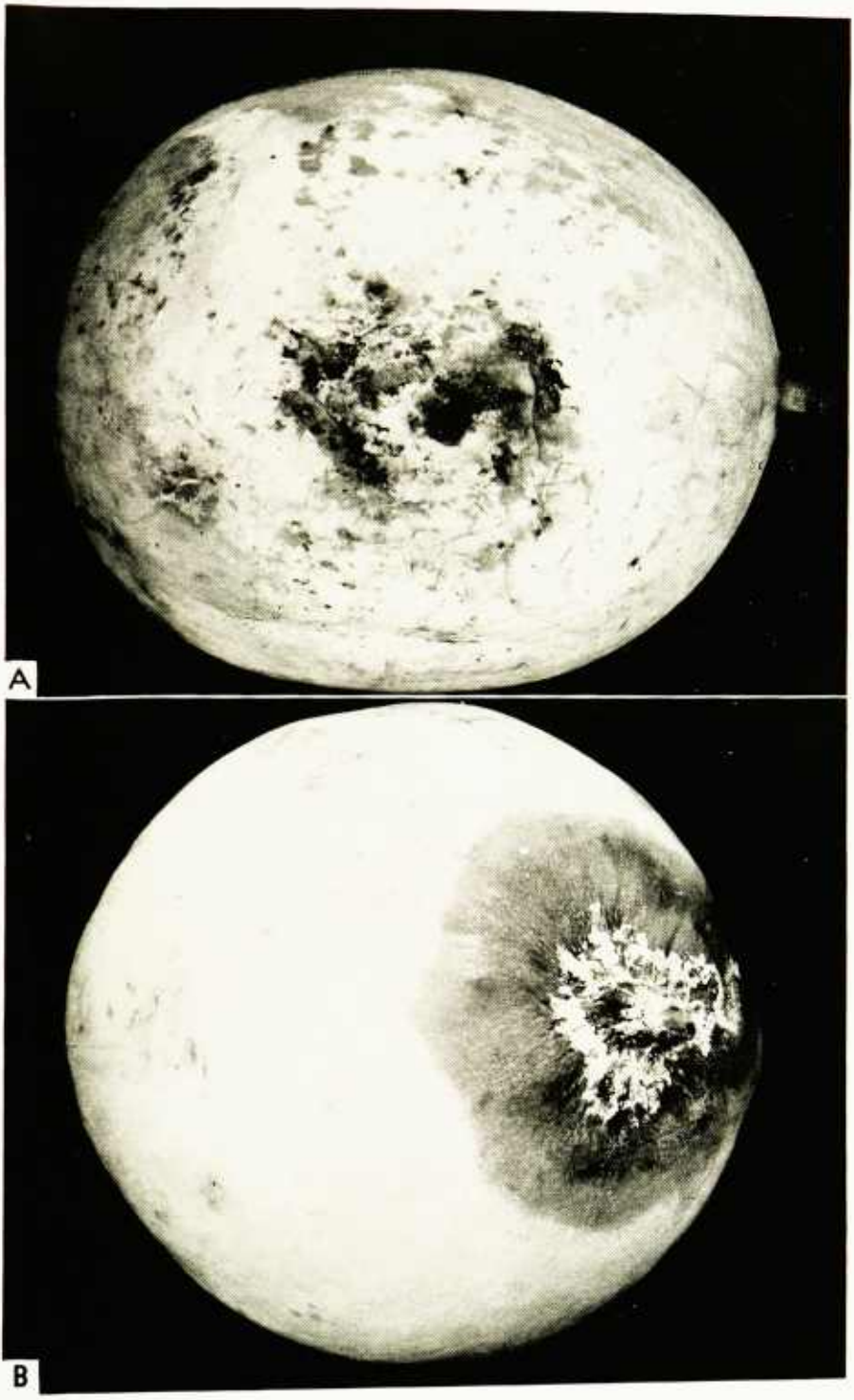

PLATE 15.—Honeydew melon disease: A, Phytophthora rot; B, pink mold rot.

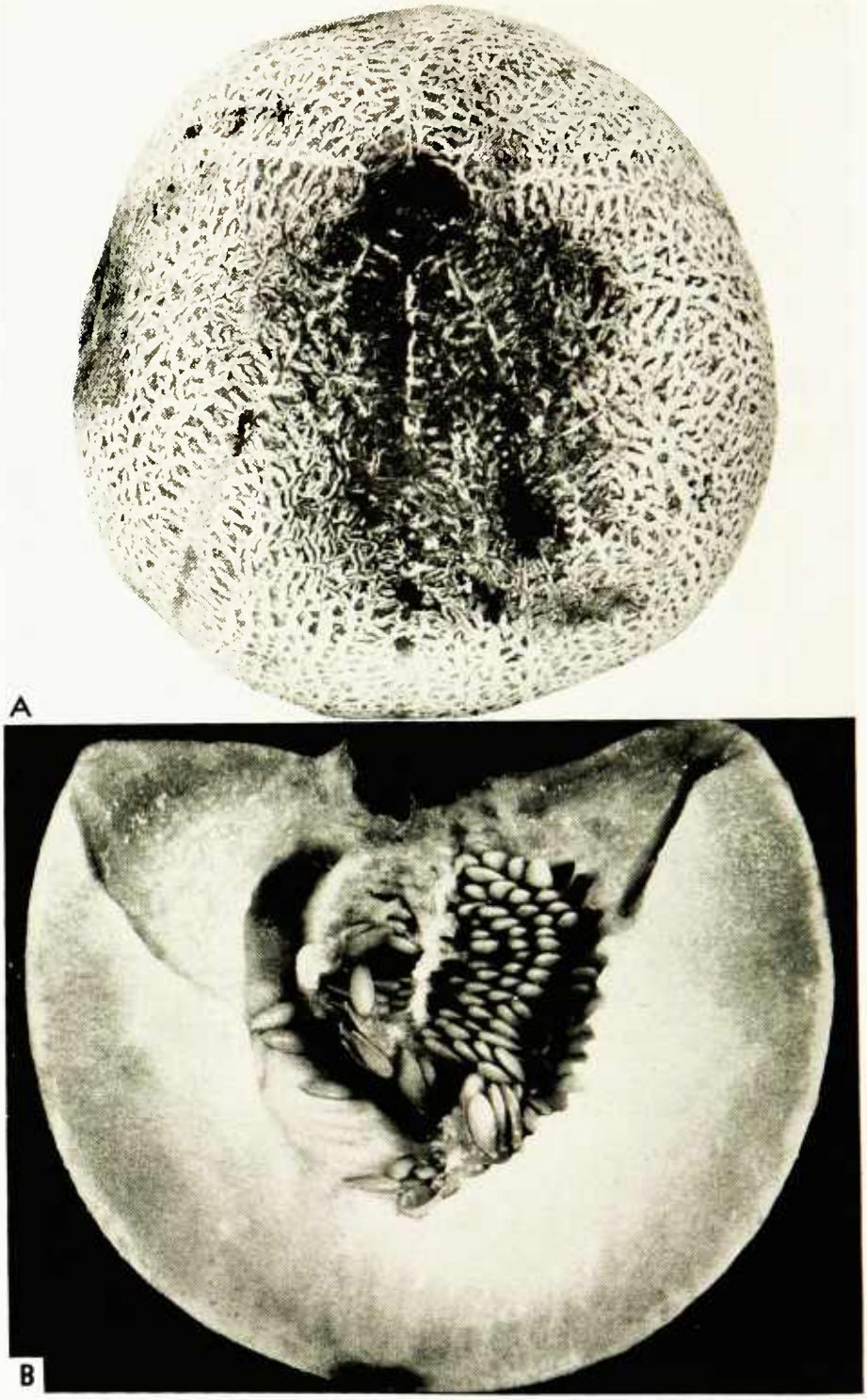

PLATE 16.—Cantaloup and honeydew melon diseases: A, Cantaloup cladosporium rot; B, honeydew rhizopus rot.

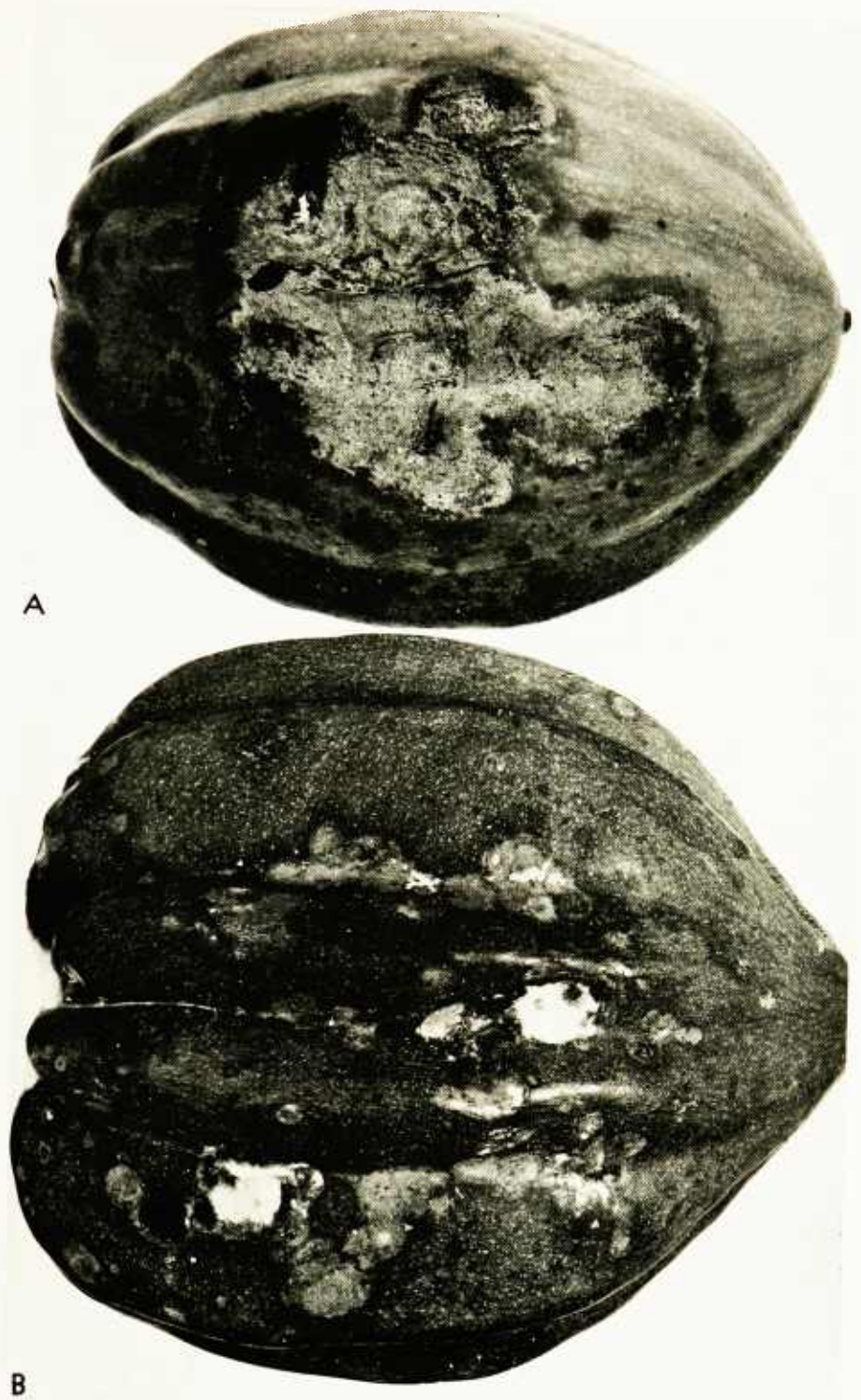

PLATE 17.—Squash diseases: A, Black rot; B, alternaria rot following low temperature injury (stored at 40° F. for 35 days).

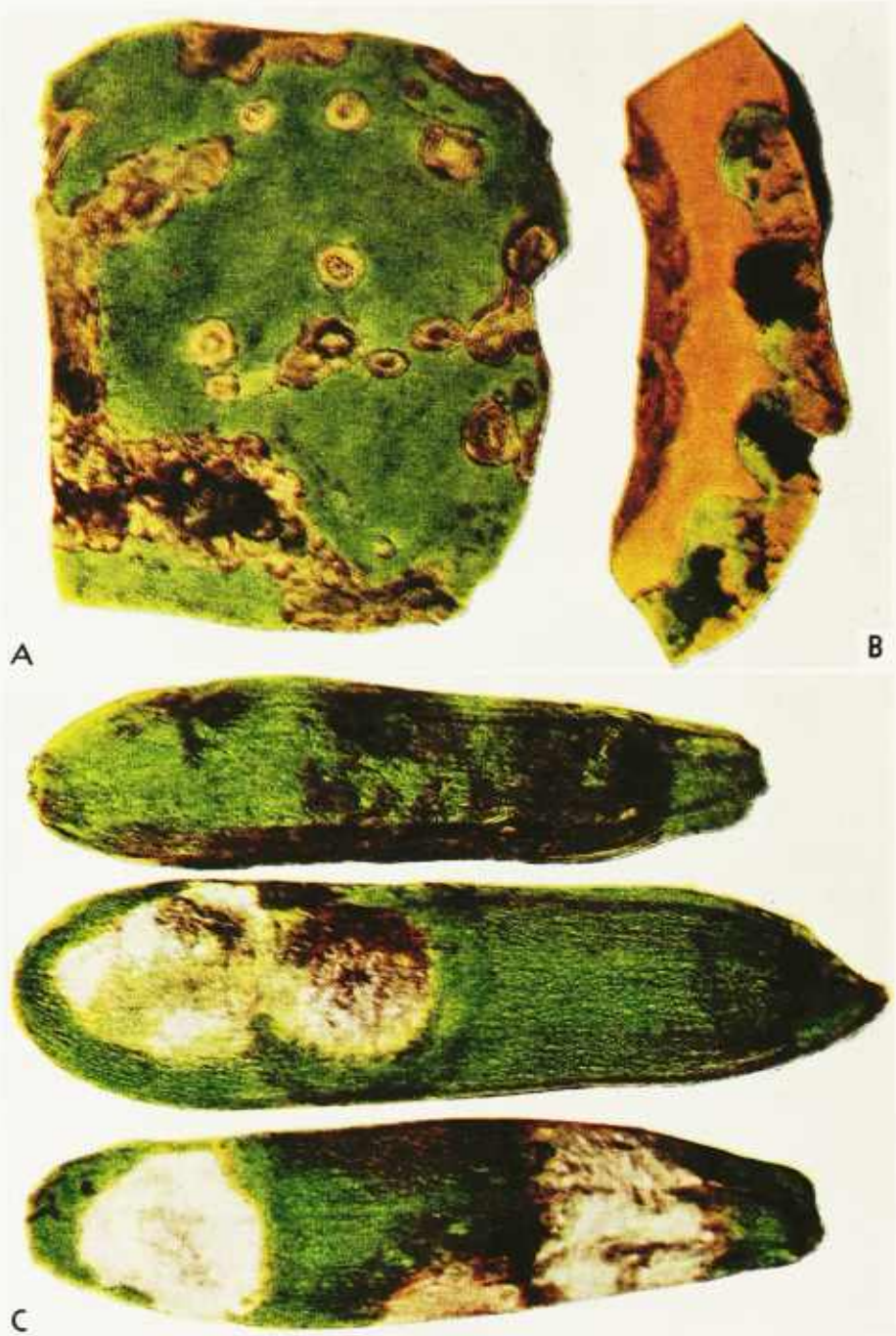

PLATE 18.—Squash disease: A, Black rot; B, alternaria rot; C, phytophthora rot.

PLATE 19.—Squash disease: Rhizopus rot.

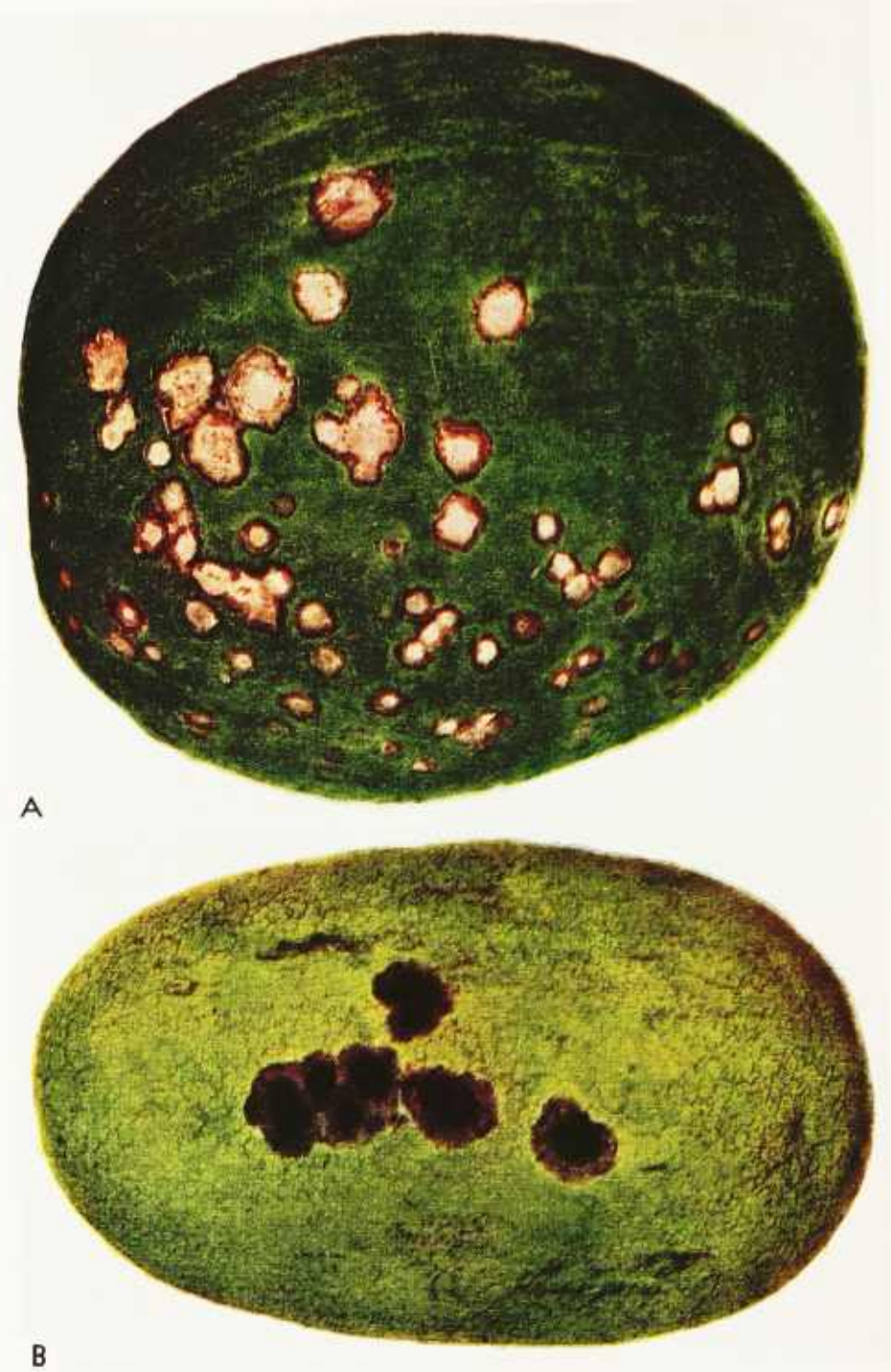

PLATE 20.—Watermelon disease: A, Anthracnose; B, black rot.

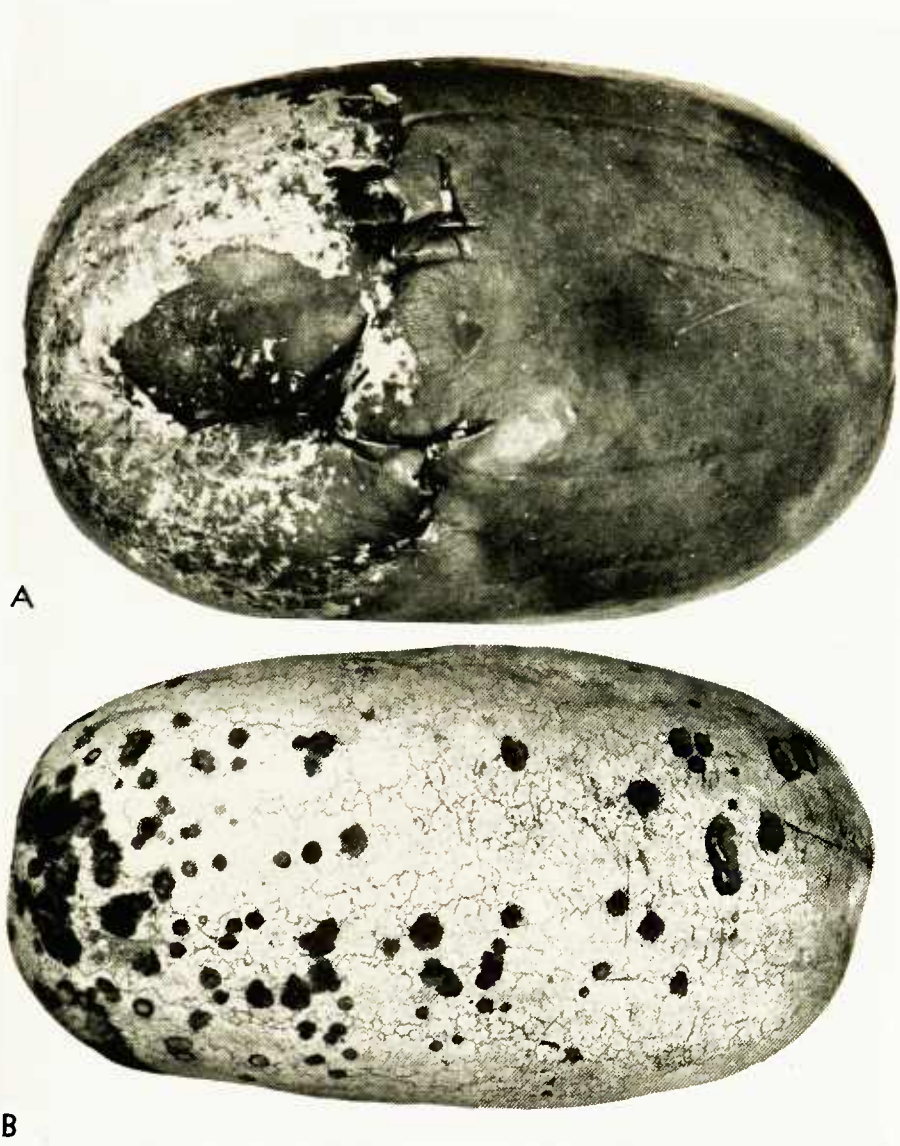

PLATE 21.—Watermelon disease: A, Phytophthora rot; B, anthracnose.

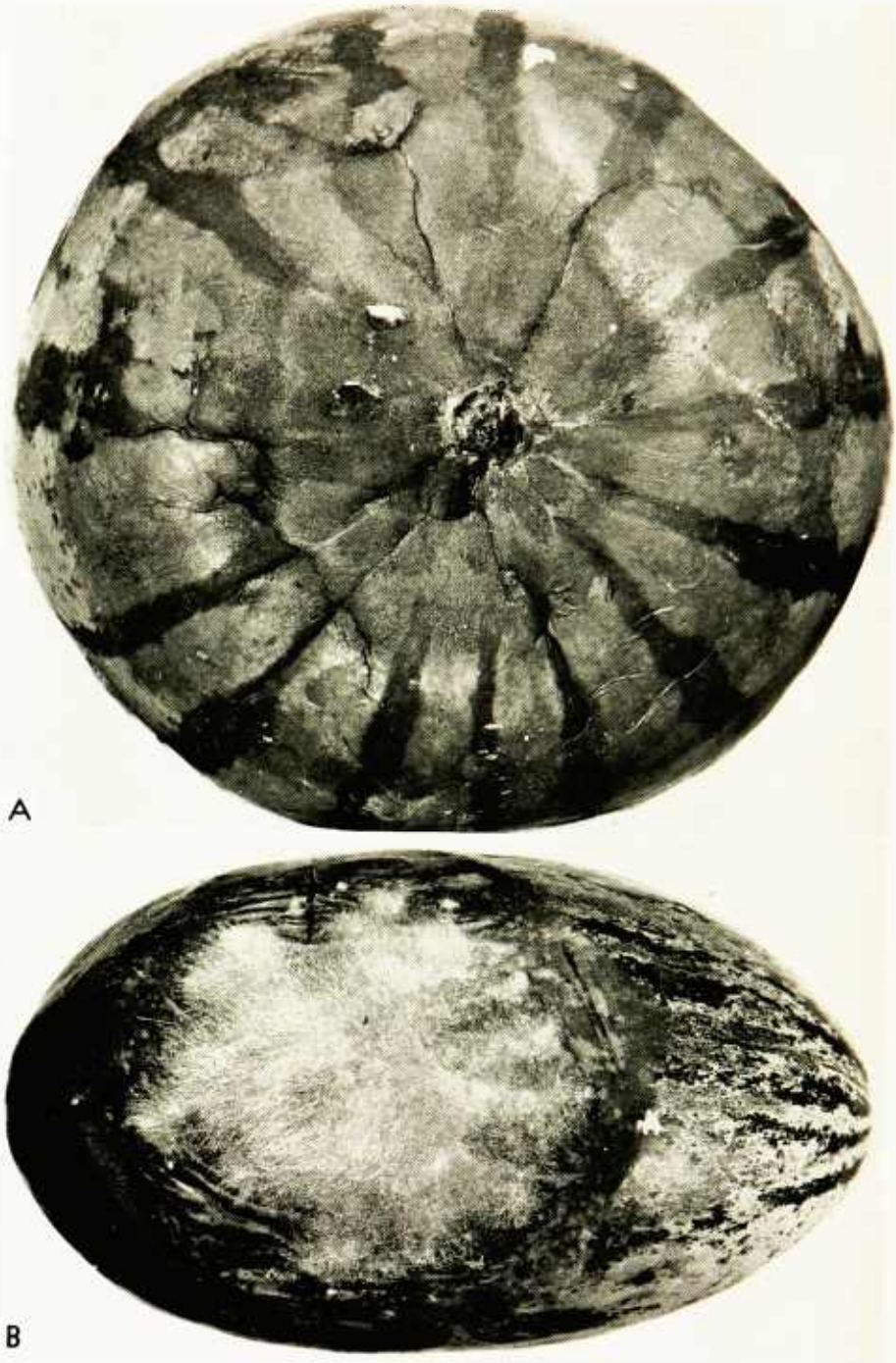

PLATE 22.—Watermelon disease: A, Stem end rot; B, rhizopus rot.

PLATE 23.—Watermelon disease: Stem end rot.

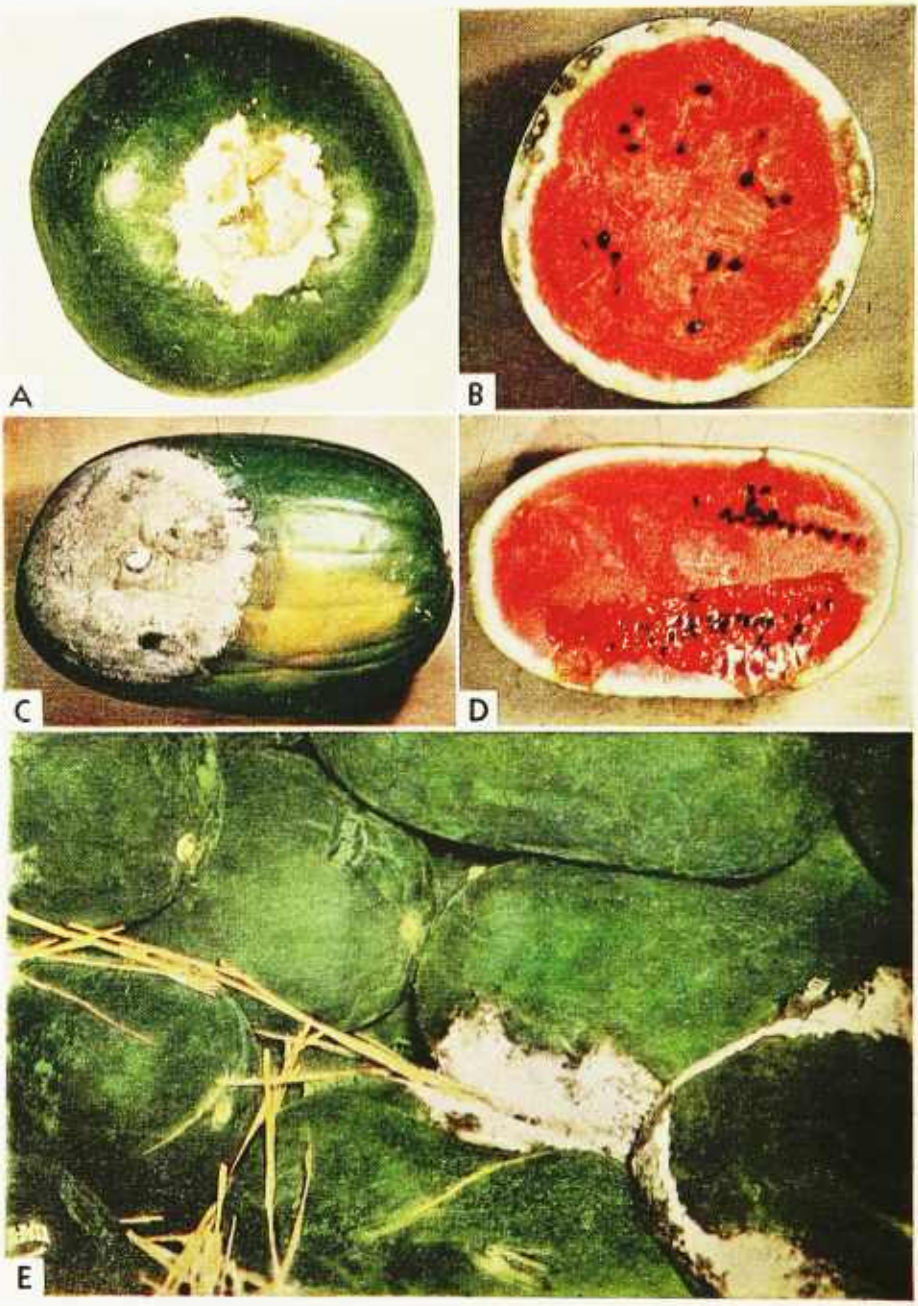

PLATE 24.—Watermelon disease: A, Fusarium rot; B, internal rind spot; C, D, and E, phytophthora rot.