



## BLACK ROT OF CABBAGE AND OTHER CRUCIFERS

Black rot, caused by the bacterium *Xanthomonas campestris* pv. *campestris*, is one of the most destructive diseases of cabbage and other crucifers. Cauliflower, cabbage, and kale are among the crucifers most susceptible to black rot. Broccoli, Brussels sprout, Chinese cabbage, collard, kohlrabi, mustards, rape, rutabaga, and turnip are also susceptible. Several cruciferous weeds are also hosts of the pathogen. Radishes are resistant to most, but not all, strains of the bacterium that causes black rot. A closely related species of *Xanthomonas* infects horseradish, radish, winter cress, and garden stock.

In warm and wet conditions black rot losses may exceed 50% due to the rapid spread of the disease. The disease is usually most prevalent in low areas and where plants remain wet for long periods. Conditions favoring plant-to-plant spread of the bacterium has led to a total loss of crucifer crops.

### Symptoms

Plants may be affected with black rot at any stage of growth. Seedling infection first appears as a blackening along the margin of the cotyledon. Later, the cotyledon shrivels and drops off, but only after the bacteria have passed into the young leaves and stem. Affected seedlings turn yellow to brown, wilt, and collapse. The bacteria most frequently invade the host plant through water pores (hydathodes) at the leaf margins. The result is initially a small, wilted, V-shaped infected area that extends inward from the leaf edge toward the midrib (Figures 1-2). The pathogen can also enter the plant through insect-feeding injuries, hail, or other mechanical wounds (Figure 3). Diseased areas enlarge and progress toward the base of the leaf, turn yellow to brown, and dry out. The veins of infected leaves, stems, and roots turn black as the pathogen multiplies. On cauliflower, black rot commonly



Figure 1. Cabbage plants infected with black rot (V-shaped lesions on leaves).



Figure 2. Typical "V-shaped" lesion on cabbage.



Figure 3. Lesion originating from insect feeding injury.

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appears on the leaves as numerous, minute brown specks. The infected lower leaves of cabbage and cauliflower are usually stunted, turn yellow to brown, wilt, and drop prematurely. Occasionally, diseased plants have a long bare stalk topped with a small tuft of leaves. In extreme cases, heading may be prevented.

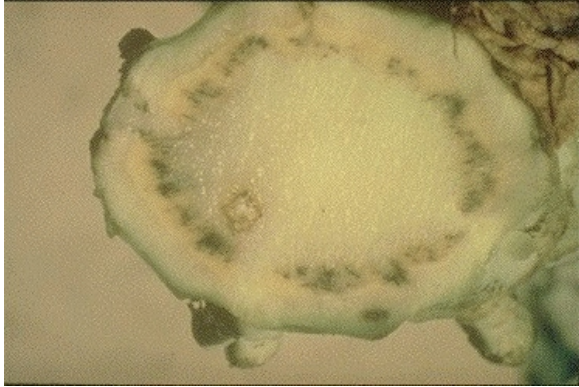


Figure 4. Vascular blacking on cabbage.

The bacteria spread through the veins of the leaf into the stem. A typical cross-section of an infected stem or petiole shows a black ring due to invasion of the water-conducting vessels (Figure 4). Dwarfing and/or one-sided growth is common both in individual leaves and in entire plants.

Affected plants may quickly rot before or after harvest due to secondary soft-rotting organisms. Soft-rot bacteria commonly invade black-rot lesions, move into the head and turn it into a slimy, foul-smelling mess. Late infections of black rot may merely spot the leaves or result in smaller heads. Infected turnip and rutabaga roots show black vascular bundles and an internal breakdown occurs.

Symptoms of black rot are often confused with those of Fusarium yellows. The *Fusarium* fungus also produces a dark ring inside diseased stems, as well as darkened petioles and one-sided growth. The discoloration, however, is dark brown rather than black. V-shaped diseased areas at the leaf margin are not as common or distinct with the yellows disease. The presence of black veins in yellow lesions along leaf margins is diagnostic of black rot. The first and most striking symptom of yellows is the dull yellow to yellowish green appearance of affected leaves. A microscopic examination may be necessary to distinguish yellows from black rot.

## Disease Cycle

The causal bacterium overwinters on and in seed and crop debris left in the field. The organism survives especially well in cabbage and Brussels sprout refuse, in plants stored for seed production, and in numerous weeds including black mustard, field mustard, charlock, shepherd's purse, Virginia pepperweed, and cress. The bacteria are spread by splashing or flowing water, blowing of detached leaves or dust particles, shipping and handling of infected plants, and insects. The bacteria are seedborne and thus are disseminated worldwide. As few as three infected seeds in 10,000 (0.03%) can cause black rot epidemics in a field.



Figure 5. Severe black rot in a cabbage field.

In the spring, when seedlings emerge, bacteria pass from the cotyledons into young leaves directly or through the stomata. The bacteria move intercellularly until they reach the xylem tissue and from there spread throughout the plant. The pathogen is spread from plant to plant by splashing rain, or in films of water moved by people, equipment, insects, and other animals. The

bacteria enter the plant through hydathodes along the leaf margins, through insect injuries, and in very susceptible crops, such as cauliflower, directly through the stomates.

The optimum temperature for growth of the organism is from 77° to 86°F (25° to 30°C), the minimum is 41°F (5°C), and the maximum is 96°F (35°C). Free moisture in the form of dew, fog, or rain is required for infection and disease development. Under the optimum conditions, symptoms may appear on plants 7 to 14 days after infection. At lower temperatures, symptoms develop more slowly.

## Control

### A. For transplant growers:

1. Purchase only certified, pathogen-free seed.
2. Treat all crucifer seed with hot water. Seedlots should be entirely free of black rot bacteria before planting; **this is critical**. Because of the difficulties in treating seed, most growers prefer to buy seed already treated. Proper hot water treatment also helps to eliminate seedborne infections of other diseases such as blackleg, Alternaria leaf spot, anthracnose, Fusarium yellows, and downy mildew.
3. Seedbeds or greenhouses should be at least 1/4 mile from crucifer production fields.
4. The soil to be used for seedbeds should have had no crucifer production for at least three consecutive years. If rotation of the plant bed is impossible, disinfest the soil using heat or fumigation.
5. Seedbeds and greenhouses must be kept free of crucifer weeds and should receive regular applications of pesticides to insure freedom from diseases and insect damage.
6. When watering plant beds, avoid sprinkling the foliage. Sprinkling is one of the most common means of disseminating black rot bacteria. Also, do not overcrowd or plant in poorly drained soil.
7. All tools and equipment used in seedbeds or greenhouses should not be used on other crucifer crops or should be decontaminated before bringing them back into the seedbed area.
8. Transplants should not be "topped" to fit into shipping containers or sprayed or dipped in water prior to transplanting.
9. Only new crates or crates not previously used for crucifers should be used for shipping transplants.
10. The transplants should be certified as disease-free by the State Department of Agriculture inspectors before shipping.

### B. For field growers:

1. Purchase your own seed and verify that the seed has been hot-water treated, certified free of the black rot bacterium, and documents that transplants were not trimmed and that only new

packaging material was used. Information such as seedlot number and source, dates of pulling and shipping, pest control schedules, and transit conditions is also useful in judging the health of plant materials and helping to identify the source of disease case problem.

2. Be sure that the transplants are certified as disease-free.
3. Grow plants in fields that have not been in a crucifer crop for at least three consecutive years. Locate crucifer plantings where both air and soil drainage are good.
4. Do not work in the seedbed or fields when plants are wet. Use clean or new harvest containers that are smooth and flexible.
5. Control all crucifer weeds which may serve as a source of inoculum.
6. Wherever feasible, clean up and burn or cleanly plow down all crop debris immediately after harvest.
7. Cabbage, rutabaga, turnip, kale, and black mustard varieties are available that have varying degrees of resistance. New varieties are constantly being developed with improved disease resistance. Some cabbage varieties with resistance to black rot include Guardian, Defender, Hancock, Gladiator, Bravo, Supermarket, and Blueboy. Consult current seed catalogs and trade publications for additional varieties.
8. Maintain balanced soil fertility in both seedbed and field, based on a soil test.
9. Control cabbage root maggots, cutworms, cabbage worms, and other insects to prevent injury which can serve as a point of infection for black rot.