

Cabbage Diseases: Ecology and Control

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Abstract

Cabbage is an important component of the human diet and a source of chemoprotective phytochemicals. Six major diseases of cabbage found worldwide are black rot, clubroot, black spot (dark spot), downy mildew, watery soft rot (white mold), and wirestem. The pathogens causing black rot and black spot can be seedborne. The pathogens causing clubroot, watery soft rot, and wirestem are soilborne; the clubroot organism is remarkably difficult to eradicate from infested soils. Important control measures include seed treatment with hot water or fungicides, crop rotation to reduce survival of foliar pathogens, scouting to detect disease outbreaks, and judicious application of protectant fungicides. Further research is needed to clarify races of the downy mildew and club root pathogens and to find useful resistance to these two diseases.

INTRODUCTION

Cabbage (*Brassica oleracea* “Capitata Group”) has long been cultivated as an important vegetable crop and a source of vitamins, minerals, and fiber, particularly during cold seasons in temperate climates. More recently, cabbage and other cruciferous vegetables (members of the Brassicaceae) have been recognized as important sources of chemoprotective phytochemicals in the diet. Cabbage is a productive vegetable based on biomass per area of cultivation. However, this crop is affected by many diseases, particularly those caused by fungi and bacteria. This entry focuses on six diseases of worldwide importance in cabbage production. These diseases also affect other cole crops, i.e., vegetables derived from *B. oleracea*, including broccoli, Brussels sprouts, cauliflower, collard, kale, and kohlrabi, and other genetically related cruciferous vegetables, such as turnip, rutabaga, Chinese cabbages, and mustards. Emphasis will be placed on stages in the life cycles of the pathogens that affect management. Control measures will be presented in an IPM context.

MAJOR DISEASES AND PATHOGEN ECOLOGY

Black Rot

Black rot is caused by the bacterium *Xanthomonas campestris* pathovar *campestris*. Because this bacterium

can be seedborne, black rot is found in most areas of the world where cabbage and other crucifers are grown. The pathogen produces V-shaped chlorotic and necrotic lesions starting at the margins of leaves, but it also causes wilting of plants if it reaches the vascular system in the stem (systemic infection). Blackening of the leaf veins is a helpful diagnostic symptom. The pathogen survives in infested crop debris but can only live a few months in soil.

Clubroot

Clubroot is caused by the slime mold-like organism *Plasmodiophora brassicae*. This soilborne organism is an obligate parasite, completing its unique life cycle within the root cells of crucifers. Infected root cells enlarge and divide to produce the diagnostic swollen, club-like roots. The pathogen produces resting spores in the clubs that persist in soil for at least 10 years after the clubs decay. Isolates of *P. brassicae* differ in host range, and races have been found that are pathogenic on the few resistant cultivars of cabbage that have been bred.

Black Spot, Dark Leaf Spot

Two species of *Alternaria*, *A. brassicae* and *A. brassicicola*, infect cabbage and other crucifers. *A. brassicicola* has higher optimal temperatures for growth, sporulation, and spore germination (20–30°C.) than

A. brassicae (18–24°C). Both fungi can be seedborne and airborne, but do not survive apart from infested host debris in soil. Infested debris left on the soil surface can be a significant source of pathogen spores for up to 12 weeks after harvest.^[1] Seedborne inoculum can lower seed germination and vigor but usually is not damaging to seedlings.

Downy Mildew

Crucifer downy mildew is caused by the Oomycete *Peronospora parasitica*. This fungus-like organism produces airborne sporangia on leaf undersides and oospores inside infected tissues. The pathogen is believed to survive as dormant oospores in roots and stems. Cabbage is affected by downy mildew particularly during the seedling and heading growth stages. High relative humidity, dew, and fog are favorable for infection. Separate host genes confer resistance in the cotyledon and adult plant stages of growth.^[2] Interactions observed between resistant plant varieties and isolates of the pathogen suggest that races of the pathogen exist.

Watery Soft Rot, Sclerotinia Stem Rot, White Mold

Sclerotinia sclerotiorum has a wide host range, but is especially damaging to cabbage, because it not only infects the head in the field but also can cause decay in storage. The common names for this disease show that infection occurs primarily on heads or stems of cabbage, particularly at maturity when wrapper leaves shade the soil, providing a cool, moist environment that favors the pathogen. This fungus produces airborne spores that infect plants, but soilborne survival structures (sclerotia) also can cause infection when they germinate near a plant.

Wirestem

Wirestem, a postemergence disease, is caused by the soilborne fungus *Rhizoctonia solani* anastomosis groups (AG) 4 and 2-1. In soils cropped repeatedly to crucifers, AG 2-1 predominates. At low pathogen levels, wirestem is more prevalent or more severe than preemergence damping-off. Seedlings may be killed by wirestem when lesions girdle stems. Older plants may be killed later as a result of seedling infections or be stunted and fail to produce a marketable-sized head. Root rot also occurs when infection is severe but is absent when discrete stem lesions are the only symptoms.

CONTROL

General Control Principles

Exclusion

It is extremely important to prevent contamination of clubroot-free land by excluding the pathogen. Movement of transplants and equipment from clubroot-infested fields or farms should be avoided. Growers in clubroot-free areas should avoid purchasing field-grown transplants or equipment from infested areas.

Eradication

Outbreaks of black leg associated with seed have been reduced by testing seed for the pathogen *Phoma lingam*. Eradicate cruciferous weeds to eliminate sources of the pathogens causing black rot, downy mildew, and clubroot (Table 1). In addition, cruciferous ornamentals can be infected by the same species of *Alternaria*, *Peronospora*, *Plasmidiophora*, and *Xanthomonas* that infect cabbage.

Avoidance

Do not plant susceptible cabbage in pathogen-infested fields. Wirestem is less severe when cabbage is planted into cool soils than into warm soils. In addition, using a shallow planting depth for transplants avoids contact of the susceptible hypocotyl with *Rhizoctonia*-infested soil. Avoid wounding plants to prevent black rot, bacterial soft rot, and watery soft rot.

Resistance

Host plant resistance is widely available in green (white) and red cabbage for yellows (caused by *Fusarium oxysporum* f. sp. *conglutinans*). Newer hybrid cultivars have partial resistance to black rot that restricts lesions to the wrapper leaves. A few cabbage cultivars (mostly red cabbage) have moderate resistance to *Alternaria*. Cabbage cultivars available in the U.S.A. are susceptible to *Sclerotinia*, downy mildew, wirestem, and clubroot.

Protection

Seed treatment is very effective to prevent damping-off caused by *Pythium* spp. and *R. solani*. Protectant fungicides are effective against foliar fungal pathogens and also are used against wirestem, clubroot, and black rot with varying degrees of success. Recently, the fungicide boscalid was registered in the U.S.A. to control *Sclerotinia* on cole crops.

Table 1 Management practices for common diseases of cabbage

Disease	Plant resistant cultivars	Use healthy seed or transplants	Control weeds	Avoid wounding	Bury crop residue	Rotate with non-host	Apply protectant fungicide or bactericide
Black spot	+	+	+	–	+	+	+
Bacterial soft rot	–	–	–	+	–	–	–
Black leg	–	+	–	–	+	+	+
Black rot	+	+	+	+	+	+	–/+
Clubroot	–	+ ^a	+	–	–	–	+/-
Downy mildew	–	–	+	–	+	+	+
Yellows	+	+ ^a	–	–	–	–	–
Sclerotinia stem rot	–	–	+	+	+	–	+/-
Damping-off	–	–	–	–	–	–	+
Wirestem	–	+ ^a	–	–	+	–	+

+, practice can be used to manage the disease.

–, practice is ineffective or inappropriate, based on the life cycle of the pathogen.

+/-, practice may be useful under certain conditions.

^aThe pathogen is not seedborne, but can be spread on infected, field-grown transplants.

Therapy

The only measure to control cabbage diseases postinfection is the application of systemic fungicides for downy mildew.

50°C for 25 minutes. Minimize leaf wetness periods when producing transplants in glasshouses, because of the ease of spreading pathogens. Apply protectant fungicides to seed crops to prevent infection of seed by *Alternaria*.

EXAMPLES OF INTEGRATED DISEASE MANAGEMENT

Controlling weeds, especially ragweed (*Ambrosia artemisiifolia*), can reduce incidence of watery soft rot. Ascospores of *Sclerotinia* infect ragweed flowers that then fall onto cabbage leaves and infect them, because flower parts provide nutrients for the pathogen.^[3] Control flea beetles (*Phyllotreta cruciferae*), which carry conidia of *A. brassisicola* on their bodies and in their frass and transmit conidia while feeding.^[4]

Private and public cabbage scouting programs have been developed and are useful for scouting production fields for diseases and insects. For example, the cabbage-scouting program in Suffolk County, New York, U.S.A., has operated for the past 20 years. In addition to insects, scouts record the presence, general severity, and field location of black rot, black spot, clubroot, downy mildew, viruses, watery soft rot, and yellows.

MANAGING SEEDBORNE PATHOGENS

Plant seed from seedlots that have tested negative for the presence of the pathogens that cause black rot and black leg. Hot water seed treatment is useful to control seedborne black rot bacteria, provided the water temperature is monitored carefully so it remains at

MANAGING SOILBORNE PATHOGENS

Soil fumigants generally are not used against soilborne pathogens in cabbage production because of the high cost, although they may be used to disinfest seedbeds and suppress clubroot. Field-grown transplants may be sources of the wirestem and clubroot pathogens and spread them to non-infested fields. Because of this risk, transplants should be produced in soilless mixes in glasshouses when possible. Do not plant any cruciferous vegetables in fields before or after cropping to cabbage. Use monocots as rotation crops, because *R. solani* AG 4 has a wide host range among dicotyledonous crops. The resting spores of the clubroot organism cannot be eradicated by rotation. Instead, liming soil to raise the pH above 7.2 with calcium oxide or hydrated lime prevents infection of roots in many soils.

MANAGING FOLIAR PATHOGENS

Diseases caused by foliar pathogens, such as *Xanthomonas* and *Alternaria*, can be managed with crop rotation during the period when infested host debris is decaying in affected fields, because these foliar pathogens of cabbage do not survive longer than one or two years in soil, respectively. Disk and bury or compost unmarketable cabbage heads. Apply protectant fungicides as needed based on environmental conditions

and host susceptibility. Because *Alternaria* spp. require relatively long periods of leaf wetness for infection (a minimum of five to nine hours), disease can be reduced by increasing row width and plant spacing to promote air circulation that dries leaves.

CONCLUSIONS

The diseases black spot, downy mildew, watery soft rot, and wirestem often can be managed successfully using a combination of cultural, biological, and chemical control measures. The cultural and biological methods listed in Table 1 also are amenable to organic production systems. Management of black rot and clubroot remains more challenging. In the future, resistance to downy mildew and improved resistance to black rot may be available in cabbage cultivars. It may be possible to transfer downy mildew resistance from broccoli to cabbage using molecular genetics methods. Additional research is needed to clarify the identity of races of the downy mildew and clubroot organisms.

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ARTICLES OF FURTHER INTEREST

Dispersal of Plant Pathogens, p. 193.
*Principles of Pest Management with
 Emphasis on Plant Pathogens*, p. 666.
*Vegetable Crop Pest Management
 (Plant Pathogens)*, p. 875.

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