

Disorders of Cole Crops

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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1. Molybdenum deficiency—cauliflower

1. **Molybdenum deficiency** occurs occasionally on cole crops. It is most common on soils with a pH below 6.0. Early stages look like nitrogen deficiency with yellow mottling between the veins of all leaves. As the plants grow, the edges of young leaves turn inward, turn yellow and then brown; soft rot often infects the affected leaf margins. If molybdenum deficiency is known to exist, treat seed with a sodium molybdate slurry before planting. If the problem appears in the field, apply 3 ounces of sodium molybdate per acre weekly in foliar sprays until symptoms disappear from young leaves.

2. **Magnesium deficiency** appears as interveinal chlorosis in older leaves. Cauliflower and Chinese cabbage are especially susceptible. Magnesium deficiency occurs most often on soils with low pH and high potassium levels. It can usually be avoided by applications of dolomitic limestone. If the problem occurs during a cropping season, apply 10 to 20 lbs magnesium sulfate (Epsom salts) in 100 gallons of water per acre as a foliar spray.

3. **Boron deficiency** causes hollow stem in cauliflower, broccoli, and cabbage. Light brown spots on the curd are evidence of boron deficiency in cauliflower and broccoli. The brown spots can expand and cover the entire head. As heads mature, soft rot bacteria often infect the hollow stem making the heads unsalable. Apply 3



2. Magnesium deficiency—Chinese cabbage

lbs actual boron per acre in broadcast fertilizer to avoid boron deficiency.

4. **Internal tipburn** is a result of an internal calcium imbalance in cabbage. Leaves inside the heads turn brown and dry up. There may be a single dry leaf, or several at different locations in the head. Affected heads appear to be sound externally. Although most Michigan soils contain high calcium levels, tipburn still occurs, usually during hot, dry periods. Maintaining adequate soil moisture levels helps reduce the incidence of tipburn, but does not eliminate it. Some newer varieties are reported to be somewhat resistant to tipburn.

5. **Buttoning** is premature heading in cauliflower and broccoli. Small heads (1 to 4 inches in diameter) develop and foliar growth ceases. The heads may continue to enlarge but are of poor quality. In cauliflower, there are insufficient leaves to blanch the curds. Buttoning can occur anytime from seeding until the plants are almost mature, but most often occurs within a month of transplanting in the field. This problem is a result of stress on young plants induced by low or high temperatures, moisture stress, transplant shock, or nutrient deficiencies. It can be avoided by growing varieties well adapted to Michigan, and taking good care of the plants in the greenhouse and field.



3. Boron deficiency—broccoli



4. Internal tipburn—cabbage



5. Buttoning—cauliflower



6a. Black rot—cabbage



6b. Black rot—cabbage

6. **Black Rot** (*Xanthomonas campestris*) symptoms first appear along the leaf margins 10-14 days after invasion by the bacteria. The bacteria enter the plant through water pores or wounds produced by insects or weather damage. The bacteria then move rapidly through the water conducting (vascular) system of the plant, eventually plugging it. Veins turn black as water flow is restricted and plant tissue around the point of invasion turns yellow in a V-shaped lesion. If the weather is cool (below 70°F daytime high) external symptoms may disappear although the organism remains in the vascular system. Plants infected in the seedbed may show no symptoms except for premature cotyledon or leaf drop. When temperatures rise, lesions appear on leaf margins; the plant wilts, loses leaves and dies. Heavily infected plants will stop growing. The heads discolor internally and plant tissues break down.

Control is best achieved by use of hot-water-treated seed which has tested negatively for the bacterium, 3-year crop rotations to non-cruciferous (mustard) crops, use of resistant varieties, elimination of cruciferous weed hosts from field margins, and spraying with approved preventive spray materials.

7. **Leafy head of broccoli and leafy curd of cauliflower** are a result of head formation during hot weather. Small leaves develop and protrude from the heads. Because of their sensitivity to hot weather, broccoli is usually grown as a spring or fall crop and cauliflower only as a fall crop in



7. Leafy curd—cauliflower



8. Thrip damage—cabbage

Michigan. Some varieties are better suited to warm season production and are less susceptible to leafy head.

8. **Thrip damage** is a major concern in mid-and late-season cabbage. Damage consists of small brown scars on inside leaves, caused by rasping and sucking of the small (1/16 inch), tan insects. Damage is most severe during hot, dry summers. Thrips enter cabbage early in head development and remain in the heads until harvest. Once thrips are inside the heads, it is impossible to control them. Damage is usually visible only by peeling off a number of outer leaves. Regular insecticide applications, commencing at heading, should control thrips.

9. **Blackleg** (*Phoma lingam*) symptoms can appear early in the growing season on seedlings not yet transplanted in the field. Rather inconspicuous, small, circular, dark lesions appear on leaves of plants affected by the fungus. The spots gradually enlarge, becoming well defined with a gray center filled with numerous black, pimple-like, spore-bearing structures. The lesions on stems are oval in shape and are often surrounded by a purplish margin. Spots spread over the whole plant including the root system. The dark cankers which form on affected roots may eventually destroy



9a. Blackleg—cabbage



9b. Blackleg—cabbage

the fibrous root system. The disease causes wilting, stunting and death of many affected plants.

Disease control is best achieved by use of disease free seed and transplants, and a 4-year crop rotation.

10. **Downy Mildew** (*Peronospora parasitica*), The initial symptom of this fungal disease is the appearance of small, irregularly shaped grayish-purple spots on stems and the undersides of leaves. Under cool, moist conditions, the spots enlarge and become covered with fluffy, grayish-white mycelium. The upper leaf surface yellows and dries out. Heavily infected leaves eventually drop off. The organism may move systemically in the plant causing internal discoloration of broccoli, cabbage and cauliflower heads.

Avoid low-lying fields with heavy soils, do not overwater, rotate to non-cruciferous crops and apply appropriate fungicides to control downy mildew.



10a. Downy mildew—cabbage head



10b. Downy mildew—cauliflower leaf



10c. Downy mildew—cauliflower head

11. **Wirestem** (*Rhizoctonia solani*) causes a number of closely related diseases of cole crops, including damping off, wirestem, bottom drop and head rot. If the fungus attacks very young seedlings, the disease is called damping off. The fungus penetrates seedlings near the soil line causing water-soaked constrictions of the stem. This results in wilting and toppling over of the plants. If plants survive this initial attack, the center of the stem decays and collapses while the stalk continues to provide sup-



11a. Wirestem—cauliflower



11b. Rhizoctonia head rot—cabbage

port and the plant remains erect. At this stage, the disease is called wirestem. Stems are discolored and wiry above the soil line. The plant grows very slowly and usually does not develop to maturity. Bottom drop occurs as a carryover from wirestem. Lower leaves wilt, rot and darken, but remain on the plant. A head rot may develop, causing a darkening and decaying of the mainstem at the base of the heads and spotting and wilting of the leaves in the center of the head.

Damping off and wirestem can be controlled in the greenhouse and field seedbeds by using sanitized soil and containers and treating seed or soil with a fungicide. Avoid overwatering. Avoid field sites that are low lying with heavy soils and do not use diseased transplants.

12. **Yellows** (*Fusarium oxysporum* f. *conglutinans*) primarily affects cabbage and radish, although other cruciferous crops are susceptible. Initially, the plants turn off-color (light green or yellow), with lower leaves affected first. Yellowing generally occurs on one side, although the entire plant may be uniformly affected. Curling and distortion of affected leaves is common. In either case, leaves continue to turn yellow. The water conducting (vascular) systems of infected plants turn



12. Yellows—cabbage



13. Soft rot—Chinese cabbage

yellowish-brown. Plants either die prematurely or form imperfect heads.

Varietal resistance is available in both cabbage and radish and is a successful means of yellows control.

13. **Soft Rot** (*Erwinia carotovora*) bacteria cause a watery, soft, foul-smelling rot of Chinese cabbage and other cruciferous hosts. Bacterial infection often occurs after chemical, mechanical, insect or other injury. In Chinese cabbage, the rot follows internal tip burn. The bacteria liquify the pectic substances in the cell wall, resulting in rapid softening of the invaded tissues and their collapse into a slimy mass.

To avoid infection, grow Chinese cabbage on light, well-drained soils and maintain adequate soil moisture to avoid tip burn. Select varieties suitable to the Michigan climate and avoid injury to the plants. Rotate fields with nonhost crops such as corn, wheat or soybeans.

14. **Sclerotinia Head Rot** (*Sclerotinia sclerotiorum*). Cabbage and other cruciferous hosts can be attacked late in the growing season by this soil-borne fungus. The fungus invades the main stem of the plant near the soil line, causing a soft decay of the outer layer of the stem. An infected plant may succumb rapidly or become stunted and decline slowly. Lower leaf drop accompanies the decline in plant vigor. A cottony, white mycelium is visible on infected plant parts. Black fruiting structures ¼ to ½ inch in diameter, called



14. *Sclerotinia* head rot—cabbage



15a. Club root—Chinese cabbage



15b. Wilting caused by club root—
Chinese cabbage



16a. *Alternaria* leaf spot—cabbage



16b. *Alternaria* head rot—cauliflower

sclerotia, are often found embedded in the mycelium growing on the outer leaves of cabbage heads.

Avoid low lying fields with heavy soils and rotate crops to reduce disease incidence.

15. **Club Root** (*Plasmodiophora brassicae*) may be quite advanced before foliar symptoms appear because only roots become infected. Infected plants wilt in the middle of hot, sunny days and leaves turn pale green to yellow. Eventually, infected plants wilt permanently and die or survive in a stunted condition.

Clubroot zoospores enter roots through root hairs or wounds. The organism stimulates plant cell multiplication causing roots to enlarge and form spheroid or spindle shaped "clubs". The growth of the clubs inhibits development of a normal root system and blocks the water conducting system. In addition, the clubbed roots decay and are invaded by soft rot bacteria releasing a toxin. Lack of sufficient water and the presence of the toxin causes foliar wilting.

Clubroot incidence can be reduced by

using clean transplants, avoiding movement of machinery from infested areas into clean fields, dipping transplants in approved fungicides and maintaining a high soil pH (7.3 or above). Crop rotation is not very effective because the resting spores can survive in the soil for many years.

16. **Alternaria Diseases** (*Alternaria spp.*), *Alternaria* fungi cause both leaf spotting and head rotting of crucifers. The initial disease symptom is the appearance of small dark spots on older leaves. The spots are generally circular, ranging from ½ inch to 1½ inch in diameter. A brown- or black-velvety mold, composed of masses of fungus spores, rapidly covers the lesion. These spores rub off the lesion surface easily. Lesions may coalesce to form large, irregular, diseased areas on the leaf surface. The margins of tightly wrapped inner leaves of cabbage may become colonized by *Alternaria spp.* if a nutritional deficiency or other injury affects the plant. Soft rot often follows infection by the fungus. Injured leaves are more susceptible to the disease than are healthy leaves.

On cauliflower, tiny brown sunken lesions appear on the curds. On broccoli, these lesions are yellow. The spots enlarge rapidly and are eventually covered with the black spores of the fungus.

To avoid the *Alternaria* diseases, use high quality, disease-free seed; irrigate early in the day so that leaves dry rapidly; tie cauliflower heads loosely and as late as possible to reduce free moisture on the head, and apply fungicides when necessary.

Other MSU Extension Bulletins with information on cole crops:

E-312 Control of insects, diseases and nematodes on commercial vegetables, 75¢

E-433 Weed control guide for vegetable crops, 40¢

E-486 Secondary and micro-nutrients for vegetables and field crops, 90¢

E-550 Fertilizer recommendations for vegetables and field crops in Michigan, 40¢

E-675-T Vegetable varieties for commercial growers, 35¢

E-968 Cole crop insect pests, free

E-1591 Commercial vegetable recommendations: Cauliflower, free

Some of the photos in this publication were contributed by Paul Williams, Dept. of Plant Pathology, U of Wisconsin, and Sandra Perry, Plant Diagnostic Clinic, Dept. of Botany and Plant Pathology, MSU