Cole crops integrated pest management

by Lina M. Rodriguez Salamanca, Michigan State University Extension

Extension Bulletin E3231

Introduction


Lina M. Rodriguez Salamanca

Cole crops belong to the mustard family, or Brassicaceae. Michigan's economically important cole crops include cabbage, cauliflower and broccoli. Cole crops grown on smaller acreages include Brussels sprouts, turnips, rutabaga, kale, mustard greens and many other types of greens. Cabbage, cauliflower, broccoli and Brussels sprouts are all the same species, *Brassica oleraceae,* and have been selected for different economic traits. For example, broccoli and cauliflower are flower mutants, while cabbage and Brussels sprouts are stem mutants. In Michigan, cole crops are grown for fresh and processing markets, while some mustards are planted as cover crops.

Cole crop integrated pest management (IPM) starts with crop rotation, cultivar selection and proper transplant production. Cole crops can be planted early in the spring and late in the fall, which makes them ideal to incorporate easily in crop rotation. The use of tunnels, cold frames and row covers protect the crops from spring and fall frost. Drip irrigation along with plastic mulch can improve moisture delivery and retention, suppress weeds and decrease disease pressure. The system can be reused for tender crops that follow early-planted cole crops in the same season, such as tomatoes, peppers, cucumbers, summer squash and zucchini among others.

When selecting cole crops cultivars, consider not only the market and days-to-maturity, but also resistance to insects, diseases and disorders. Cole crop production must start with healthy transplants in the greenhouse that are frequently scouted for disease and insect pests. Be sure to practice sanitation. Avoid excessive watering or heavy nitrogen fertilization at this stage, which can contribute to poor root system development or disease development.

WEED MANAGEMENT

Crop rotation, cultivation, mulching and use of cover crops are practices that contribute to weed management. Maintain a record of weed species or types observed in the field in the previous season. It is important to have an idea of the population of broad leaf and grass weeds in your field to select the best herbicide combinations. (**Consult Michigan State University Extension bulletin E-433 for current labeled herbicides**.) When selecting herbicides, use different Weed Science Society of America (WSSA) classifications listed on the herbicide label to minimize the risk of resistance development. Use at least two herbicides preemergence of the weeds either before or after transplanting. Always read the labels for potential limitations. Most herbicides require moisture for activation.

Herbicide injury. The main two causes of herbicide injury in crops are improper timing or rate, and unintended exposure of the crop to herbicides. High rates of clomazone (WSSA11) can cause marginal leaf chlorosis in some cabbage cultivars. High rates of trifularin combined with wet conditions can cause injury in seedlings that range from stunting to hypocotyl (stem) enlargement.

Glufosinate (WSSA 10) drift causes chlorosis and desiccation at the contact point. Herbicides in WSSA group 2 (Sulfonylureas), whether applied as foliar or soil incorporated, can result in foliar discoloration (chlorosis or purpling of the new growth). The extent of the damage depends on the rate the herbicide was applied and environmental conditions. Triazine and benzoic acid (WSSA 5 and 3 respectively) can injure crops due to carryover. For example, Triazines can cause leaf margins or interveinal chlorosis. Always consult the label for rotational restrictions, appropriate rate and timing.

Problematic weeds. Controlling weeds in the mustard family, including wild mustards, wild radish, shepherds purse, marsh yellow cress and mouse ear cress, is very important for disease management as they can be alternate hosts for diseases.

NUTRIENT-RELATED PHYSIOLOGICAL DISORDERS

Nutritional deficiencies can occur in cole crops due to inadequate nutrient uptake related to soil pH, soil moisture, weather conditions and lack of appropriate fertilization. Soil and plant tissue analysis is recommended to help pinpoint the specific nutrient deficiency.

Nitrogen deficiency is associated with yellowing of older leaves. In contrast, excess nitrogen can impact the quality of cabbage heads due to the increase in foliage development.

Potassium deficiency shows as yellowing along leaf margins or scattered, chlorotic spots that turn necrotic. This deficiency may impact crop quantity and quality if the symptoms are observed in early stages of the crop.

Boron deficiency may occur on acidic (pH less than 6.0) or alkaline soil (pH greater than 7.0). It is associated with lack of appropriate soil moisture and is most common in sandy or organic soils with low organic matter. Low soil moisture accentuates boron deficiency. Excess rainfall may leach boron from the root zone of sandy or muck soils. Symptoms in seedlings can be observed as brittle, yellow and distorted young tissue. Boron deficiency may play a role in broccoli and cauliflower hollow stem.

Calcium deficiency may occur on acidic soils with intermittent or low moisture and when weather conditions are favorable for rapid crop development. Slow calcium translocation can be driven by high concentrations of other cations (e.g., Na^+, K^+, $NH4^+$, $Mg2^+$), high salinity, low temperatures and high humidity. Symptoms of calcium deficiency include tip burn in cabbage heads, broccoli brown bud and cauliflower curd breakdown and leaf tip burn (see photo).

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Tip burn in cauliflower leaves, a symptom of calcium deficiency.

Manganese or magnesium deficiencies. Interveinal chlorosis could be a symptom of manganese or magnesium deficiencies. Manganese deficiency causes an olive-green to yellowish discoloration between the veins, while magnesium deficiency results in a mottled yellowing between the veins. *Manganese deficiency* is more likely to occur when the soil pH is above 6.5 in mineral soils and above 6.0 in muck soils. *Magnesium deficiency* may occur in acidic sandy soils (pH less than 5.8) and is more prevalent in older leaves.

Molybdenum deficiency is common in cauliflower and causes the symptoms known as whiptail, a narrowing of the leaf blades when severe. When less severe, leaf blade expansion is moderately restricted.

Sulfur deficiency results in a general yellowing of the leaves and is most likely to occur on low organic matter sandy soils.

Other less common micronutrient deficiencies are iron and zinc. For additional information, consult Rimmer S. R, et. al (see resource section). For specific nutrient management recommendations, consult **MSU Extension bulletins E2934 and E486.**

INSECT MANAGEMENT

A combination of IPM tactics is needed to manage the key insects that damage cole crops in Michigan (Table 1). These tactics include cultural practices, cultivar selection, biological and chemical control. When using pesticides, monitoring pests and using treatment thresholds can reduce the number of applications needed to achieve effective control. When treatment thresholds are reached, alternate insecticides with different modes of action to prevent insecticide resistance from developing. The Insecticide Resistance Action Committee (IRAC) group number on the insecticide label represents modes of action. Alternation of IRAC groups minimizes the risk of insecticide resistance. Products labeled for organic insect management in cole crops includes Spinosad, botanicals and oils. Consult the "Production guide for organic cole crops" NYS IPM publication No 1342.

Cabbage maggot

Delia radicum

Larvae are yellow-white and approximately 0.25 inches long. Cool, wet springs favor this pest. Select plant varieties tolerant to this pest when available, rotate away from cole crops and thoroughly incorporate crop residue. Time planting to avoid adult peak flight – at least one week

Table 1. IPM strategies to manage key cole crop insects in Michigan

Insect pest		Cabbage maggot	Flea beetle	Diamond back moth	Imported cabbage worm	Cabbage looper	Cabbage aphids	Onion thrips
Resting/ Overwinter stage		Pupae in soil	Adults in grass and leaf litter	Adults over-winter, others migrate	Pupae on plant debris	Migratory	Eggs in crop residue	Adults and nymphs on grain, clover, alfalfa
Plant parts damaged		Larvae feed on roots	Adults feed on foliage, larvae feeds on roots	Larvae feed on foliage			All stages suck plant juices	All stages rasp and suck cabbage foliage
Timing in the season		Early		Mid		late		
Monitor		DD model	Whole plants	Whole plants	Whole plants	Whole plants	Whole plants	Leaves/whole plants
Threshold/ Phenology		Peak flight 300 DD43[Y]	2-5 beetles/ plant	10 to 30% of plants infested depending on crop stage[X]	1 to 5 larvae per plant of plants infested depending on crop stage[X]		Prior to heading 100 aphids/ plant. After heading 1-2 % plants infested	3 thrips/leaf or 30 thrips/plant
Tactics[Z]	**CP**	X	X	X	X	X	X	X
	HR	X	-	X	-	-	-	X
	BC	-	-	X	X	X	X	-
	CC	X	X	X	X	X	X	X

[Z]CP: Cultural Practices, HR: Host Resistance, BC: Biological control, CC: Chemical control,[Y]To calculate degree days (DD) for cabbage maggot peak flight, consult Enviro-weather (http://enviroweather.msu.edu), [X]Consult **MSU Extension bulletin E3165** for details.

before or after the peak. To check for peak flight, visit the MSU Enviro-weather website at www.enviroweather.msu.edu and navigate to the vegetable tab. If cole crops are planted during peak flight period, apply a soil insecticide. (Check MSU Extension bulletin E312 for registered insecticide options.)

All photos this page: Lina M. Rodriguez Salamanca

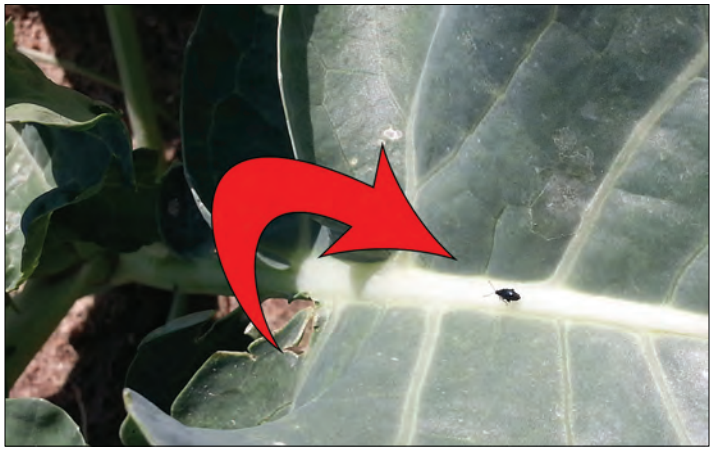
At left, a field with cabbage maggot damage. Below, a red arrow points to a cabbage maggot on a cabbage root.

Flea beetles

Many genera and species, Family Chrysomelidae

Adult beetles are approximately 2 to 3 millimeters long and have strong hind legs for jumping. Early crop planting and soil applied insecticides are recommended on fields with known infestations. Rotating crops and destroying crop residue can help decrease flea beetle numbers in the field. Row covers can be used to exclude flea beetles.

Flea beetle adult and damage caused in cole crops.



Cabbage aphids

Brevicoryne brassicae

Cabbage, turnip and green peach aphids attack cole crops and can cause severe infestations in warm weather. Crop residue removal and conservation of natural enemies can help to manage the aphid populations in the field. When threshold is reached (see Table 1), thorough coverage with an insecticide, including the underside of leaves, is critical. Select an insecticide spray program that protects natural enemies; avoid using broad-spectrum insecticides and use those that target aphids specifically, such as pymetrozine or flonicamid.

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Cabbage aphids on cabbage.

Thrips

Thrips tabaci

Thrips rasp cole crop tissues, which results in scratch-like patterns (see photo) on cabbage and cauliflower. Thrips numbers quickly increase in hot and dry weather. Select varieties that can tolerate thrips and avoid planting cole crops close to alfalfa, clover or small grains, which can be a source of this pest. Insecticide applications are more effective at the beginning of cupping or curd formation.

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Damage caused by thrips on cabbage head.

For additional information on caterpillar pests, including diamond back moth, imported cabbage worm and cabbage looper, consult MSU Extension bulletin E3165.

DISEASE MANAGEMENT

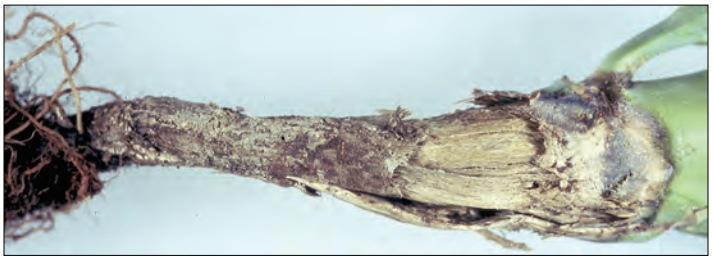
Manage diseases with multiple tactics that apply the principles of plant disease control (Table 2). The sum of the tactics is the IPM strategy. The FRAC group (Fungicide Resistance Action Committee group) number on the fungicide label represents the fungicide mode of action. Spray programs that rotate fungicides with different modes of action are needed to prevent fungicide resistance development.

Wire stem

Caused by the soil and seedborne pathogen *Rhizoctonia solani*

In young plants, characteristic wire stem symptoms are constriction and girdling of the stems that can result in wilting and damping off in the greenhouse and field (see photo). In mature plants, this pathogen causes black, sunken lesions called crater rot in radishes, rutabagas and turnips. It causes a soft head rot in cabbage. Conditions that favor this disease are planting on soils with low macronutrient levels (N, P and K), high copper levels and seasons with high rainfall that result in high soil moisture levels and temperatures greater than 68 degrees Farenheit.

Wire stem symptoms in broccoli.



Robert Wick, Bugwood.org

Wire stem damage evident in a seedling flat and on a cabbage transplant.

Both photos: Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Table 2. IPM strategies to manage key cole crop diseases in Michigan.

Principle	Tactic	Examples	Diseases[Z]				
			WS	CR	BR	ALS	DM
Avoidance	Site selection	Fields with good water infiltration and drainage	X	X	-	-	X
Host resistance	Resistant varieties	Plant resistant varieties when available	-	X	X	X	-
Exclusion	Clean seed/ Treated seed	Certified seed, fungicide treated seed	X		X	X	X
	Pathogen-free transplants	Plant only healthy seedlings	X	X	X	X	X
Detection/ID	Early detection, scouting	Scout transplants and discard infected plants	X	X	X	X	X
	Accurate disease identification	Submit sample to MSU diagnostics lab[X]	X	X	X	X	X
Plant protection	Fungicide sprays	See materials in E-312[Y], FRAC group alternation	-	-	-	X	X
Reduction/ Eradication	Crop rotation	Rotate crops with non-cole crops	X	X	X	X	X
	Weed control	Manage weeds in the mustard family in the field and in greenhouse	-	X	X	X	X
	Sanitation	Clean trays, benches, field residue management (plowing under crop as soon as possible to allow breakdown by microorganisms)	X	X	X	X	X
	Rouging infested/symptomatic plants	Eliminate symptomatic plants, whole seedling trays in the GH or hot spots in the field	X	X	X	X	X
	Biological control	Multiple options	X	X	-	-	X
	Adequate irrigation	Water at time of day when foliage can dry rapidly	X	X	X	X	X

[Z]Diseases, WS= Wire Stem, CR= Club Rot, BR=Black Rot, ALS=Alternaria Leaf Spot, DM=Downy mildew
[X]Checklist for submitting samples to a diagnostic lab: http://goo.gl/2Rn3Kf
[Y]Consult **MSU Extension bulletin E- 312** for labeled fungicides

Black rot

Caused by the seedborne pathogen *Xanthomonas campestris pv. campestris*

Distinctive symptoms are V-shaped, brown lesions with yellow margins (see photo) in the leaves including head leaves. Black rot is favored by warm (68–77 F), humid conditions. This bacterial pathogen spreads from plant to plant through splashing rain or irrigation water.

Black rot V-shaped lesions on cabbage leaves.

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Above, lesions at the leaf margins from black rot. Below, black rot visible in a seedling flat.

Tom Creswell, Purdue University, Bugwood.org

Club root

Caused by the soilborne pathogen *Plasmodiophora brassicae*

Typical symptoms include club-like, deformed roots (see photo) and stunted plants. Low soil pH of less than 6.5 and wet conditions favor this disease. Swimming spores move in water to infect plant roots. Resting spores can survive many years in the soil.

Foliage affected by club root.

Both photos: Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Clubroot in cabbage roots deforms roots.

Alternaria leaf spot

Caused by several *Alternaria spp.* (*A. brassicae, A. brassicicola and A. japonica*)

The symptoms caused by these seed-borne pathogens are brown-to-gray, round lesions with concentric circles and yellow margins (see photo). Sunken, dark-brown lesions can occur in broccoli curds and cabbage heads. These fungal pathogens are spread by wind, rain or runoff water, and favored by high relative humidity and temperatures ranging from 52-88 F.

Alternaria leaf spot on cabbage.

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Alternaria leaf spot symptoms.

Elizabeth Bush, Virginia Polytechnic Institute and State University, Bugwood.org

Chinese cabbage plants showing extensive Alternaria leaf spotting.

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Resources

Michigan State University Extension bulletins (available at the MSU Extension Bookstore section of shop.msu.edu):

- **Bulletin E2934** Nutrient Recommendations for Vegetable Crops
- **Bulletin E486** Secondary and Micronutrients for Vegetable and Field Crops
- **Bulletin E0433** Weed Control Guide for Vegetable Crops
- **Bulletin E0312** Insect, Disease and Nematode Control for Commercial Vegetables
- **Bulletin E3165** Caterpillar Pests in Cole Crops

MSU Diagnostic Services. See their website for how to submit samples: www.pestid.msu.edu
For specific tips for preparing samples from vegetable fields, see http://bit.ly/vegSample

Downy mildew

Caused by *Hyaloperonospora parasitica*

Downy mildew occurs under cool (about 59 F) and humid conditions. This pathogen is windborne and can be dispersed short distances by water splashed from irrigation or rainfall. Typical symptoms are discolored, greenish-yellow to light-brown lesions with sporulation on the leaf undersides, while gray-to-brown discoloration can occur in curds and heads in the field or postharvest. The pathogen can overwinter in cruciferous weeds or, especially in years following a mild winter, in cole crop volunteers.

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Downy mildew symptoms on cabbage seedling leaves.

Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

Cabbage plants with downy mildew on the older leaves.

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Additional reading

Bennett, W.F. (ed.) 1993. Nutrient deficiencies and toxicities in crop plants. APS St. Paul MN.

Foster, R. and Flood B (eds.) 2005. Vegetable Insect Management. Purdue Research Foundation, West Lafayette IN.

Rimmer, S. R., Shattuck, V. I., Buchwaldt, L. (eds.) 2007. Compendium of Brassica diseases. APS St Paul MN.

Production guide for organic cole crops NYS IPM publication No. 1342. (http://nysipm.cornell.edu/organic_guide/cole_crops.pdf)

Midwest Vegetable Production Guide for Commercial Growers (http://www.btny.purdue.edu/pubs/id/id-56/).

Growing broccoli, cauliflower, cabbage and other cole crops in Wisconsin, a guide for fresh market growers. University of Wisconsin Publication A3688.

For cabbage variety ratings for disease and insect resistance, consult table 15 of the 2014 Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production (http://veg-guidelines.cce.cornell.edu/15frameset.html).

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500 JNL-IPM

Sample scouting sheet

Date:	Crop:	Crop stage:	Scouted by
Scouting sheet			
Pest	How field was scouted (circle sample unit if applicable)	Summary numbers #	Threshold (if applicable)
Flea beetle	Sample unit: plants #Sample units: #Samples/location: #Locations:		2-5 beetles/ plant
Diamond back moth	Sample unit: plants #Sample units: #Samples/location: #Locations:		Varies by crop and crop stage, see MSUE Bulletin E3165
Imported cabbage worm	Sample unit: plants #Sample units: #Samples/location: #Locations:		
Cabbage looper	Sample unit: plants #Sample units: #Samples/location: #Locations:		
Onion thrips	Sample unit: leaves or plant #Sample units: #Samples/location: #Locations:		3 thrips/leaf or 30 thrips/plant
Cabbage aphids	Sample unit: plants #Sample units: #Samples/location: #Locations:		Prior to heading 100 aphids/plant. After heading 1-2 % plants infested
Disease/ Disorder:	Sample unit: plants #Sample units: #Samples/location: #Locations:		

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