ORGANIC INSECT AND DISEASE CONTROL FOR BRASSICA CROPS

INTRODUCTION

Brassica plants belong to the mustard family, Brassicaceae. They are also called crucifers and cole crops. This diverse family, whose members have various edible plant parts such as roots of radish and turnips, stems of kohlrabi, leaves of cabbage and other leafy brassicas, and seeds of mustard and rape are consumed as fresh, cooked or processed vegetables. Other members of this family include broccoli, Brussels sprouts, cauliflower, collards, kale, rape and rutabaga. Many weed species are also in this family and can harbor insect and disease pests.

I. INSECT CONTROL

CABBAGE APHID (*Brevicoryne brassica*)

The primary aphid species is the cabbage aphid **(Photo 1.1)** whose colonies resemble clumps of "white ashes." They suck plant sap, causing leaf distortion and poor growth. Cabbage aphids are particularly difficult to control once they get in sheltered parts of the plant, such as cabbage heads or Brussels sprouts. Cabbage aphids can damage crops in the summer, but they tend to be more problematic in the fall. In recent years, late season aphid outbreaks have been increasing in fall brassica crops on organic farms, though the reasons are not clear. Green peach aphids are also sometimes a problem on brassica crops. They are notorious for transmitting virus diseases, which render some brassica crops unmarketable. The presence of live aphids, or even dead aphids that have been parasitized, may make the product unmarketable.

Cultural Control:

Encourage natural enemies by diversifying the habitat and their food sources, and refraining from use of broad-spectrum pesticides. The primary parasite of cabbage aphids in the Northeast is a very small, black wasp, *Diaeretiella rapae*, which lays its eggs inside the aphid. The parasite larva feeds inside the aphid, turning it a bronze color and killing it. It may take 2-3 weeks from the time the parasite lays its eggs inside the aphid until an adult parasite emerges from the dead aphid. Generally,

there is a lag period between the outbreak of aphids and control by the parasite, so some other control should be used, but one that does not harm the parasite. A diversified cropping system with several potential aphid hosts can allow *D. rapae* to maintain itself in an area during periods of low levels of aphid abundance on one crop. Many other insects, such as ladybird beetles and *Aphidoletes aphidimyza*, can also be effective biological control agents against aphids (Weeden et al. 2004).

Materials Approved for Organic Production:

1) Soap: Scout brassica plantings once or twice a week, especially in the fall, and apply insecticidal soap sprays if aphids are found. Do not wait until aphids reach high numbers and dense colonies; apply when numbers are low. Repeat applications two or three times and ensure coverage of the parts of the plant where aphids live, including undersides of leaves and in the buds, shoots or heads of Brussels sprouts, broccoli, cabbage, etc. In recent studies, soaps have been ineffective against green peach aphid. Other studies we examined indicated 5 good, 1 fair, and 2 poor results against other aphid species.

2) Rotenone is recommended in the older literature (currently, no rotenone products are on the OMRI approved list).

3) Neem products can provide some control. Based on a limited number of studies, neem products gave good control of turnip aphid (2 studies); fair (4) to poor (3) control of green peach aphid; and mostly good control of other aphids (2 good, 2 fair, 1 poor). Please see the neem chapter for a discussion of the different types of neem products.

4) Summer oils (2 fair and 3 poor results) will provide some control.

5) Kaolin clay will reduce aphid populations but will leave a white residue that may affect marketability.

CABBAGE LOOPER (*Tricholousia ni)*, **DIAMONDBACK MOTH** (*Plutella xylostella*), **IMPORTED CABBAGEWORM** (*Pieris rapae*)
The larvae of these *Lepidoptera* (moths and butterflies) eat the leaves of plants and may contaminate the marketable portion of brassica crops by their presence or their fecal matter. The imported cabbageworm **(Photo 1.2)** is the most common of these three, and overwinters locally throughout the Northeast so it is generally a pest every year. It overwinters as a pupa in crop debris, fence rows and weedy fields. The large white butterflies of the imported cabbageworm **(Photo 1.3)** can easily be seen during the day feeding on nectar from wild and cultivated crops, or moving from plant to plant laying eggs. Adult flights are a good warning of later potential problems on cultivated crucifers. The cabbage looper **(Photo 1.4)** does not overwinter outdoors in the Northeast and the diamondback moth's **(Photo 1.5)** ability to overwinter in northern sections is spotty. The diamondback moth and cab-

bage looper are commonly carried north from southern overwintering sites on weather fronts, but this does not occur every year. Invasions may also arise from infested transplants, especially those from southern areas. All three pests may produce multiple generations each summer. Scout brassicas by searching the undersides of leaves, so that young caterpillars and early feeding damage can be detected. Scout especially just before head formation begins, or when marketable leaves are small.

Cultural Controls:

1) Be sure to purchase only clean transplants or raise your own in clean greenhouse settings in order to avoid all three species. They are seen somewhat commonly on transplants from southern regions.

2) Cruciferous weed control near crop fields is important not only because weeds can act as an overwintering site for the imported cabbageworm, but can also support populations of all three pests during the crop season. In weedy fields, populations can build to epidemic levels from one generation to the next.

3) After harvesting early season brassica crops, the crop debris should be tilled into the soil to destroy larvae and pupae that could lead to higher populations on later brassica crops.

4) Trap crops have had variable success. Trap crops are plants that are more attractive to moths for egg laying; however one has to be careful that populations that build up on the trap crop do not spill over to the cash crop. See Appendix C for a more thorough discussion on trap cropping.

5) Encourage natural enemies. Several species of predatory and parasitoid wasps, as well as some generalist predators, prey on these caterpillars.

Materials Approved for Organic Production:

1) Spinosad can provide very good control (10 recent studies showed good control, 3 fair and one poor).

2) Bt gives some control of all three species but is best on imported cabbageworm. Recent studies showed 21 good, 13 fair, and 9 poor results. For fall crops, spray on the morning of a warm day when caterpillars will be actively feeding.

3) Neem products (4 good, 3 fair, and 7 poor results from recent studies) may require several applications. Please see the neem chapter for a discussion of the different types of neem products.

4) It is best to rotate a Bt product (e.g. Bt *aizawi* or Bt *kurstaki*) with another insecticide with a different mode of action (e.g. spinosad or neem) to avoid resistance development. The best course for delaying resistance is to apply only one class (bared on moode of action) to each insect generation. Do not mix two insecticides.

CABBAGE MAGGOT (*Delia radicum*)

The damage is caused by the larvae of a fly that lays its eggs at the base of the plants. The larvae feed on the roots **(Photo 1.6)** and the first symptom of infestation is wilting during the day. Infested plants are stunted and often die, especially during hot and dry conditions. Note that high soil organic matter seems to attract cabbage maggot flies.

Cultural Control:

1) Timing and avoidance - The life cycle of the cabbage maggot is shown in **Photo 1.7**. Insects overwinter as pupae, and adult flies emerge and become active about the same time that forsythia and yellow rocket are in bloom. More detailed emergence guidelines can be obtained by using degree day models obtained from your extension agent. Although there are two to three generations a year, the first, arising from the overwintering pupae, is the largest. Cabbage maggot eggs are very sensitive to high soil temperatures (above 95°F) and will die if exposed to these temperatures for several days in a row. If no mustard family crops are planted before about July 1 and early brassica weeds are well-controlled, cabbage root maggot pressure on later plantings will be minimal. However, fall root crops such as turnip, rutabaga and daikon can be damaged by later generations of maggot fly, which are active in late August and early September when soils are cooling down.

2) Exclusion methods can be very effective. Since flies lay their eggs on the soil around the base of the plant, placing a barrier at the plant base will prevent egg laying. In Europe small scale growers may use 'circles' of a material (e.g. heavy cloth or felt, or a firmer substance) to block eggs from being laid in the soil. The circle should be 5 inches in diameter and slit to the center so that it fits tightly around the base of the plant. Adults can also be excluded by using spunbonded row covers. Place the row covers on at the time of seeding and seal the edges with soil. Be sure to rotate fields to avoid flies emerging from overwintering sites under the row cover. Plants should also be tilled under as soon as possible after the last harvest to minimize overwintering populations.

3) Members of the Brassica family are the only hosts for cabbage maggots, therefore destroying wild relatives will help reduce cabbage maggot populations. This practice will also help in disease control. However, this may also reduce potential sites for natural enemies.

4) Some growers have adopted their own methods and there may be merit in trying such approaches. A grower in southeast PA claims success using sticky tape reels over early brassica rows plus foliar sprays based on the microbial product, EM5. "Effective Microorganisms" (EM) are used in a Japanese system known as Nature Farming (Diver 1998).

Materials Approved for Organic Production:

Nematodes have shown some efficacy, but the cultural controls (barriers and row covers) probably provide more cost effective control.

CRUCIFER (*Phyllotreta cruciferae*) **AND STRIPED FLEA BEETLE** (*Phyllotreta striolata*)

These small black beetles **(Photo 1.8)** can hop or fly from plant to plant where they feed on leaf margins or make small holes in leaves. Damage is most severe to seedlings; though plants can often outgrow the damage, the harvest will be delayed. With salad greens, kale, bunched turnips, or any harvest that includes leaves, the damage reduces marketability or yield.

Most flea beetles do not overwinter in cultivated fields. They spend the winter as dormant adults in leaf litter in windrows, headlands, treelines, fencerows, etc. Adults emerge from overwintering sites in early spring and begin feeding on the first cruciferous weeds. Eggs are laid in soil at the base of plants and larvae feed on the roots. A summer generation of adults emerges in late July and August.

Cultural Control:

1) Crops mulched with straw or other organic materials appear to suffer less damage.

2) The most effective control of flea beetles, however, is often the use of spunbonded row covers to exclude the beetles. Place the row covers on at the time of transplanting or seeding and seal the edges with soil.

3) Controlling brassica weeds can reduce flea beetle populations.

4) Perimeter trap cropping may work with flea beetles because they move into the field from the edges. Completely encircle the field with glossy leaf collards or Chinese giant mustard one to two weeks before establishing the main crop to allow the trap crop to reach an adequate size before the crop does. Be careful that flea beetles do not move from these trap crops to the cash crops. It may be necessary to treat the trap crop.

5) Timing of planting – fall-harvested crops only. If uncovered brassica crops are only grown after early July and brassica weeds have been strictly controlled, flea beetle pressure will be minimal on these late brassica crops.

6) Crop rotation. Avoid planting spring crops close to last fall's plantings, especially near woody or shrubby borders. Plant late brassicas (those planted after mid June) in a different field from spring brassicas so that summer adults emerging from spring crops do not attack new late summer plantings.

Materials Approved for Organic Production:

1) Since flea beetles can recolonize rapidly, especially on sunny days, frequent treatment with any material may be required. It is advisable to treat all brassicas in the field to reduce influx from untreated areas.

2) Growers have noted good control with rotenone (currently, no rotenone products are on the OMRI approved list).

3) Research trials have indicated that spinosad can be effective, though results are variable (1 good, 3 fair and 3 poor results).

4) Pyganic™ has also shown variable results (1 good, 3 fair, 1 poor) even with high rates.

5) Neem products are similarly effective (2 fair, 2 poor results). Please see the neem chapter for a discussion of the different types of neem products.

6) Capsaicin gives some control (45% in one study). The product, Miller's Hot Sauce is OMRI-approved and labeled for use on crop plants as a mammal repellant. If so used, it will also reduce flea beetle damage.

ONION THRIPS (*Thrips tabaci)*
Onion thrips **(Photo 1.9)** can be a severe pest on many crops, including cabbage. On some cabbage varieties their feeding causes bronze discolorations **(photo 1.10)**. Many cabbage varieties have high levels of tolerance/resistance. The key to control of thrips on cabbage is to use a tolerant variety. A list of varieties and their tolerance can be seen at the Cornell Management Guidelines (Cornell 2004) in the cabbage chapter.

Cultural Control:

1) Avoid susceptible varieties.

2) Since onion thrips often migrate into cabbage from surrounding fields of wheat, oats and alfalfa, separating cabbage fields from these crops will help reduce the potential infestation.

3) Avoid planting onions close to brassicas, because the same species of thrips attacks both crops.

Materials Approved for Organic Production:

Spinosad (1 good, 6 fair, and 2 poor control in recent studies).

II. DISEASE CONTROL

One of the most important measures in disease control is to start with healthy plants. While this seems obvious, disease symptoms can be easily overlooked. Sources of pathogens include infested seed, debris from previous infected plantings, and infected weeds for transplants grown outdoors. Many growers use transplants for brassica crops. If using transplants, it is important to make certain that the plants are disease-free. One way to do this is to grow your own transplants, so that they can be inspected weekly for disease symptoms. If plants are purchased commercially, be certain to carefully check transplants for disease symptoms before planting.

DISEASES CAUSED BY BACTERIA

BLACK ROT (*Xanthomonas campestris* pv. *campestris*)
Infected plants develop yellow to tan V-shaped lesions at the leaf margins **(Photo 1.11)**. The pathogen frequently will enter the plant through pores on the leaf margin, and spread systemically. Within the yellow lesion, veins can become black. The bacterium can survive on seeds, and in infected crop debris. Black rot is common in seedlings, but plants can be infected at any age. The pathogen can be spread by splashing water, workers moving from an infected field to a healthy field, insects or animals and on transplants. Because the disease can be seed-borne, it is important to inspect all greenhouse transplants for black rot. Systemically infected seedlings will become yellow, drop lower leaves and may die. Any yellowing plants or plants with V-shaped lesions should not be planted in the field as they will serve as a source of bacteria that may spread to other plants.

Cultural Control:

1) Plant varieties with some level of resistance/tolerance. A list of varieties and their tolerance can be seen at the Cornell Management Guidelines (Cornell 2004) in the cabbage chapter.

2) Use hot water treated seed. For cabbage and Brussels sprouts soak seed for 25 min in 122°F water, soak for 20 min for Chinese cabbage, broccoli and cauliflower. Precise time and temperature control is essential to minimize damage to the seed.

3) Destroy crop debris after harvest.

4) Avoid overhead irrigation.

5) Use a 3-year rotation away from crucifer crops.

Materials Approved for Organic Production:

Copper compounds can be used, but have not been effective in recent studies (two poor results).

HEAD ROT (several bacteria including *Psuedomonas* and *Erwinia* spp.)
This disease is worse on broccoli, causing a rotting of the head that starts in the center. Warm, wet conditions favor the development of head rot.

Cultural Control:

1) Use well-domed varieties.

2) Harvest when heads are tight.

3) Cut stalks at an angle so that water cannot collect on the cut stalk left in the field to avoid providing bacteria a place to become established.

Materials Approved for Organic Production:

Copper is somewhat effective.

DISEASES CAUSED BY FUNGI AND FUNGAL-LIKE ORGANISMS

ALTERNARIA LEAF SPOT (*Alternaria brassicae, A. brassicicola, A. raphani*)
The most common symptom of this disease is leaf spotting **(Photo 1.12)** but damping-off and damage to the flowers and seed also occurs. Leaf lesions begin as small black dots and enlarge to form target-like dark brown spots. Large numbers of spores are produced and can be spread by wind and rain. These spores rarely move farther than adjacent fields, thus infested seed is the chief means of spread to a farm. Greenhouse transplants should be inspected weekly for pinpoint black circular spots, as these are the first signs of the disease.

Cultural Control:

1) Use hot water treated seed. For cabbage and Brussels sprouts soak seed for 25 min in 122°F water, soak for 20 min for Chinese cabbage, broccoli and cauliflower. Precise time and temperature control is essential to minimize damage to the seed.

2) Use clean transplants.

3) Long rotations (3 years) without crucifer crops or cruciferous weeds such as wild mustard.

4) Destroy cull crop and crop debris after harvest.

5) Plant later plantings upwind of earlier plantings.

6) Allow for good air movement (i.e. wide spacings, rows parallel to prevailing winds, not close to hedgerows).

Materials Approved for Organic Production:

Copper compounds are labeled, but have not been effective in recent studies (two poor results).

BLACKLEG (*Phoma lingam*)
Seedling infection may be first seen on the cotyledons or first true leaves. Bluish lesions may appear on stems that later elongate into light brown sunken areas with black margins and the stem will become girdled and blackened **(Photo 1.13)**. Inspect all greenhouse transplants for stem lesions.

Cultural Control:

1) Use hot water treated seed. For cabbage and Brussels sprouts soak seed for 25 min in 122°F water, soak for 20 min for Chinese cabbage, broccoli and cauliflower. Precise time and temperature control is essential to minimize damage to the seed.

2) Use a 4-year crop rotation without crucifer crops.

3) Avoid manure from livestock fed cruciferous crops.

4) Eliminate cruciferous weeds.

5) Destroy cull crop and crop debris after harvest.

6) Plant later plantings upwind of earlier plantings.

7) Allow for good air movement (i.e. wide spacings, rows parallel to prevailing winds, not close to hedgerows).

Materials Approved for Organic Production:

None known to be effective.

CLUBROOT (*Plasmodiophora brassicae*)

The symptoms of clubroot are seen below ground before any symptoms appear on the above ground plant. Infected roots enlarge to form galls **(Photo 1.14)**. Severely distorted roots are unable to absorb water and minerals and the top growth is later stunted with yellow lower leaves. The disease overwinters as resting spores in the soil. Transplants should be checked for clubroot symptoms and destroyed if found.

Cultural Control:

1) Attain soil pH above 7.2 and high calcium and magnesium levels.

2) Rotate infested fields out of brassicas for a minimum of 7 years.

Materials Approved for Organic Production:

None known to be effective.

DOWNY MILDEW (*Peronospora parasitica*)

First symptoms are seen as discolored spots on the cotyledons, which can be a source of spores and later turn yellow and die. Discrete yellow areas on the upper surface of leaves and fluffy, white pathogen growth on the undersurface appears later. Irregular black spots develop on broccoli. The affected areas enlarge and turn tan and papery under moist conditions **(Photo 1.15)**. Spores overwinter in the soil and on crop debris.

Cultural Control:

1) Use a 3- year rotation without crucifer crops.

2) Avoid overhead irrigation.

3) Allow for good air movement (i.e. wide spacings, rows parallel to prevailing winds, not close to hedgerows).

Materials Approved for Organic Production:

Copper compounds.

WHITE MOLD (*Sclerotinia sclerotiorum*)

White mold is a fungal disease caused by *Sclerotina sclerotiorum*, which has a very wide host range including tomatoes, eggplants, peppers, beans, carrots, lettuce, cole crops and many weeds. Early symptoms are water soaked lesions followed by a rotting of stem tissue or entire head of cabbage **(Photo 1.16)**. Later a pure white fungal growth will appear and hard, black sclerotia (overwintering structures of the fungus) often develop in this growth **(Photo 1.17)**. These sclerotia will survive in the soil for several years. This disease is worse on heavy soils with poor drainage.

Cultural Control:

1) Use raised beds and install drainage tiles to improve drainage if necessary.

2) Rotation is difficult because so many crops and weeds are hosts and the sclerotia are very long-lived in the soil. Four years of cereal crops or sweet corn will likely work if weed hosts are controlled.

3) Avoid excessive irrigation.

4) Avoid over crowding and weeds that prevent air circulation in the field.

Materials Approved for Organic Production:

Coniothyrium minitans (Contans™). Contans is a fungus that once applied and incorporated into the soil, attacks and destroys the white mold sclerotia. Contans™ is applied at or before planting time. It is dissolved into water and sprayed directly onto the soil surface. Contans™ should be applied after a crop with high levels of white mold infection to reduce survival of the sclerotia.

REFERENCES

Cornell 2004. Integrated Crop & Pest Management Guidelines for Commercial Vegetable Production. http://www.nysaes.cornell.edu/recommends/ Cornell Cooperative Extension.

Diver, S. 1998. Nature Farming and Effective Microorganisms. http://www.nationalwatercenter.org/natfarm.htm

Weeden, C.R., A.M. Shelton, Y. Li, M. P. Hoffman. 2004. *Biological Control: a Guide to Natural Enemies in North America.* Cornell University. http://www.nysaes.cornell.edu/ent/biocontrol/

CHAPTER 1 - BRASSICA

Photo 1.1 Cabbage aphid colony. Bronze aphid is parasitized.

Photo 1.2 Imported cabbageworm larva.

Photo 1.3 Imported cabbageworm adult.

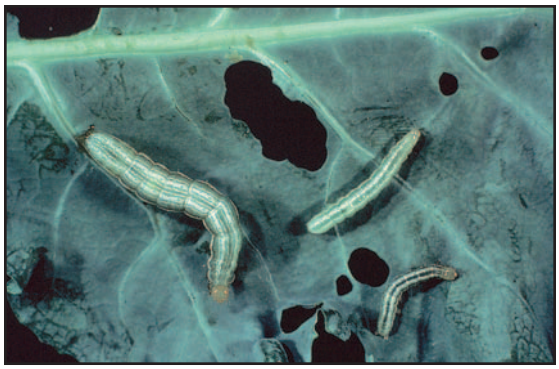

Photo 1.4 Cabbage looper larvae.

Photo 1.5 Diamondback moth larva.

Photo 1.6 Cabbage maggot larvae feeding on roots.

Photo 1.7 Cabbage maggot eggs, larva, pupa and adult.

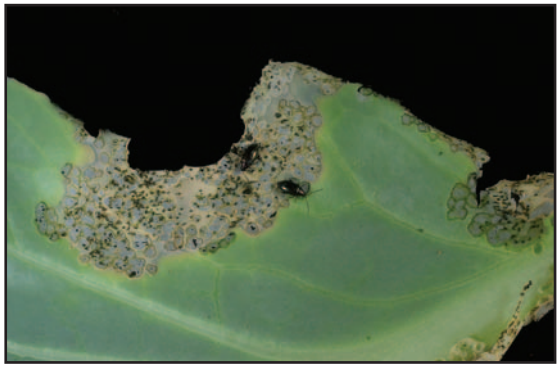

Photo 1.8 Flea beetles on cabbage.

Photo 1.9 Onion thrips adult greatly magnified.

Photo 1.10 Onion thrips damage on cabbage.

Photo 1.11 Black rot symptoms on cabbage.

Photo 1.12 Alternaria leaf spot symptoms on cabbage.

Photo 1.13 Black leg symptoms on cauliflower (courtesy G.S. Abawi).

Photo 1.14 Club root symptoms on Brussels sprouts (courtesy G.S. Abawi).

Photo 1.15 Downy mildew symptoms on broccoli (courtesy G.S. Abawi).

Photo 1.16 White mold symptoms on cabbage.

Photo 1.17 White mold symptoms on Brussels sprouts (courtesy G.S. Abawi)