# Crop Profile for Cabbage in New York

**Prepared: May, 1999**

## General Production Information

NY ranks number one in the country in production of fresh cabbage, and number two in processing cabbage. Valued at over $62 million per year, cabbage and other crucifers (broccoli, cauliflower, Brussels sprouts, radishes, kale, collards, turnips, rutabagas, turnip and mustard greens, Chinese cabbage, and several other specialty vegetables) rank second in economic importance among New York vegetables, just after potatoes. Because cabbage represents the great majority (84%) of acres of crucifers in NY, the information in this Crop Profile pertains to this crop, except where explicitly noted.

Crucifers are attacked by a wide variety of pests, and pest management is complex and costly for these extremely important vegetable crops. While producers use a variety of insecticides of varying classes, organophosphates, including chlorpyrifos, diazinon, dimethoate, endosulfan, and oxydemeton-methyl, play a very important role in cabbage insect management. Organophosphates and carbamates are the only effective materials currently available for control of cabbage maggots. Their use in rotation with other classes of insecticides greatly aids in resistance management and control of diamondback moth and onion thrips, two of the most difficult insect pests to manage in cabbage. Aphid control without organophosphates could be significantly more problematic and expensive. Without the registration of new effective materials to replace them, the loss of chlorpyrifos, diazinon, dimethoate, endosulfan, and oxydemeton-methyl would have significant impacts on production and profitability.

Many cabbage diseases are managed primarily through cultural practices, however foliar fungicides (such as chlorothalonil) are necessary for disease control, especially for stored cabbage. Cabbage producers have fewer and fewer herbicides available for weed control, and the industry has a critical need for registrations of new effective herbicides.

Registration of new materials by the EPA, even those designated as "low risk", does not guarantee that NY growers will have immediate access to them. The New York State Department of Environmental Conservation conducts its own in-depth reviews before registering new pesticides for use in NY, and may or may not register new materials for portions of or for the entire state.

**Basic Commodity Information:**

| | *Cabbage, Fresh and Storage* | *Cabbage, Processing* | *Cauliflower, Fresh* |
|---|---|---|---|
| **State Rank:** | 1 | 2 | 3 |
| **% U.S. Production:** | 24 | 38 | 3 |
| **Acres Planted:** | 12,600 | 3,000 | 1,400 |
| **Acres Harvested:** | 12,100 | 3,000 | 1,400 |
| **Cash Value:** | $49,909,000 | $2,868,000 | $9,637,000 |
| **Production Costs:** | NA | NA | NA |

**Other Cruciferous Vegetables:** While figures on minor cruciferous crops are not collected annually by NYS Agricultural Statistics Service, the 1997 US Census of Agriculture lists the following production in the state: 810 acres radishes; 612 acres broccoli; 46 acres turnips and turnip greens; 67 acres collards; 64 acres kale; and 54 acres Brussels sprouts. In addition, there are probably another 500-1000 acres of untracked Oriental cruciferous vegetables produced in the state.

**Production Regions:** Fresh market and processing cabbage are produced primarily in the Lake Plains (Genesee, Orleans, Monroe, Niagara, Erie, Chautauqua Counties) and Finger Lakes regions (Ontario, Wayne, and Yates Counties). Significant fresh market cabbage is also produced in Suffolk County. Suffolk, Erie, Niagara and Monroe Counties contribute the majority of cauliflower acreage. Most of the other cruciferous vegetables listed above are produced in Suffolk, Orange and Ulster Counties for nearby urban markets.

## Cultural Practices

Cabbage is a cool-season crop that grows best on well-drained soils with good moisture holding capacity. Loams, clay loams, and muck soils are ideal, but lighter soils can also produce good cabbage if managed carefully. Cabbage grows well under moderate temperatures (up to $85^0$ F) and withstands moderate frosts. It requires constant and adequate moisture; dry periods can result in small head size and tipburn. Cabbage is very sensitive to nutrient deficiencies and low pH. Because of disease problems, crop rotation with non-cruciferous crops is essential.

Several types of cabbage are grown in New York. Fresh market green and red cabbage cultivars are compact and grow rapidly. These are marketed immediately after harvest. Processing cabbage varieties are larger at maturity, and are made into sauerkraut. Storage types are late-maturing, medium- to large-sized varieties that will store well for up to five months. Storage cabbage is sold for cole slaw, salads or other processed food products, and to a lesser extent for fresh market retail sale. While crops planted for processing almost always end up as kraut, there is more of an overlap between fresh market and storage crops. Good prices and strong demand may mean that some storage cabbage is sold out of the field and never stored.

Most cabbage in NY is transplanted either as bare-root seedlings or as plug transplants, but a considerable portion of the crop grown for late summer or fall harvest is direct seeded. Planting of fresh market cabbage usually starts in late April or early May in upstate NY and one to two weeks earlier on Long Island. Storage cabbage is usually transplanted in June or early July for mid- to late-fall harvest. Plants four to six weeks old, slightly hardened, with four to five true leaves are best. Transplants for summer plantings are usually grown in field nurseries known as "seed beds". Seed is sown densely, often in muck soils, and plants are gently lifted out of the seed bed at approximately four weeks for transplanting in the field. For early spring planting, plants are grown in greenhouses, or they are shipped in from southern states as plug transplants or bare-root seedlings. For direct seeded crops, seed can be planted outdoors relatively early in the spring. A direct seeding can be more difficult to establish than a transplanted crop, but if the seed is relatively inexpensive, direct seeding can be less costly.

Spacing varies by type and market. Row spacing is typically 30", but can vary from 24 to 36 inches. In-row spacing for fresh market cabbage is 10-14 inches, 14-18 inches for storage cabbage, and 18-24 inches for kraut cabbage. In dry seasons, fresh market cabbage, and less frequently storage and processing cabbage, can be irrigated. Cultivation is necessary for weed control and to aerate the soil.

Processing cabbage is harvested almost entirely by machine, but fresh-market and storage cabbage are hand-harvested. Harvest aids such as conveyer belts that carry cabbage into pallet boxes in the field are frequently used for large storage cabbage fields. Fresh market cabbage is cut with four to five wrapper leaves, and harvest may begin as early as the first week of July, continuing through the fall. Storage and processing harvests run from mid-October through November. Stacks of pallet bins filled with storage cabbage are placed in insulated storage buildings. These facilities are kept cool through the winter and spring using ventilation with outside air or refrigeration. The cabbage is brought out of storage throughout this period, trimmed of all outside leaves, and packed in mesh bags or bulk bins.

## Insect Pests

**Cabbage Root Maggot** (*Delia brassicae*, aka *Hylemya brassicae*)

**Frequency of Occurrence:** Annually

**Damage Caused:** The larvae or maggots of this small fly feed on the roots and lower stems of cruciferous crops. Young plants attacked by maggots usually wilt and die. Mature plants attacked by later generations are weakened and are predisposed to secondary infections such as blackleg and soft rot. Maggots from later generations sometimes burrow up into the core of the cabbage, rendering it unmarketable. Similarly, later generations may burrow into brussels sprouts.

**% Acres Affected:** 100% at risk; up to 75% affected per year.

**Pest Life Cycles:** The cabbage maggot is a serious pest in early direct-seeded or transplanted cabbage and other cruciferous crops. Cabbage maggot problems are most serious in cool, wet weather. Pupae overwinter in the soil. The adult flies are small, bristly and gray. They emerge from the soil in early May and lay small, white eggs on plants and related weeds near the soil surface or in the soil at the base of the plants. The short (1/4 inch), white maggots emerge a few days later and burrow into the plant stems and roots. There are three generations of cabbage maggot each year. The first generation does the most damage because it emerges when transplants and seedlings are small. Later generations do less damage because many are killed by high soil temperatures and the crops are advanced enough to withstand some injury.

**Timing of Control:** April through July, at planting and early seedling stages.

**Yield Losses:** Can be as high as 50% in severely affected fields. Entire loads of processing cabbage have been rejected because of maggots in the cores.

**Cultural Control Practices:** Spunbound row covers can provide some control (up to 90%) of cabbage maggots where they can be used practically (i.e. smaller plantings). Crop rotation will help reduce root maggot populations. Plants grown in light, sandy soils are more susceptible to injury. Crop debris should be destroyed as soon as possible after harvest to minimize the spread of this insect pest. No resistant varieties are available. Broccoli and cauliflower are more susceptible to early generation damage than cabbage and Brussels sprouts.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** None.

**Other Issues:** Research on control of cabbage maggot is currently underway (Shelton). The focus of this research is on finding effective, non-OP alternatives to chlorpyrifos and diazinon.

**Chemical Controls for Cabbage Maggot:**

| Pesticide | % Trt. | Type of Appl. | Typical Rates lbs ai/acre | Timing | # of Appl. | PHI[1] days | REI hours |
|---|---|---|---|---|---|---|---|
| **chlorpyrifos** *(Lorsban)* | 30 P[2] 40 F | Ground[3] | 1.0 | At planting | 1 | 60 | 24 |
| **diazinon**[4] *(Diazinon)* | 1-5 P, F | Soil incorporated | 2.0-3.0 | At planting | 1 | 60 | 24 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **azinphos-methyl** *(Guthion)* | <1 | soil drench | 4.2 | At planting | 1 | 60 | 48 |

**1.** PHI on this and all tables indicates the shortest actual number of days between application and harvest, not label PHIs.

**2.** P=processing cabbage; F=fresh market and storage cabbage.

**3.** Applied as a granular or spray band at planting over the row and incorporated shallowly during planting. For direct seeded and transplanted crops.

**4.** For seedbed use only. Although treated acreage is low, this provides protection for a very large number of plants.

**Use in IPM Programs:** As-needed use of above materials is consistent with Cornell IPM recommendations. IPM guidelines provide a method to predict the arrival of the first generation of cabbage maggots (correlates with blooming of yellow rocket, a naturalized plant species). It has also been determined that there is no need to spray for this pest if soil temperatures have been high for several consecutive days, as this will kill cabbage maggot eggs. Thus, the acreage needing a chemical control is limited by timing of planting, and in some years, by prevailing weather.

**Use in Resistance Management:** No resistance reported.

**Alternatives:** Thiamethoxam, a new material from Novartis (trade name Adage) may be an effective alternative, but trials have yet to be conducted. Cyromazine (Trigard) may also be useful for cabbage maggot control but additional trials are needed.

**Imported cabbageworm** (*Pieris rapae*)

**Frequency of Occurrence:** Annually.

**Damage Caused:** Damage from imported cabbageworms (ICW) can cause a loss in the quality (100%) and quantity yield (25-60%) of cabbage crops. Some injury can be tolerated in cabbage prior to heading. Their feeding can kill small plants and delay maturity of older plants.

**% Acres Affected:** 100%

**Pest Life Cycles:** Imported cabbageworm adults, the white butterflies often seen around cruciferous crops, overwinter as pupae and emerge in late April or early May and lay their yellow eggs singly on the leaves of cruciferous crops and weeds. The velvety green worms, which grow to over one inch in length, eat holes in leaves and leave large amount of green debris on the leaves. They pupate on the leaves or may wander, especially in the fall, and pupate on nearby structures. There are commonly three generations a year, and the adults and larvae may be active until frost.

**Timing of Control:** June through September

**Yield Losses:** Up to 100% in severely affected fields. Loads of fresh market and processing cabbage can be rejected by buyers due to presence of worms.
**Cultural Control Practices:** No resistant varieties are available.

**Regional Differences:** None.

**Biological Control Practices:** Predators can reduce ICW populations by as much as 40%. Parasites such as *Cotesia glomeraus* or the newly immigrated *C. rubculla* can have rates of parasitism as high as 75%. Natural enemies can be preserved by using pesticides that are less harmful to them. Mycotrol, a commercial product containing the entomopathogenic fungus *Beauvaria bassiana*, is is being tested for control of ICW (Shelton).

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible after harvest to minimize the spread of ICW to other plantings

**Other Issues:** Research on control of ICW and other lepidopteran pests (DBM and cabbage loopers) is ongoing (Shelton; Gilrein). The focus of this research is to screen new insecticide materials, evaluate biocontrol methods, and to develop resistant varieties.

**Chemical Controls:** Pesticide use patterns can vary considerably depending on type of cabbage grown, geographic region, timing of planting and harvest, and yearly variations in pest pressure. The following tables provide estimated insecticide use for processing cabbage (first table) and fresh market and storage cabbage (second table). The first table is based on several years of processor records; the second is based on surveys and estimates of key growers and consultants.

**Insecticides for Foliar Insect Control in Processing Cabbage:**

| Pesticide | Target Pest[1] | % Trt. | Type of Appl. | Typical Rates, lbs ai/acre | Timing | # of Appl. | PHI days | REI hours |
|---|---|---|---|---|---|---|---|---|
| **Bacillus thuringiensis** *(many)* | ICW DBM CL | 20 | foliar | varies with formulation | as needed through season | 2 | 14 | 4 |
| **methomyl** *(Lannate)* | ICW DBM CL | <1 | foliar | 0.9 | as needed through season | 1 | 14 | 48 |
| **esfenvalerate** *(Asana)* | ICW CL OT | 10 | foliar | 0.025-0.05 | as needed through season | 1.5 | 14 | 12 |
| **endosulfan** *(Thiodan)* | ICW FB | 18 | foliar | 0.6 | as needed through season | 1 | 14 | 24 |
| **permethrin** *(Ambush, Pounce)* | ICW DBM CL, OT | 10 | foliar | 0.1 | as needed through season | 1.5 | 14 | 12 |
| **cypermethrin** *(Ammo)* | ICW DBM CL, OT GPA | <1 | foliar | 0.5 | as needed through season | 1 | 14 | 12 |
| **zeta-methrin** *(Mustang)* | all | 5 | foliar | 0.05 | as needed through season | 1 | 14 | 12 |
| **lambda-cyhalothrin** *(Warrior)* | all | 75 | foliar | 0.025 | as needed through season | 2 | 14 | 12 |
| **spinosad** *(Spintor)* | ICW DBM CL | 18 | foliar | 0.05-0.1 | as needed through season | 1.5 | 14 | 4 |
| **carbaryl** *(Sevin)* | ICW FB | 6 | foliar | 0.5 | as needed through season | 1 | 14 | 12 |

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|---|---|---|---|---|---|---|---|---|
| **diazinon** *(Diazinon)* | CA | <1 | foliar | 0.5 | as needed through season | 1 | 21 | 24 |
| **dimethoate** *(Dimethoate)* | OT CA | 50 | foliar | 0.5 | as needed through season | 2 | 14 | 48 |
| **oxydemeton-methyl** *(Metasystox-R)* | CA | 20 | foliar | 0.5 | as needed through season | 1.5 | 14 | 48 |
| **azinphos-methyl** *(Guthion)* | ICW DBM CL | 2 | foliar | 0.5 | as needed through season | 1 | 21 | 48 |
| **imidacloprid** *(Admire, Provado)* | CA | 0 | soil, banded; sidedressed; or foliar | 0.16-0.38 (soil); 0.05 (foliar) | at planting; or through season | 1 | 60 | 12 |
| **disulfoton** *(Di-Syston)* | CA FB | 0 | soil-applied systemic | 1.0 | at planting or 1st sidedressing | 1 | 42 | 48 |

**1.** Key to target pests: ICW=imported cabbage worm; DBM=diamondback moth; CL=cabbage looper; FB=flea beetle; CA=cabbage aphids; GPA=green peach aphids; OT=onion thrips.

**Insecticides for Foliar Insect Control in Fresh and Storage Cabbage:**

| Pesticide | Target Pests | % Trt. | Type of Appl. | Typical Rates lbs ai/acre | Timing | # of Appl. | PHI[1] days | REI hours |
|---|---|---|---|---|---|---|---|---|
| **Bacillus thuringiensis** ***(many)*** | **ICW DBM CL** | **55** | **foliar** | **varies with formulation** | **as needed through season** | **2.5** | **3** | **4** |
| **methomyl** ***(Lannate)*** | **ICW DBM CL BAW** | **<1** | **foliar** | **0.9** | **as needed through season** | **1** | **7** | **48** |
| **esfenvalerate** ***(Asana)*** | **ICW CL OT** | **55** | **foliar** | **0.04** | **as needed through season** | **2.5** | **3** | **12** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **endosulfan** *(Thiodan)* | ICW FB | 18 | foliar | 0.75 | as needed through season | 1 | 7 | 24 |
| **permethrin** *(Ambush, Pounce)* | ICW DBM CL, OT | 15 | foliar | 0.05-0.2 | as needed through season | 1 | 3 | 12 |
| **cypermethrin** *(Ammo)* | ICW DBM CL, OT GPA | <1 | foliar | 0.5-1.0 | as needed through season | 1 | 3 | 12 |
| **zeta-methrin** *(Mustang)* | all | 25 | foliar | 0.05 | as needed through season | 2 | 3 | 12 |
| **lambda-cyhalothrin** *(Warrior)* | all | 85 | foliar | 0.015-0.025 | as needed through season | 3.5 | 3 | 12 |
| **spinosad** *(Spintor)* | ICW DBM, CL, BAW | 20 | foliar | 0.05-0.1 | as needed through season | 2 | 3 | 4 |
| **carbaryl** *(Sevin)* | ICW FB | <5 | foliar | 0.5-2.0 | as needed through season | 1 | 7 | 12 |
| **diazinon** *(Diazinon)* | CA | <1 | foliar | 0.5 | as needed through season | 1 | 21 | 24 |
| **dimethoate** *(Dimethoate)* | OT CA | 90 | foliar | 0.25-0.5 | as needed through season | 3 | 7 | 48 |
| **oxydemeton-methyl** *(Metasystox-R)* | CA | 23 | foliar | 0.5 | as needed through season | 1 | 7 | 48 |
| **azinphos-methyl** *(Guthion)* | ICW DBM CL | 8 | foliar | 0.5-0.75 | as needed through season | 1.5 | 21 | 48 |
| **imidacloprid** *(Admire, Provado)* | CA | 1-5 | soil, banded; sidedressed; or foliar | 0.16-0.38 (soil); 0.05 (foliar) | at planting; or through season | 1 | 60 | 12 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **disulfoton** ***(Di-Syston)*** | **CA** **FB** | **15** | **soil-applied systemic** | **1.0** | **at planting or 1st sidedressing** | **1** | **42** | **48** |

1. Key to target pests: ICW=imported cabbage worm; DBM=diamondback moth; CL=cabbage looper; FB=flea beetle; CA=cabbage aphids; GPA=green peach aphids; OT=onion thrips; BAW=beet army worm.

**Use in IPM Programs:** As-needed use of materials listed above is consistent with Cornell IPM recommendations for ICW control. A well-developed procedure for scouting cabbage for ICW and other lepidopteran pests is currently in use. Economic thresholds based on pest infestations, size of pests, crop stage, and crop market have been established. For more information, see Reference #3.

**Use in Resistance Management:** None reported.

**Efficacy Issues:** Of the three lepidopteran pests of cabbage, ICW is the easiest to control with currently available insecticides. Some materials (e.g. permethrin) perform better under cool weather conditions, while others (e.g. Bts) are most effective when weather is warm.

**Alternatives:** Several new insectides currently under development, including emamectin benzoate (Proclaim; Novartis), and indoxacarb (Avaunt; DuPont), may become effective options. Other possible alternatives include biphenthrin (trade name Capture), a pyrethroid, and Alert (from American Cyanamid). Efficacy tests need to be conducted on all of these materials.

**Cabbage Looper**(*Trichoplusia ni*)

**Frequency of Occurrence:** Annually.

**Damage Caused:** Cabbage loopers (CL) cause foliar injury and can be a contaminant at harvest. Plant damage and product contamination are similar to that of imported cabbage worm.

**% Acres Affected:** 100%

**Pest Life Cycles:** Cabbage looper can be a serious mid- and late season pest of cabbage and other crucifers. They do not overwinter in NY; adults migrate into the state during July and August. The adults are about 1 to 1½ inches across, gray-brown, and fly and lay eggs mostly at night. Eggs are laid singly on the underside of the foliage. The larvae are light green, with a white stripe on each side, about 1 inch long, and move by humping their back like an inch-worm, hence the name "looper." There may be 2 or 3 generations per year. As the larvae grow, they become more difficult to control. Hosts of the cabbage looper include crucifers, celery, tomatoes and potatoes.

**Timing of Control:** Late July through harvest.

**Yield Losses:** Can be as high as 100% in severely affected fields. Loads of fresh market and processing cabbage can be rejected by buyers due to presence of worms.

**Cultural Control Practices:** Some varieties are more susceptible than others. Adverse weather conditions (cool and wet) will reduce looper populations.

**Regional Differences:** Because of its migratory nature, this insect arrives earlier in Long Island (mid-July) than in upstate NY.

**Biological Control Practices:** Natural enemies may help to control CL populations. They can be conserved by using insecticides that are less harmful to them. Mycotrol, a commercial product containing the entomopathogenic fungus *Beauvaria bassiana*, is still being tested aganst cabbage looper (Shelton).

**Post-Harvest Control Practices:** None.

**Other Issues:** Research on control of CL and other lepidopteran pests is ongoing (Shelton; Gilrein). The focus of this research is to screen new insecticide materials, evaluate biocontrol methods, and to support efforts to develop resistant varieties.

**Chemical Controls:** See Imported Cabbage Worm section, above.

**Use in IPM Programs:** As-needed use of materials listed above is consistent with Cornell IPM recommendations for CL control. A well-developed procedure for scouting cabbage for CL and other lepidopteran pests is currently in use. Economic thresholds based on pest infestations, size of pests, crop stage, and crop market channel have been established. For more information, see Reference #3.

**Use in Resistance Management:** None reported.

**Efficacy Issues:** Cabbage loopers are best controlled while still small, and thus scouting is very important. Larger loopers can be difficult to control. Some materials (e.g. permethrin) perform better under cool weather conditions, while others (e. g. Bts) are most effective when weather is warm. Spintor is reasonably effective but is an expensive option.

**Alternatives:** Several new insectides currently under development, including emamectin benzoate (Proclaim; Novartis), and indoxacarb (Avaunt; DuPont), may become effective options. Other possible alternatives include biphenthrin (trade name Capture), a pyrethroid, and Alert (from American Cyanamid). Efficacy tests need to be conducted on all of these materials.

**Diamondback Moth** (*Plutella maculipennis*)

**Frequency of Occurrence:** Annually.

**Damage Caused:** The larval stage of the diamondback moth (DBM) eats numerous small holes in the leaves, and sometimes leaves fine webbing in the center of the plant. Foliar injury lowers the quality of the crop, and weakens the plant. The larvae themselves can be a contaminant of the final product. Of the three lepidopteran pests of cabbage, DBM is by far the most difficult to control in NY.

**% Acres Affected:** 100%

**Pest Life Cycles:** DBM adults can migrate from southern states into NY in late April and May but the majority of the problem appears to be DBM which enter the state on southern-grown transplants. While DBM does not overwinter in upstate NY, it does overwinter on Long Island in most years. Eggs are laid singly or in groups of two or three on the underside of lower leaves or stems. After hatching, larvae pass through four instar stages over a period of 14-30 days. The pupa develops within a loosely spun cocoon attached to the leaves and stems of plants. Adults emerge in 7-15 days. Four to six generations can occur per season. Hot dry conditions favor survival and reproduction, making control difficult.

**Timing of Control:** June 1 through harvest.

**Yield Losses:** Can be up to 100% in severely infested fields. Loads of fresh market and processing cabbage can be rejected by buyers due to presence of worms.

**Cultural Control Practices:** No resistant varieties are available, but there are differences in susceptibilities among commercial varieties. Adverse weather conditions can reduce DBM populations.

**Regional Differences:** None.

**Biological Control Practices:** Natural enemies can help to control DBM populations. They can be preserved by using pesticides that are less harmful to them. Mycotrol, a commercial product containing the entomopathogenic fungus *Beauvaria bassiana,* has shown some efficacy on DBM, but is not as effective as other materials such as spinosad (Shelton).

**Post-Harvest Control Practices:** None.

**Other Issues:** Research on control of DBM and other lepidopteran pests is ongoing (Shelton; Gilrein). The focus of this research is to screen new insecticide materials, evaluate biocontrol methods, and to support efforts to develop resistant varieties.

**Chemical Controls:** See Imported Cabbage Worm section, above.

**Use in IPM Programs:** As-needed use of materials listed above is consistent with Cornell IPM recommendations for CL control. A well-developed procedure for scouting cabbage for CL and other lepidopteran pests is currently in use. Economic thresholds based on pest infestations, size of pests, crop stage, and crop market crop have been established. For more information, see Reference #3.

**Use in Resistance Management:** Resistance management is a key aspect of DBM control, because this insect is well known to quickly develop resistance to insecticides, such as Bts and pyrethroids. Depending on the source of moths, insects found in a field may be resistant to pyrethroids, organophosphates, carbamates, and/or Bt products. Preliminary research suggests that there may be a possibility of cross-resistance to pyrethroids and spinosad. For these reasons it is essential to have a broad range of insecticides from different classes available for resistance management. For example, some growers are successfully managing DBM (and hence, resistance) by using organophosphate insecticides early in the season, and then switching to alternating applications of Bts, pyrethroids, and spinosad later in the season. It is estimated that without the availability of organophosphates, and without the registration of new materials having different modes of action, insecticide use could increase in cabbage largely due to diamondback moth control.

**Efficacy Issues:** Spintor has proved to be very effective on DBM so far, although it is an expensive option, and some producers have reported control failures. Use of spinosad is expected to increase in the future as producers gain experience with the insecticide and as availability increases. Some materials (e.g. permethrin) perform better under cool weather conditions, while others (e.g. Bts) are most effective when weather is warm.

**Alternatives:** Several new insecticides currently under development, including emamectin benzoate (Proclaim; Novartis), and indoxacarb (Avaunt; DuPont), may become effective options. Other possible alternatives include biphenthrin (trade name Capture), a pyrethroid, and Alert (from American Cyanamid). Efficacy tests need to be conducted on all of these materials.

**Onion Thrips** (*Thrips tabaci*)

**Frequency of Occurrence:** Annually

**Damage Caused:** Onion thrips are very small (1/16 inch), yellow or brown insects that damage cole crops by rasping the leaf surface and sucking the sap. They cause economic injury primarily on cabbage, where they live and eat inside several layers of leaves. Injury looks like constellations of tiny, raised, roughened white to yellowish brown spots (also known as intumescense) on the inner leaves. Large areas of leaves can be affected during heavy infestations. Badly infested heads are not usable for fresh market or processing. Thrips damage usually increases during the hot, dry weather of mid- and late summer.

**% Acres Affected:** 100%.

**Pest Life Cycles:** Both adults and larvae overwinter in field and forage crops, and move into cabbage fields in late spring or early summer. Males are extremely rare and are not needed for reproduction. Females lay eggs in cabbage leaves, and eggs hatch in 5-10 days. Thrips go through two larval stages and one pupal stage within the cabbage head. Developmental time from egg to adult may range from ten to thirty days, depending on temperature. There are 5-8 generations per season.

**Timing of Control:** Precupping through harvest.

**Yield Losses:** Losses are due to decreased quality as well as quantity. Quality losses can result in loss of a market or premium price. Quantity losses occur when cabbage must be harvested before it has reached full maturity due to thrips pressure, or when storage cabbage must be severely trimmed to get rid of thrips-damaged leaves. Losses can range from 10-80%.

**Cultural Control Practices:** The selection of resistant varieties is one of the most important control measures available for thrips control. Varieties show marked differences in tolerance to thrips damage, although even the most resistant can show thrips damage when pest pressure is high. Thrips-tolerant varieties may also be lacking in other horticultural qualities. There is some concern that varieties which were at one time quite tolerant, are becoming more susceptible. Site selection may also help in managing this insect pest. Since onion thrips can move into cabbage fields from small grains, thrips sensitive varieties should not be planted near these fields. Thrips populations decline rapidly during periods of heavy rainfall.

**Regional Differences:** Thrips are a more serious problem in upstate NY than in Long Island.

**Biological Control Practices:** The effects of natural enemies on populations of thrips on cabbage is not well understood. Mycotrol, a commercial product containing the entomopathogenic fungus *Beauvaria bassiana*, is only partially effective on onion thrips (Shelton).

**Post-Harvest Control Practices:** None

**Other Issues:** Research on onion thrips in cabbage has been conducted for decades, and continues to be ongoing in NY (Shelton) and other affected states (Wisconsin, Michigan). Biocontrol measures, such as fungal pathogens, have been tried repeatedly with limited success (while measurable levels of control can be obtained, it is still not up to commercial standards). The use of insecticides yields variable results both in research plots and in growers' fields. Improving application methods may provide some limited improvement in control. New varieties are continuously being screened for thrips tolerance (Shelton, Orfanedes, Reiners). Research objectives for 1999 include developing methods for monitoring thrips flights as a basis for scheduling insecticide applications, and possibly planting dates. Better information on thrips flights could help improve scouting protocols as well.

Most markets for NY cabbage have fairly low tolerances for thrips damage on the final product. However, one important group of markets, processors of kosher products, have a zero tolerance for thrips contamination in the raw product. Given the difficulty in managing onion thrips in cabbage using chemical and non-chemical control measures, it can be extremely difficult for growers to produce to this very high standard.

**Chemical Controls:** See Imported Cabbage Worm section, above.

**Use in IPM Programs:** As-needed use of foliar insecticides such as permethrin, esfenvalerate, and lambda-cyhalothrin are consistent with Cornell IPM recommendations. A scouting protocol and economic thresholds have been developed and are used by consultants and growers. These may be improved with ongoing research.

**Use in Resistance Management:** Although resistance to insecticides in onion thrips has not been documented in cabbage in NY per se, researchers are beginning to see signs of resistance in onion thrips in onions (see NY Onion Crop Profile). Therefore, this is a real possibility in cabbage, particularly if available insecticide classes were limited. In their attempts to control thrips in cabbage, producers routinely alternate insecticides of different classes (singly or in combination), hence helping to manage resistance.

**Efficacy Issues:** Once thrips are inside cabbage heads, it is impossible to control them. For this reason, growers begin insecticide applications when plants begin to cup, or form heads. When thrips become most active in late summer, growers typically apply insecticides on a weekly basis. High pressure sprays for worm control directed down into the heads will help in thrips control. Results from different insecticides are often variable, but many growers find that dimethoate is usually effective, as well as not too expensive, and is therefore frequently used for thrips control. The NY cabbage industry has a critical need for more effective thrips controls, either chemical, non-chemical, or a combination.

**Alternatives:** Thiomethoxam, a new insecticide from Novartis (trade name Adage), is currently being tested for efficacy on onion thrips, and may be a useful alternative. The use of imidacloprid (Admire) has provided promising results in research trials.

**Cabbage and Green Peach Aphids** (*Brevicorne brassicae, Myzus persicae, and others*)

**Frequency of Occurrence:** Annually

**Damage Caused:** Aphids suck sap from plants. Heavy infestations cause leaves to cup and curl inward, and plants may be stunted. Aphids live in the outer leaves of cabbage, and the presence of live or dead aphids makes the cabbage unmarketable. Both cabbage and green peach aphids can vector virus diseases of crucifers.

**% Acres Affected:** 100% of acres potentially affected; approximately 25-30% of cabbage acreage is typically treated for aphids.

**Pest Life Cycles:** Cabbage aphids (*Brevicorne brassicae*) are small (1/16 inch), blue-gray insects that can live on the outer leaves of cabbage and other cruciferous crops. Green peach aphids (*Myzus persicae*) are slightly larger, green in color, and have a wider host range. A crop may be infested with either or both, although cabbage aphids are the more common pest in cabbage. Aphids overwinter as eggs on crop residue or host plants. Winged forms, less frequently found than wingless forms, enable the insect to move into a field from other areas. Females can reproduce without mating with males. Aphids are generally most abundant from mid-summer through October. Their severity is greatly influenced by weather patterns.

**Timing of Control:** mid-June through harvest.

**Yield Losses:** Aphids can cause a 100% loss in the quality of the crop.

**Cultural Control Practices:** No resistant varieties are available. Aphid populations decline rapidly during periods of heavy rainfall. Certain reflective foil mulches may slow down colonization of plants by winged aphids, although this is not practical for large acreage plantings.

**Regional Differences:** Aphid pressure seems to be increasing over the past several seasons in upstate NY.

**Biological Control Practices:** Naturally occuring predators, parasitoids, and pathogens help suppress aphid populations. Increases in aphid populations are sometimes associated with applications of insecticides that have killed natural enemies.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible after harvest.

**Chemical Controls:** See Imported Cabbage Worm section, above. In addition, acephate (Orthene) is labeled for use on cauliflower and Brussels sprouts only, at a rate of 1.33 lb ai/acre. Since the loss of methamidophos (Monitor), dimethoate and metasystox-R have become the primary insecticides used for aphid control.

**Use in IPM Programs:** As-needed use of materials listed above is consistent with Cornell IPM recommendations. A scouting protocol and thresholds have been established.

**Use in Resistance Management:** None reported.

**Efficacy Issues:** Materials listed in the above section for aphid control have varying degrees of efficacy depending on aphid type. In general, organophosphates are more effective on aphids than pyrethroids. Permethrin, cypermethrin and acephate (cauliflower and Brussels sprouts only) only have activity on green peach aphid. Diazinon, dimethoate, imidacloprid, and disulfoton only have activity on cabbage aphids. Lamda-cyhalothrin and zeta-methrin have activity on both. Imidacloprid has been used in Long Island with good results.

**Alternatives:** Two new materials from Novartis, pymetrozine (trade name Fulfill) and thiomethoxam (trade name Adage) may be effective alternatives for aphid control.

**Flea beetle** (*Phyllotreta striolata* and *P. cruciferae*)

**Frequency of Occurrence:** Annually, although severity of infestations varies from year to year.

**Damage Caused:** These small insects chew tiny holes in the cotyledons and early foliage of small seedlings, weaking the plant. They are especially damaging to newly emerging direct-seeded cabbage. Damage to maturing plants is more cosmetic then yield-reducing, but can result in unsightly, and hence unmarketable, heads. Flea beetles can also contribute to disease spread in a field.

**% Acres Affected:** 100% potentially affected; typically about 30% of acreage is treated for flea beetles.

**Pest Life Cycles:** Cabbage flea beetles are small (1/16$^{th}$ in long), shiny black insects that overwinter as adults in crop debris or in protected places surrounding fields. Flea beetles mate in late spring, and lay eggs which hatch in 5-8 days. There are 2-3 generations per year.

**Timing of Control:** From crop emergence to heading.

**Yield Losses:** Can be up to 100% in severely affected fields.

**Cultural Control Practices:** No resistant varieties are available. Spunbound row covers can control flea beetles on seedlings where practical (e.g. smaller plantings and seed beds). However, yields of late plantings may be reduced by row covers.

**Regional Differences:** Flea beetles are a more serious problem in upstate NY than in Long Island.

**Biological Control Practices:** The species and effect of natural enemies is not known.

**Post-Harvest Control Practices:** None.

**Chemical Controls:** See Imported Cabbage Worm section, above.

**Use in IPM Programs:** As-needed use of above listed materials is consistent with Cornell IPM recommendations. A scouting protocol with economic thresholds has been established.

**Use in Resistance Management:** None reported.

**Alternatives:** Thiomethoxam, a new insecticide from Novartis (trade name Adage) may be a useful alternative.

**Beet Armyworm** (*Spodoptera exigua*)

**Frequency of Occurrence:** Occurs approximately two years out of every five.

**Damage Caused:** Early instars most frequently damage the young terminal growth, resulting in abnormal heads. Large larvae feed in the center of heads.

**% Acres Affected:** 5% of statewide acreage; 100% of acreage in Long Island.

**Pest Life Cycles:** The beet armyworm can be a serious late season pest of cabbage and other crucifers. They do not overwinter in NY; adults migrate into the state during August. Eggs are white to pink and are layed in clusters. The larvae are green or black with a dark head. There may be two generations per year. Other hosts of beet army worm include beets, spinach, pepper, tomatoes and potatoes.

**Timing of Control:** August through October.

**Yield Losses:** Can be up to 100% in severely affected fields.

**Cultural Control Practices:** None.

**Regional Differences:** Only a problem in Long Island.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** None.

**Chemical Controls:** See Imported Cabbage Worm section, above.

**Use in IPM Programs:** As-needed use of above listed materials is consistent with Cornell IPM recommendations. A well-developed scouting procedure for beet army worms and other lepidopteran pests is currently in use. Economic thresholds based on pest information, size of pests, crop stage, and crop market channel have been established. For more information, see Reference #2.

**Use in Resistance Management:** None reported.

**Efficacy Issues:** Lannate is most effective on Long Island. Reports from the mid-Atlantic states indicate that spinosad is very effective as well.

**Alternatives:** Indoxacarb (Avaunt; Dupont) or Alert (American Cyanamid) may be possible alternatives.

## Diseases

**Alternaria leaf spot** (*Alternaria* spp.)

**Frequency of Occurrence:** Annually; seems to be increasing in severity in upstate NY.

**Damage Caused:** *Alternaria* is a fungus that causes leaf spotting and head rotting of crucifers, particularly in wet conditions. Flea beetles can spread the disease through a field. The disease can advance during storage, necessitating earlier marketing, or resulting in yield loss due to rotted heads or severe trimming. The disease is much more of a problem in storage cabbage and in cauliflower than fresh market or processing cabbage.

**% Acres Affected:** 100% at risk; up to 80% affected, but usually below economic levels.

**Pest Life Cycles:** The initial disease symptom is the appearance of small dark spots on older leaves. The spots are generally circular, and range greatly in size. A brown or black velvety mold, composed of masses of fungal 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. Cabbage leaf margins are often colonized by *Alternaria* spp. Plants are highly susceptible after tipburn or other injuries. Bacterial soft rot often follows *Alternaria* infection. On cauliflower, tiny brown sunken lesions appear on the curds. On broccoli heads the lesions are yellow. The spots enlarge rapidly and are eventually covered with black spores.

**Timing of Control:** seedling through harvest.

**Yield Losses:** Up to 40% in severely affected cabbage crops; typical losses are 1-5%. Losses on broccoli and cauliflower can be as high as 100%.

**Cultural Control Practices:** Some cabbage varieties show some tolerance to this disease. Use of hot water treated and/or certified seed can reduce seed-borne inoculum, however this treatment can severely reduce seed germination if not carefully controlled. Growers should practice crop rotation with a minimum of three years away from crucifers. Control of cruciferous weeds (e.g. mustards, wild radish, yellow rocket) is an important control measure. Land for seed beds and late-season crops should not be near those fields used for early-season crops to minimize the movement of pathogens from old to young plants.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible to remove this source of disease from other plantings and to initiate decomposition.

**Other Issues:** Research on control of alternaria is ongoing (Dillard), and focusing on screening varieties for tolerance to the disease, as well as screening foliar fungicides and seed treatments for efficacy.

**Foliar Fungicides for Disease Control in Cabbage:**

| Pesticide | % Trt. | Type of Appl. | Typical Rates lbs ai/acre | Timing | # of Appl. | PHI[1] days | REI hours |
|---|---|---|---|---|---|---|---|
| **chlorothalonil[1]** *(Bravo)* | 2 P[4]<br>75 F | foliar | 0.75 P<br>1.125 F | as needed during head formation | 1.5 P<br>2.5 F | 21 | 48 |
| **copper compounds[2]** *(many)* | 0 P<br>10 F | foliar | varies with formulation | as needed during head formation | 2.5 F | 7 | 12 |
| **fosetyl-Al[3]** *(Aliette)* | 0 P<br>1-5 F | foliar | 1.6-4 | as needed during head formation | 1-2 F | 3 | 12 |
| **maneb[3]** *(Maneb)* | 0 P<br>30 F | foliar | 1.6 F | as needed during head formation | 2 F | 7 | 24 |
| **mefenoxam[3]** *(Ridomil Gold)* | 0 P<br>1-5 F | foliar | 0.07 | as needed during head formation | 1 F | 7 | 48 |

**1.** For Alternaria leaf spot and downy mildew control.

**2.** For black rot and bacterial rot control.

**3.** For downy mildew control.

**4.** P=processing cabbage; F=fresh market and storage cabbage.

**Use in IPM Programs:** As-needed use of chlorothalonil is consistent with Cornell IPM recommendations. No thresholds are available.

**Use in Resistance Management:** None reported.

**Efficacy Issues:** Chlorothalonil is useful, but does not always provide commercially acceptable levels of control. New effective fungicide alternatives are greatly needed by the cabbage producers of NY.

**Alternatives:** Recent research has shown that azoxystrobin (Quadris), tebuconazole (Folicur), and iprodione (Rovral) are more effective than the currently labeled fungicide, chlorothalonil. Although it has not yet been tested, trifloxystrobin (Flint) may also provide good control. None of these fungicides are yet labeled for use on cabbage, but IR-4 is scheduled to run residue tests on azoxystrobin in 1999.

**Black Rot** (*Xanthomonas campestris*)

**Frequency of Occurrence:** Limited outbreaks of this devastating disease are seen almost annually.

**Damage Caused:** Black rot is caused by a bacterium. Cotyledons on infected plants become water soaked and shrivel and drop off. On true leaves, the infection generally appears as a yellow v-shaped area along the leaf margin that progresses to the midrib. As the lesions enlarge, the leaf veins within them turn black. Early infections may result in death of seedlings. Later infections may become systemic, resulting in blackening of veins inside cabbage heads. Cauliflower is even more susceptible than cabbage.

**% Acres Affected:** 100% of acreage is potentially affected, although in any given year, between 1-3% of total acreage is typically affected.

**Pest Life Cycles:** Black rot is a seed-borne bacterial disease affecting all the cole crops. The pathogen moves through the leaf into the water-conducting (vascular) system, causing a blackening and a plugging of the veins. Once in the veins the bacteria multiply and spread. Under conditions favorable for black rot development (80 to 86º F and high humidity), the disease moves rapidly through infected plants and spreads to adjoining plants in wind and rain. The black rot organism overwinters on crop debris in the field, but infection occurs more often from infected seed.

**Timing of Control:** Planting through harvest.

**Yield Losses:** In severely affected fields, losses of 100% are not uncommon.

**Cultural Control Practices:** Cultural practices are the primary method by which producers manage black rot. These include: minimum three year rotation away from crucifers; control of cruciferous weeds; use of varieties with some black rot tolerance; siting late plantings and seed beds away from early plantings; planting hot water treated and/or certified seed; avoiding clipping of seedlings. If disease develops, cultivation or pesticide applications should only be performed when foliage is completely dry. Field equipment should be thoroughly cleaned before moving it to another field.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible to remove this source of inoculum.

**Chemical Controls:** See table in Alternaria section, above.

**Efficacy Issues:** Copper compounds can be used to slow disease development and spread, but they do not provide complete control of the disease.

**Black Leg and Seed Decay** (*Phoma lingam*)

**Frequency of Occurrence:** Once a very serious disease of cabbage and other crucifers, suitable controls have now nearly eliminated it.

**Damage Caused:** Black leg causes dark, sunken cankers at the base of the stem or light brown circular leaf spots. Cankers can girdle the stem and destroy the root system, causing wilting, stunting, and plant death.

**% Acres Affected:** While 100% of the acres are potentially at risk, it is very infrequently seen.

**Pest Life Cycles:** Blackleg is most common on cabbage, but it also affects other crucifers. Symptoms may appear early in the growing season on seedlings not yet transplanted in the field. Inconspicuous, small, circular, dark lesions appear on the leaves of the infected plants. The spots gradually enlarge, becoming well defined with a gray center filled with numerous black, pimple-like, spore-bearing structures called pycnidia. Spores are splashed by rain or carried by insects to neighboring plants where new infections arise. The fungus can live at least three years in the soil, and is carried upon and within the seed. When infected seed is planted, the dead seeds permit the fungus to live and fruit in the soil while the tiny leaves of the viable seeds push above the soil to serve as fruiting places for the pathogen. Infection also occurs at the base of the new stem from the fungus harbored under the seed coat.

**Timing of Control:** At planting.

**Yield Losses:** Can be up to 100% is severely affected fields, but this has not been seen in many years.

**Cultural Control Practices:** Cultural control practices are extremely important in maintaining control of this disease. These include crop rotation (minimum of four years away from crucifers); control of cruciferous weeds; siting seed beds and late plantings at a distance from early plantings; and hot-water treating infected seed lots if necessary. No resistant varieties are available.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible to remove this source of inoculum.

**Chemical Controls:** Essentially 100% of cabbage seed planted in NY is commercially treated with thiram fungicide at a rate of 0.25 lbs/cwt of seed (equivalent to 0.005 lbs ai/acre). Iprodione is labeled for use on broccoli only, but is almost never used (<1%). No other fungicides are labeled for control of this disease.

**Alternatives:** None of the newer fungicides currently being registered are likely to be effective.

<u>Downy Mildew</u> (*Peronospora parasitica*)

**Frequency of Occurrence:** Sporadic; occurs most often in seedbeds, and along shady field edges. Oriental crucifer crops are particularly susceptible.

**Damage Caused:** 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 mycelia. The upper surface turns yellow and dries out. Heavily infected leaves eventually drop off. The organism may move systemically in the plant causing internal darkening of cabbage or cauliflower heads. If left unchecked, an infection starting in a seedbed can develop into a serious problem in the field. Broccoli and cauliflower are more prone to damage.

**% Acres Affected:** Up to 75% of acreage is potentially at risk, but affected acreage is usually <1%.

**Pest Life Cycles:** Downy mildew is promoted by cool wet weather in the spring and fall. Downy mildew overwinters in plant debris or on cruciferous weed hosts. It spreads in the field with splashing water during cool weather, and is primarily a problem during the fall.

**Timing of Control:** seedling through harvest

**Yield Losses:** In severely affected fields, losses can run as high as 75%, but this is not common.

**Cultural Control Practices:** Rotation away from crucifers for a minimum of three years can help in disease management. Controlling cruciferous weeds is also important. No resistant varieties are available.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible to remove this source of inoculum.

**Chemical Controls:** See table in Alternaria section, above.

**Alternatives:** While research has yet to be conducted, azoxystrobin (Quadris) may potentially be an effective fungicide against downy mildew on crucifers.

**Bacterial Rots** (*Pseudomonas* spp. and *Erwinia carotovara*)

**Frequency of Occurrence:** Bacterial rots are often found in most years, but at low levels.

**Damage Caused:** Soft rot bacteria cause a watery, soft, foul-smelling rot of the cole crops. Chinese cabbage and broccoli are particularly susceptible to soft rot damage.

**% Acres Affected:** 100% at risk of infection, but typically only between <1% of acres show plants with symptoms.

**Pest Life Cycles:** Bacterial infection often occurs after chemical, mechanical, pest or other injury. This disease is promoted by warm wet conditions. It often follows external or internal tipburn. The bacteria soften the cell walls of plant tissue, which results in a rapid collapse into a slimy mess. Soft rot may be a primary pathogen on broccoli heads, especially during warm, humid weather. The bacteria become established in small droplets of water that remain on the heads. Cultivars with domed heads that shed surface water are less susceptible. The bacterial pathogens responsible for this disease have a fairly wide host range.

**Timing of Control:** heading to harvest.

**Yield Losses:** Up to 50% in severely affected fields; typical losses are <5%.

**Cultural Control Practices:** To avoid soft rot, crucifers should be grown on well-drained soils with adequate soil moisture maintained to avoid tipburn. Injury to plants should be avoided. Crop rotation can be helpful, as can avoiding movement through wet fields. Equipment should be cleaned before moving to new fields.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible to remove this source of inoculum.

**Chemical Controls:** See table in Alternaria section, above.

**Efficacy Issues:** Copper compounds can be used to slow disease development and spread, but they do not provide complete control of the disease.

**Clubroot** (*Plasmodiophora brassicae*)

**Frequency of Occurrence:** Annually.

**Damage Caused:** Roots become large, swelled, and spindle-shaped. Yellowing and wilting occurs on aboveground plant parts. Plants are weakened significantly, and frequently die.

**% Acres Affected:** 100% of acres are at risk of infection. An estimated 10-35% of the acreage is probably infected with the clubroot pathogen.

**Pest Life Cycles:** *Plasmodiophora brassicae* is a fungal pathogen that attacks the roots of all crucifer crops and weeds. The organism is capable of surviving in the soil for 7-10 years or longer as resting spores. The resting spores can be spread from field to field by infested soil, contaminated water supplies, infected transplants, infested soil on farm machinery, and even by roving animals such as deer. Spores germinate to produce zoospores which move to infect susceptible plant root hairs. There, the organism develops rapidly, causing an increase in the number and size of cells, resulting in the "clubbing" of roots. New zoospores are produced to continue the disease cycle. Resting spores are formed within the diseased plant tissue, and are released into the soil when the plant roots disintegrate.

**Timing of Control:** At planting.

**Yield Losses:** Can be as high as 50% in severely affected fields. Typical yield losses are 1-15%.

**Cultural Control Practices:** Long crop rotation (minimum seven years) can aid in control, but this is not always practical. Adjusting soil pH to 6.8-7.2 with lime is very effective since resting spores will only germinate in acidic soils. Infested soil should not be introduced into clean fields on transplants, equipment, or crop debris. No resistant varieties are available.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Crop debris should be destroyed as soon as possible.

**Fungicides for Clubroot and Root Rot Control in Cabbage:**

| Pesticide | % Trt. | Type of Appl. | Typical Rates | Timing | # of Appl. | PHI days | REI hours |
|---|---|---|---|---|---|---|---|
| **PCNB**[1,2] *(Terrachlor)* | 0 P[4] 1-5 F | soil; in-furrow, broadcast, or as transplant solution | 15 lbs ai/acre | at planting | 1 | 60 | 12 |
| **mefenoxam**[3] *(Ridomil Gold)* | 0 P <1 F | soil; banded | 0.06 lbs ai/acre | at planting | 1 | 60 | 12 |

**1.** For control of clubroot and Rhizoctonia wirestem.

**2.** Used in cauliflower as well as cabbage.

**3.** For control of root rot caused by *Pythium* spp.

**4.** P=processing cabbage; F=fresh and storage cabbage.

**Use in IPM Programs:** Use of these materials on an as-needed basis is consistent with Cornell IPM recommendations.

**Use in Resistance Management:** None reported.

**Root Rot, Wirestem, and Head Rot** (*Pythium ultimum and Rhizoctonia solani*)

**Frequency of Occurrence:** Sporadic, but can be found at low levels in most years.

**% Acres Affected:** 100% at risk of infection, but typically between 1-10% of acreage will show plants with symptoms.

**Damage Caused and Pest Life Cycles:** The fungus *Rhizoctonia solani* causes a number of closely related diseases of cole crops, including damping off, wire stem, bottom rot, and head rot. If the fungus attacks very young seedlings, damping off will occur. The fungus penetrates seedlings near the soil line causing water-soaked constrictions of the stem, which girdle and usually kill the plant. If plants survive the initial attack, the center of the stem decays while the outer stalk provides sufficient support to keep the plants erect. At this stage the disease is called wirestem. Stems are brown or black and wiry above the soil line. The plants grow very slowly and usually do not develop to maturity. Bottom rot occurs as a carry-over from wire stem. *Rhizoctonia* can attack low lying leaves at the petioles and midribs. This produces reddish brown lesions, and the leaves will eventually become slimy and brown while the disease progresses to inner leaves. Head rot may develop, causing a darkening and decaying of the stem at the base of the heads and spotting and wilting of the leaves in the center of the head.

*Rhizoctonia* overwinters as mycelia or sclerotia in the soil or on infected plant material. Once the pathogen is present in soil it remains there indefinitely. It has a wide host range, including several other vegetables grown in rotation with cabbage. The pathogen can be spread through moving water, transport of contaminated soil and equipment, and contaminated seeds, transplants, and transplant flats. The sexual state of *Rhizoctonia solani* (*Thanatephorus cucumeris*) is now present in NY. The sexual spores, or basidiospores, are windborne and can function as a source of inoculum. The disease develops more rapidly in moderately wet soils as opposed to saturated or dry soils. Plants that grow rapidly and vigorously tend to resist infection better than slow growing plants.

*Pythium ultimum* has a wide host range and can survive in soil for many years as oospores. It is most damaging during cool wet weather, and can cause damping off and seedling death in young plants.

**Timing of Control:** At planting.

**Yield Losses:** Can be up to 50% in severely affected fields. High losses are usually from damping off rather than other stages of Rhizoctonia infection. Losses from head rot seem to be increasing in upstate NY.

**Cultural Control Practices:** Minimum three year rotation away from vegetables; control of cruciferous weeds; planting disease-free seed; planting on well-drained and light-textured soils.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Destroying crop debris soon after harvest.

**Chemical Controls:** See table in Clubroot section, above. In addition, essentially 100% of cabbage seed planted in NY is commercially treated with thiram fungicide at a rate of 0.25 lbs ai/cwt of seed, equivalent to 0.005 lb ai/acre, although this is probably providing little control of these diseases. No chemicals are labeled for use later in the season once the disease is observed.

**Alternatives:** Fludioxonil (Maxim) may be a potential alternative, but efficacy trials would need to be conducted. Fludioxonil would need to be combined with mefenoxam for control of *Pythium* and *Rhizoctonia*.

**Fusarium Yellows** (*Fusarium oxysporum f. sp. conglutinans*)

**Frequency of Occurrence:** Occurs annually in *Fusarium*-infested soils.

**Damage Caused:** This soil-borne fungus attacks the roots and vascular system of cabbage and other crucifer vegetables. Infected plants show distinct yellowing and wilting symptoms, usually predominantly on one side of the plant. Plants are weakened and some may die within several weeks of infection. Others may decline through the season, dying slowly or producing a poor head.

**% Acres Affected:** Probably between one third and one half of the cabbage acreage in NY is infested with the pathogen. It is easily transferred to uncontaminated fields via equipment, wildlife, workers, etc.

**Pest Life Cycles:** The fungus grows in the soil and on crop debris. It produces both short-lived spores and long-lived resting spores. Fusarium can remain alive in the soil for many years and even increase in soil free of crucifer plants. The fungus does poorly at temperatures below 61º F or above 95 º F. The pathogen penetrates young roots, migrates to water vessels of the vascular system, and progresses up the stem into the leaves. When plant tissues die, the fungus mycelia spread through them and produce spores on the surface for continuing infection.

**Timing of Control:** At planting.

**Yield Losses:** Can be up to 75% in severely affected fields when susceptible varieties are grown.

**Cultural Control Practices:** The primary method of control of fusarium yellows is the choice of resistant varieties for use in infested fields. Some cabbage varieties with highly desirable horticultural traits (e.g. long term storability) are susceptible. Rotation is minimally effective. Infested soil should not be introduced into clean fields on transplants, equipment, or crop debris.

**Regional Differences:** None.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Destruction of crop debris is minimally effective.

**Chemical Controls:** No pesticides are available to manage this disease.

**Sclerotinia White Mold** (*Sclerotinia sclerotiorum*)

**Frequency of Occurrence:** Annually. Degree of disease infestation varies greatly.

**Damage Caused:** This disease can cause serious losses in the field, in storage, and under transit and market conditions. Infections begin as tan, water-soaked, circular areas, which soon become covered by white, cottony fungal growth. The cabbage tissue becomes soft and watery, and the fungus eventually colonizes the entire cabbage head.

**% Acres Affected:** 100%

**Pest Life Cycles:** Sclerotinia is widely distributed in soils in NY cabbage growing regions, and attacks a number of vegetable crops including dry and snap beans. It overwinters as sclerotia, which are large black seedlike structures formed on diseased tissue. In the spring, summer, and fall months, under wet conditions, the sclerotia develop small, tan, trumpet-shaped mushroom-like structures called apothecia. The spores produced in the apothecia are called ascospores, and these are forcibly discharged and carried by wind to susceptible plants. In cabbage fields, apothecia are frequently found in moist protected locations underneath the lower leaves of mature plants. Most cabbage plants are infected after midseason, usually at the top or on the sides of midseason to mature cabbage heads. Ascospores require nutrients and a thin film of water on the plant surface to be able to germinate and infect a plant. Blossoms of many plants, including weeds, are an excellent source of nutrients for ascospore germination, and the most frequently observed source of these nutrients in NY cabbage fields is ragweed flowers. Ragweed flower parts are often infected with Sclerotinia and infected ragweed parts can pass the disease to healthy cabbage when the plants are in contact with each other. Insect feeding holes are also possible infection sites.

**Timing of Control:** Planting through harvest.

**Yield Losses:** Can be as high as 50% in severely affected fields and storages. Typical losses run from 1-5%.

**Cultural Control Practices:** White mold on cabbage can be managed most successfully by combining cultural practices that discourage disease develoment. Growers should avoid planting cabbage in fields that are surrounded by dense woods that will restrict air circulation. Rows should be planted in the direction of the prevailing winds to promote drying of plant and soil surfaces. Crop rotation away from susceptible crops and avoiding fields with known white mold problems are essential. However, crop rotation alone is ineffective because the fungus has such a wide host range. Removing all susceptible weeds from the field and controlling insect pests are useful white mold control measures.

**Regional Differences:** None

**Biological Control Practices:** None.

**Harvest and Post-Harvest Control Practices:** Bruises and other types of mechanical injuries to cabbage heads during harvesting operations leave wounds that can be colonized by the white mold fungus. Infection can occur at bruise sites. The fungus can completely colonize a bruised cabbage head in storage and infect healthy cabbage heads that are in contact with the diseased tissues.

**Chemical Controls:** No pesticides are registered to manage this disease on cabbage, and recent research has indicated that new fungicides such as azoxystrobin, tebuconazole, and propiconazole are not effective either.

**Viruses** (*Turnip mosaic and Cauliflower mosaic viruses*)

**Frequency of Occurrence:** Sporadic.

**Damage Caused:** Symptoms vary widely depending on virus present and on host type. In general, viruses can cause spotting and distortion of leaves, mosaic coloration, necrosis, stunting, yellowing, or weakening of the plant. TuMV can cause internal necrotic spots in cabbage, and these symptoms can become more severe in storage, although will not spread from head to head. "Pepper spotting", internal spots of smaller size than caused by TuMV, was previously thought to be a symptom of CaMV, but more recent research indicates that this may rather be largely a physiological disorder.

**% Acres Affected:** 100% of the acreage is at risk; typically <1% of total acreage is affected in any one year.

**Pest Life Cycles:** Turnip mosaic virus (TuMV) is probably the most important of the viruses infecting crucifers. It has a fairly wide host range of vegetables and ornamentals. The virus is not seed-borne, but is efficiently transmitted in a nonpersistant manner by cabbage aphids and green peach aphids (see Aphid section, above). The most important source of the virus seems to be mustard-type weeds such as pennycress and shepherd’s purse. Cauliflower mosaic virus (CaMV) is also transmitted by the same aphid species, but has a host range limited to cruciferous crops and weeds.

**Timing of Control:** planting through crop maturity

**Yield Losses:** Usually small (1-2%), but in some susceptible crops such as Chinese cabbage and other Oriental crucifers, losses can be as high as 100%.

**Cultural Control Practices:** Controlling all cruciferous weeds is a very important cultural control practice. Some varieties of different crucifers have tolerance or resistance to these viruses.

**Regional Differences:** None.

**Biological Control Practices:** Practices which help keep aphid populations controlled will aid in disease management.

**Post-Harvest Control Practices:** None.

**Chemical Controls:** No pesticides are available to manage this disease directly. Control of aphid vectors (see Aphid section, above), may be helpful in containing the spread of infection, but will not provide complete control since viruses are spread to plants before insecticides kill the aphids.

**Sugar Beet Cyst Nematode** (*Heterodera schachtii*)

**Frequency of Occurrence:** Sporadic, but difficult to monitor. Improved rotation practices have made this a minor pest compared to fifteen years ago.

**Damage Caused:** Nematode infections greatly weaken cabbage plants, resulting in smaller, spongy heads.

**% Acres Affected:** <1%

**Pest Life Cycles:** The sugar beet cyst nematode is a soil dwelling plant pathogenic nematode that attacks a number of vegetable crops and weeds in the Crucifereae and Chenopodiaceae families. The eggs are enclosed in brown, leathery, lemon-shaped cycts, 1/40$^{th}$ inch in length. When first evident on the root surface, females are white and cream colored. The nematode causes more damage in sandy soils.

**Timing of Control:** at planting.

**Yield Losses:** Minimal

**Cultural Control Practices:** Crop rotation away from susceptible hosts (including beets) can significantly reduce nematode populations.

**Regional Differences:** Not a problem in Long Island.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** None.

**Chemical Controls:** The nematicide fenamiphos (Nemacur) is labeled for use on cabbage and transplanted Brussels sprouts for control of this and other nematodes. It is not frequently used in upstate NY, although it is used on some acreage on Long Island (<1% of total state acreage).

## Weeds

**Broadleaf and Grass Weeds**

**Frequency of Occurrence:** Annually.

**Damage Caused:** Reduced yields from weed competition, and loss due to interference with harvesting crews or equipment. Cruciferous weeds such as mustards, wild radish, and others can be sources of inoculum for diseases of cabbage and other crucifer crops. Ragweed and velvetleaf can be very important sources of inoculum for white mold disease (see White Mold section, above).

**% Acres Affected:** 100%

**Pest Life Cycles:** Annual and perennial weeds such as ragweed, lambsquarters, henbit, galinsoga, mare's tail, yellow nutsedge, annual and perennial grasses, mustards, and others, are a problem throughout the growing season. Velvetleaf is an increasing problem weed in cabbage.

**Timing of Control:** Preplant, preemergence, and postemergence.

**Yield Losses:** Can be 100% if not treated, 5% if treated.

**Regional Differences:** Weed species spectra can vary regionally, but weeds are a serious pest in all growing areas.

**Cultural Control Practices:** Cultivation is routinely performed at least once during the growing season, often in conjunction with sidedressed nitrogen applications. In addition, growers will frequently use hoe-crews (often two or three times per season) for cleaning up weeds which have escaped herbicide controls. Banding of herbicides at planting is not useful in cabbage production due to the relatively small number of registered products and their narrow weed control spectra.

**Biological Control Practices:** None.

**Post-Harvest Control Practices:** Cultivation. Post-harvest application of herbicides to control perennial weeds.

**Other Issues:** Research on weed control in cabbage is ongoing (Bellinder). Current objectives include screening of new herbicide materials for efficacy and crop tolerance; fine-tuning rates, timing, and application methods; and comparing crop tolerance in transplanted and direct seeded cabbage. Recently completed research focused on the use of new cultivation tools for weed control.

**Chemical Controls:**

| Pesticide | % Trt. | Type of Appl. | Typical Rates lbs ai/acre | Timing | # of Appl. | PHI days | REI hours |
|---|---|---|---|---|---|---|---|
| **trifluralin** *(Treflan)* | 50 P[1] 90 F | soil incorporated | 0.5 | preplant | 1 | 65 | 12 |
| **bensulide** *(Prefar)* | 0 P <1 F | soil; incorporated or surface | 5.0 | preplant, preemerge | 1 | 60 | 12 |
| **DCPA**[2] *(Dacthal)* | 0 P, F | soil; incorporated or surface | -- | preplant, preemerge | 1 | 60 | 12 |
| **napropamide**[3] *(Devrinol)* | 0 P <1 F | soil; incorporated or surface | 1.0 | preplant, preemerge | 1 | 60 | 12 |
| **oxyfluorfen**[4] *(Goal)* | 1 P 13 F | soil surface | 0.5-0.8 | pretransplant | 1 | 45 | 24 |
| **metolachlor**[5] *(Dual, Dual Magnum)* | 6 P 50 F | soil surface | 1.0-1.5 | pretransplant or immediate post transplant | 1 | 45 | 12 |
| **sethoxydim** *(Poast)* | <1 P 15 F | soil surface | 0.28 | post-emergence | 1 | 30 | 12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **pyridate**[6] *(Lentagran)* | 6 P<br>2 F | soil surface | 0.225 P<br>0.9 F | post-emergence | 1-2 | 45 | ? |

**1.** P=Processing; F=fresh market and storage.

**2.** Not for use on Long Island. Manufacturer has stopped production. Existing stocks may be used.

**3.** Registrations include several specialty crucifer crops, both direct seeded and transplanted.

**4.** Labeled for use on transplants only.

**5.** Available (except in Long Island) under a Third Party Registration with the NYS Vegetable Growers Association.

**6.** No longer available. Existing stocks may be used. This lower rate is used under a 2(ee) recommendation for two applications ten days apart when weeds are very small.

**Use in IPM Programs:** Use of herbicides listed above are consistent with Cornell IPM recommendations. Post-emergent materials (sethoxydim and pyridate) support the use of scouting and as-needed herbicide applications.

**Use in Resistance Management:** There are reported cases of triazine resistant lambsquarters and pigweed in the state, but it is difficult to estimate the extent and severity of this problem. No other resistance problems have been reported. Having an array of herbicides with different modes of action will minimize future problems with resistance.

**Efficacy Issues:** The listed herbicides have different but overlapping spectra of species control (for complete information, see Reference #3). Of existing materials, only DCPA provides any ragweed control, and DCPA is no longer being manufactured.

**Alternatives:** Increasingly fewer herbicides are labeled for use in cabbage and other crucifers. The cabbage industry in NY has a critical need for registrations of new herbicides for effective and economical weed control in this important crop. Pendamethalin (Prowl) and clopyralid (Stinger) herbicides are moving toward registration in cabbage, and will be very helpful in controlling grassses and broadleaves, especially ragweed (clopyralid). Ragweed control is essential because of its association with white mold (see White Mold section, above). Preliminary research indicates that sulfentrazone (Authority) and flufenacet (FOE 5043) may be effective alternatives, but further research is needed. IR-4 recently ran residue analyses on sulfentrazone.

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7. Information for and review of this Crop Profile were provided by members of the New York State Cabbage Advisory Committee, comprised of producers, processors, consultants, researchers and Extension Educators. Pesticide use information was provided by key growers, consultants, and processor records. Many other individual producers provided input and review as well.

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