Crop Profile for Cabbage and Broccoli in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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The authors recognize the efforts of the Pest Management Regulatory Agency (PMRA), provincial pest management representatives, industry specialists and growers in the gathering of information that was required, and the review and validation of the content of this publication.

Product trade names may be included and are meant as an aid for the reader to facilitate the identification of products in general use. The use of these trade names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

Information on pesticides and pest control techniques are provided for information purposes only. No endorsement of any of the pesticides or pest control techniques discussed is implied.

Information contained in this publication is not intended to be used by growers as a production guide. Provincial publications should be consulted by growers for this information.

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Information for many of the tables in this crop profile is incomplete. It has been collected and will be published in an updated version of the crop profile on this website in the near future.

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Crop Profile for Cabbage and Broccoli in Canada

Broccoli and cabbage are cole crops, members of the mustard (Cruciferae) family. Cole crops, including broccoli and cabbage, are important fresh and processing vegetable crops in Ontario, Quebec and the Atlantic provinces. Cole crops are biennials, but are generally grown as annuals. They are suited to the climate of many regions across Canada.

Cabbage

Cabbage is believed to have originated in western Europe and it was the first cole crop to be cultivated. Prior to cultivation and use as food, cabbage was mainly used for medicinal purposes. In addition to the fresh market, cabbage is now processed into Kraut, egg rolls and cole slaws and there is the potential for other specialty markets for the various types including red, savoy and mini cabbage. Cabbage is an excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet. 250 mL of raw cabbage contains 21 kilocalories and cooked, 58 kilocalories.

Broccoli

Broccoli has been known for over 2000 years. It was a favourite food of the ancient Romans and has been grown in France and Italy since the 1500's and in England since the early 1700's. It was first grown commercially in North America by immigrants from Italy in New York. Broccoli is rich in vitamins and minerals; it is a good source of vitamins A and C, potassium, folacin, iron, phosphorus and fibre. It also contains important phytochemicals such as beta-carotene, indoles and isothiocyanate. There are two main types of broccoli, the most common being sprouting/Italian broccoli (*Brassica oleracea italica*) and the other heading broccoli (*Brassica oleracea*).

Broccoli is grown for three main markets in Canada: fresh, frozen and organic, with the majority going to the fresh market. There is little information on the size of the organic market and how much of the demand is being met by local production. Currently, all domestically produced broccoli is consumed in Canada. There is potential for the expansion of the market with the production of frozen broccoli florettes.

General Production Information

	Cabbage	Broccoli
Canadian Production (2003)	146,093 metric tonnes 5,583 hectares	32,411 metric tonnes 4,045 hectares
Farm gate value (2003)	$34.585 million	$31.755 million
Domestic consumption (2001)	160,000 metric tonnes (fresh) 120,000 metric tonnes (processed)	109,000 metric tonnes (fresh) 10,860 metric tonnes (processed)
Export (2001)	44,540 metric tonnes	-
Imports (200)	158,000 metric tonnes	86,840 metric tonnes

Source(s): Statistics Canada

Production Regions

Cabbage

Cabbage is grown commercially in most provinces in Canada. The majority of production takes place in Quebec (57%) and Ontario (30%), with minor production in British Columbia (4%), Manitoba (2%), New Brunswick (2%), Newfoundland (1%), Nova Scotia (2%), and Prince Edward Island (1%).

Broccoli

Broccoli can be grown in all provinces, but commercial production is concentrated in only a few. Quebec (64%), Ontario (23%) and B.C. (11%) are the largest producers, with Newfoundland (>1%) and New Brunswick (>1%) also producing significant amounts commercially.

Cultural Practices

Cabbage and broccoli grow best in well-drained clay and clay loam soils, but also do well in sandy loam and loam soils. Well drained sandy loam soils are best suited for early varieties, while loamy and clay loam soils are best suited for late varieties. Late season varieties are somewhat more tolerant of poor drainage. A soil pH of 6.0-6.8 gives optimal yields. Maintaining soil pH close to neutral helps prevent diseases that thrive in acidic soils, such as clubroot. Lime is applied 6 weeks prior to planting if soil pH is below 6.2 in mineral soils. In order to ensure optimum growth, adequate soil nutrient levels must be maintained. A soil test should be performed in the fall or spring, several weeks before seedbed preparation begins. Nutrients should be applied on a field-by-field basis, depending on the results of the soil test and the requirements of the specific variety being grown. Fertilizers are broadcast and disked into the soil before seeding or transplanting. Boron, magnesium and molybdenum may be needed on sandy soils with low organic matter or when pH is <5.5 in soils that cannot be limed due to rotational considerations. Broccoli and cabbage tend to require large amount of nitrogen up front with the remainder side dressed once or twice at four and eight weeks after planting. If the crop is grown on leachable soil, the nitrogen can be split between planting and two side dress applications to eliminate broadcast application.

Seedlings for early season crops are first established in greenhouses. For later plantings, seedlings can be established in cold frames. Direct seeding for late summer and early fall crops can be done in well drained soils and is common in Quebec for the July to September harvest, but is not practiced in Ontario or the Atlantic provinces. It is recommended to treat the seeds

with a fungicide before planting to prevent seed-borne diseases. Seedbeds that have previously been planted with cole crops should be fumigated to prevent contamination of seedlings. In the greenhouse, seeds should be sown directly into blocks of growing medium or plug trays, or if seedbeds are used, the beds should be well drained. For transplants, seeds should be planted in rows 25 –30 cm apart, with 20 seeds per 25 cm. About 50,000 seeds are needed to produce seedlings for one ha. For direct seeding, seeds are planted about 12 mm deep and 0.6–1.2 kg of seed is used per ha. In the field, broccoli and cabbage should be planted in rows 75-90 cm apart with 25-40 cm between plants within the row. Plants that are direct seeded will mature about 2 weeks earlier than those sown in seed beds at the same time. In B.C., seed can be sown into outdoor seedbeds or directly into the field when the weather is warm enough for germination and growth (above 10^{o}C).

Seedlings are transplanted into the field at 4-7 weeks when they are about 15 cm high and have 6-8 true leaves. Before transplanting, the seedlings should be "hardened off" by decreasing water and temperature and increasing ventilation. The seedlings should be moved outside during the day and kept under cover overnight. Seedlings that appear weak or have blackened stems should be discarded. If the weather is cold at the time of transplanting, a starter solution including phosphorous should be applied to improve seedling vigour. Stem elongation occurs during the developmental stage, which lasts from the end of the seedling stage through to heading (weeks 5-9). Heading occurs from week 10 to harvest. Seeding to harvest takes 12-13 weeks altogether. Broccoli is often transplanted in pairs so that the plants compete against each other, causing an increase in the stalk length, which is desirable in the marketplace. Cabbage is sometimes planted so that every second transplant is skipped in order to leave enough room to reach the desired head size. Broccoli and cabbage are produced for early, mid and late season harvest. Growers plant in successive stages so that from the earliest harvest to the end of the season there is continual production. Often growers have contracts for supply with grocery store chains and thus must have a constant supply ready for shipment. The use of plastics placed over the soil can allow cabbage transplants to reach maturity as early as late June.

Broccoli and cabbage are considered to be cool season crops and are cold tolerant, but cabbage is more tolerant than broccoli. Young cabbage plants are able to withstand temperatures of -10°C for short periods of time. Growth, however, is arrested below 0°C and above 25°C, and is highest between 15 and 20 °C. The plants require a regular water supply of 25 mm per week during the growing season, with water shortages being detrimental to head development. Seeds germinate at temperatures as low as 5°C, with optimum germination being achieved at 27°C. High summer temperatures delay maturity and increase vegetative growth, while cool temperatures hasten maturity and may induce bolting.

The harvest season for broccoli begins in June and ends in October, with the harvest season for cabbage being from June until November. Broccoli and cabbage are generally hand harvested. A mechanical harvesting aid that transports cartons to and from the workers using a series of conveyor belts may be used. Another system involves a tractor that pulls a mini-plant on which workers work. Broccoli is washed in the box, cooled and slush ice pumped into the boxes to remove the field heat as quickly as possible to maintain firm heads. Broccoli harvested for processing and cabbage harvested for storage may be collected in pallet boxes.

Broccoli cannot be stored for very long, therefore, is shipped directly to retail outlets or a wholesale location. Cabbage destined for storage is harvested during the months of October and November. Cabbage store best when they are harvested slightly immature, before the top cover leaves begin to lose their bright green color. Before storage, the heads are trimmed to remove

loose leaves. Heads showing signs of insect, freezing, sunscald or bruising damage are discarded or sent directly to market. Cultivars vary in their ability to be stored, with dense-headed, slowly maturing cultivars being able to be stored for longer periods of time. Long term (5-6 months) storage of cabbage is possible and allows continuous supply until the following March. However, temperatures must be maintained at 0°C and relative humidity maintained at 98-100%. Controlled atmosphere storage is an option for long term storage to help maintain quality and improve competitiveness with imported cabbage. Storing at 0-1°C with 95-98% relative humidity in a controlled atmosphere with 3-5% oxygen and 5-7% carbon dioxide has been found to improve the quality of stored cabbage.

Crop rotation for broccoli and cabbage varies by grower. Often, cole crops (cauliflower, cabbage and broccoli) are rotated with each other. This kind of rotation can pose serious problems by increasing insect, weed and disease pressures. A rotation of between 2-5 years out of the cole crop family is preferred. Common restrictions faced by growers include the limited availability of land and finding land that has not had applications of imazethapyr or other residual herbicides used in the corn or soybean production. If transplants are not used and a direct seeded crop is being planted into a field previously planted with cole crops, fumigation or seed treatments may be required.

Production Issues

The major production issues facing the broccoli and cabbage industries include new pest pressures (swede midge), the limited number and the lack of effectiveness of registered herbicides for post-emergent grass and broadleaf weed control and the effect of extreme heat during summer which is believed to reduce the effectiveness of pyrethroid insecticides. Nutritional disorders are also an issue. There is concern that the introduction of nutrient management legislation in many parts of Canada will severely impact the ability of growers to maintain current yield and quality standards. Also falling under nutrient management regulations, will be the regulating of wash water quality and disposal and fate of crop residues, both in field and in plant and restrictions on manure application rates. Water quality and availability are of increasing concern in recent summers.

The primary concern in maintaining broccoli quality is to make sure that the heads or florettes maintain a bright green colour. To achieve this, it is important to keep insect and disease damage in the field to a minimum, especially those that directly affect the heads. The main concern for broccoli and cabbage that are destined for fresh and processing markets, is removing the field heat from the crop as quickly as possible after harvest to keep turgor pressure high. Broccoli and cabbage heads that are not cooled and humidified rapidly, will turn yellow or lose their bright color, and will wilt after a few days of storage, directly affecting shelf life. To remove field heat, growers have employed various techniques, such as cold water baths, hydro-cooling and the use of slush ice in waxed storage boxes.

Table 1. Canadian cabbage and broccoli production and pest management schedule

Time of Year	Activity	Action
November - February	-	No action
March	Plant care	Begin early variety transplant germination in cold houses
	Weed management	Burn down weeds (weather dependent)
April	Plant Care	Begin hardening off of early variety transplants
	Soil care	First pass with discs if necessary
	Weed management	Burn down of perennials (weather dependent)
May	Plant Care	Transplanting begins in successive stages form early to late varieties
	Soil care	Broadcast fertilizer applications
	Disease management	Fungicide applications begin on first plantings
	Insect & mite management	Occasional sprays for some early season or sporadic pests
	Weed management	Possible application of post emerge herbicides
June	Plant Care	Transplanting continues and possibly irrigation (weather dependent)
	Soil care	Side dressing of begins with earliest plantings
	Disease management	Fungicide applications begin on a 7-10 day spray schedule unless IPM program in place
	Insect & mite management	Insecticide applications begin 7-10 day spray scheduele unless IPM program in place
	Weed management	Post emerge applications for late flush continues
July	Plant Care	Irrigation and supplemental foliar feeding based on tissue sampling results
	Disease management	7-10 day preventative program maintained
	Insect & mite management	7-10 day preventative program maintained if no IPM monitoring in place
	Weed management	Scuffling between rows to break up newly emerging weeds
August	Plant Care	Irrigation and supplemental foliar feeding continued based on tissue sampling results
	Soil care	Scuffling between rows to improve moisture penetration
	Disease management	7-10 day preventative spray program maintained
	Insect & mite management	7-10 day spray program maintained unless IPM monitoring program in place
September	Plant Care	Early varieties may be harvested, irrigation continues
	Disease management	7-10 day preventative spray program maintained
	Insect & mite management	7-10 day spray program maintained if no IPM monitoring program in place
October	Plant Care	Harvest of later varieties continues until the end of the month
	Soil care	Disc or plough under crop debris

Adapted from the Cabbage and Broccoli profiles, BC Crop Profiles 2002-2004, BC Ministry of Agriculture, Food and Fisheries, 2003.
Source(s): Tracy Hueppelsheuser, BC Ministry of Agriculture, Food and Fisheries.

Abiotic Factors Limiting Production

Key Issues

- More research is needed to study the uptake, removal and utilization of nutrients by cabbage and broccoli and the effect of nutrient on crop yield and quality.
- The quality and availability of irrigation water are of increasing concern.
- There is concern over new nutrient management acts regulating wash water quality and the disposal of crop residues.
- There is concern over restrictions on manure application and rates.

Nutritional Balance

With increased pressures to improve yield and quality as well as increased pressures on a diminishing land base (especially in southern Ontario) there has been a corresponding increase in the focus on nutritional balance of the crops and soil. Typical disorders caused by nutrient imbalances or adverse environmental conditions include tip burn (calcium deficiency), hollow stem, watery core (boron deficiency), interveinal cholorosis (magnesium deficiency), whip tail (molybdenum deficiency) and sulphur deficiency. There is a lack of data on the uptake, removal and utilization of nutrients in relation to yield and quality in Canada.

Cabbage Splitting

Cabbage splitting is mainly a problem with early season cabbage. The disorder occurs when moisture stress is followed by heavy rain. The quick growth associated with the sudden moisture input, high temperatures and high fertility can cause the head to split. Proper irrigation can help to prevent splitting and varieties can be chosen that are less susceptible to the problem. Deep cultivation to break some of the plants roots can also help prevent the disorder.

Oedema

Oedema usually occurs in the fall, when cabbage is left in the field following wet weather or over-irrigation. Water trapped between the leaves causes the development of puffy, white to brown eruptions on the outer surfaces of the leaves. To make the head marketable, several outer leaves may need to be removed. The presence of thrips may aggravate the condition.

Water Quality and Availability

Water quality and availability have been of increasing concern in recent summers when drought periods extended over longer periods of time. The use of wells as a source of irrigation water became a must for good yields and quality in the Montreal area. However, this resulted in complaints from neighbours using shallow wells.

Wash Water Quality and Disposal of Residues

Under the new nutrient management regulations that have been implemented, wash water quality and the disposal of crop residues are being controlled.

Manure Application Rates

New restrictions on manure application and rates have been implemented.

Diseases

Key Issues

- There is a need for the registration of fungicides for many diseases for which there are no current chemical control options.
- The registration of new products with new modes of action are required for the control of downy mildew to enable rotation and decrease the potential for resistance development.
- More research is needed to develop a regional forecasting system for downy mildew to help growers time fungicide applications and reduce the number of sprays.
- There is concern over the lack of trained personnel for scouting, monitoring, and controlling diseases.

Table 2. Degree of occurrence of diseases in Canadian cabbage production

CABBAGE	Degree of occurrence							
Major Diseases	**BC**	**MB**	**ON**	**QC**	**NB**	**NS**	**PE**	**NL**
Bacterial leaf spot	NDR	NDR	E	E	NDR	NDR		NDR
Black rot	NDR	NDR	E	E	NDR	NDR		NDR
Blackleg	NDR	NDR	E		NDR	NDR		NDR
Clubroot	NDR	NDR	E	E	NDR	NDR		NDR
Fusarium wilt (yellows)	NDR	NDR	E	E	NDR	NDR		NDR
Gray & black leaf spot	NDR	NDR	E	E	NDR	NDR		NDR
Rhizoctonia rot	NDR	NDR	E	E	NDR	NDR		NDR
Sclerotinia rot	NDR	NDR	E	E	NDR	NDR		NDR
Minor Diseases	**BC**	**MB**	**ON**	**QC**	**NB**	**NS**	**PE**	**NL**
Powdery mildew	NDR	NDR	E		NDR	NDR		NDR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

NDR - No data reported

E – established

D – invasion expected or dispersing

Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF, and other provincial crop specialists.

Table 3. Degree of occurrence of diseases in Canadian broccoli production

BROCCOLI	Degree of occurrence				
Major Diseases	**BC**	**ON**	**QC**	**NB**	**NL**
Black rot	NDR	E	E	NDR	NDR
Blackleg	NDR	E	E	NDR	NDR
Clubroot	NDR	E	E	NDR	NDR
Downey mildew	NDR	E	E	NDR	NDR
Fusarium wilt (yellows)	NDR	E	E	NDR	NDR
Gray & black leaf spot	NDR	E	E	NDR	NDR
Head Rot	NDR	E	E	NDR	NDR
Rhizoctonia rot	NDR	E	E	NDR	NDR
Minor Diseases	**BC**	**ON**	**QC**	**NB**	**NL**
Bacterial leaf spot	NDR	E	E	NDR	NDR
Powdery mildew	NDR	E	D	NDR	NDR
Sclerotinia rot	NDR	E	D	NDR	NDR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

NDR - No data reported

E – established

D – invasion expected or dispersing

Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF, and other provincial crop specialists.

Major Diseases

Black Rot (*Xanthomonas campestris* pv. *campestris*)

Pest Information

Damage: Black rot is considered one of the most serious bacterial diseases of crucifer crops worldwide. The pathogen can infect plants at any growth stage. On young diseased plants, cotyledons turn black and drop off. On true leaves, symptoms appear as a yellowing along the leaf margins in a V-shaped pattern. As the lesions expand toward the base, the leaf becomes necrotic and drops off. Infections tend to move along the vascular tissue, down the stem and into the roots. As the infections spread through the vascular tissue, leaves, stems and roots turn black. Secondary infections, usually in the form of soft rot, tend to follow primary infections.

Life Cycle: The primary source of inoculum for black rot in production fields are infested seeds, infected transplants, and infected cruciferous weeds. Even extremely low levels (0.03%) of inoculum can cause serious epidemics. The causal agent of black rot can persist on plant residue for up to 2 years or until material is completely decayed. It can also survive in soil for

up to 60 days. The pathogen enters emerging seedlings via the stomata on cotyledon margins and migrates into the xylem tissue from which it spreads throughout the plant. The optimum temperature range for the pathogen to spread is 25-30°C. The pathogen is spread within a crop primarily by wind, splashing water, field workers, machinery, and occasionally by insects.

Pest Management

Chemical Controls: None available.

Cultural Controls: Use of certified, disease-free seeds or transplants can help reduce inoculum and disease pressure in the field. A hot water seed treatment should be used to reduce the number of bacteria present in infested seeds. Use of sterilized flats and soilless mixes helps to produce disease-free seedlings in the greenhouse. Care should be taken to minimize crop residues on the soil surface. The removal of cruciferous weeds and choosing fields that have been rotated out of cole crops for several years will also help to reduce the incidence of disease. A minimum of 2-3 years of rotation out of cruciferous crop should be practiced for best results.

Alternative Controls: None identified.

Resistant cultivars: There are some resistant cultivars.

Issues for Black Rot

1. There is a need to register products for the control of this disease.

Blackleg *(Leptosphaeria maculans, Phoma lingam)*

Pest Information

Damage: Crop losses caused by blackleg disease in Canada, exceed thirty million dollars annually. Seedling infection occurs in the cotyledons or the first true leaves. Some plants that are infected at this early stage will die. On infected, surviving plants that make it to transplanting, a bluish lesion appears on the stem. A purplish or black margin forms later on the stem lesion near the soil line. These lesions eventually blacken and girdle the stem, spreading below the soil line where roots and root hairs are killed.

Life Cycle: The fungus can survive for at least 4 years in seed and 3 years in field crop residues. Plants may become infected in the seedbed or in the field. Once plants are infected, pycnidia are formed from which conidia exude in long, pink coils. Conidia are splashed to nearby plants, spreading infection. The longer the wetting periods the greater the chance of disease spread.

Pest Management

Chemical Controls: None available.

Cultural Controls: To avoid blackleg, crop residues should be buried deeply and cull piles should be removed from fields to be planted. Seed should be treated with hot water. A crop rotation of 4 years out of crucifer crops should be practiced. Cruciferous weed species should be controlled and planting in fields that have had canola or rapeseed grown recently should be avoided. Good water drainage and air circulation are important to reduce canopy humidity.

Alternative Controls: None identified.

Resistant cultivars: There are some varieties that are more susceptible than others.

Issues for Blackleg

1. There is a need to register products for the control of this disease.

Clubroot (*Plasmodiophora brassicae*)

Pest Information

Damage: Early infections are difficult to detect, as symptoms begin underground. The pathogen infects the root, causing irregular galls to form that restrict the flow of water and nutrients to aboveground plant parts. The symptoms will range from wilting, stunting, yellowing, premature ripening and seed shrivelling.

Life Cycle: The fungus overwinters as resting spores which germinates at 15-16 ^{o}C to produce motile zoospores. After infecting root hairs of the host, zoospores develop into a plasmodium which spreads through host cells producing the clubbed root effect. The resting spores are extremely long lived in soil, ranging from 10 to 20 years. This is the most serious aspect of this disease from a management point of view. The fungus is spread by infected seedlings, contaminated manure, drainage water, farm implements, in soil blown by the wind and on the feet of animals and people.

Pest Management

Chemical Controls: Transplants can be treated with quintozene.

Cultural Controls: Cultural practices play a very important role in effective long-term control of clubroot. To prevent the disease, soil should be well-drained and high in calcium and magnesium, with a pH above 7.2. Seedlings should be planted in disease-free soil. If the disease is present, the seedbeds may be fumigated, but seedbed fumigation is not reliable. Clubroot fungi can persist on alternate weed hosts in the Cruciferae family (e. g. wild mustard, shepherd's-purse) and in unrelated weeds (e. g. sorrel, dock, and bentgrass). The application of lime will mask symptoms. A crop rotation out of crucifers for at least 2 years is needed.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Clubroot

1. There are no fungicides registered for the control of this disease.

Downy Mildew *(Peronospora parasitica)*

Pest Information

Damage: The disease is particularly damaging to young seedlings. The specific symptom of the disease is production of a fluffy white growth found mostly on the underside of leaves. A yellow irregular shaped area appears on the upper side of the leaf opposite where sporulation occurs. On the surface of cabbage heads, the pathogen causes numerous sunken black spots with little or no sporulation. Broccoli floral heads develop dark brown internal streaks.

Life Cycle: The fungus overwinters between crops as oospores or on cruciferous weeds, including related volunteers, such as rutabaga. The development of the pathogen is favoured by temperatures between 10°C and 25°C and when humidity is high, such as after drizzle, in the morning when dew forms and under heavy fog.

Pest Management

Chemical Controls: Zineb, copper sulfate, chlorothalonil and fosetyl-al are all registered as foliar sprays.

Cultural Controls: Seedbeds should have clean, well-drained soil. Excessive irrigation should be avoided. Adequate spacing is essential for air circulation and quick drying of leaves. Crop refuse, weeds, and volunteers should be destroyed to prevent the spread and overwintering of downy mildew.

Alternative Controls: None available.

Resistant cultivars: A few broccoli varieties are resistant to downy mildew.

Issues for Downy Mildew

1. There is concern over the development of pathogen resistance to currently used chemical controls.

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

Pest Information

Damage: The disease was first observed in Ontario in 1931. Losses can be significant during a warm growing season. Initial symptoms include a uniform yellowing of the plants, which can often be mistaken for the early stages of black rot infections. Symptoms tend to be localized to one side of the plant. Vascular tissue turns brown and the plants become brittle.

Life Cycle: The pathogen can infect plants at any growth stage. Plants are infected through seedling rootlets damaged by transplanting, with the pathogen moving directly into the xylem tissue. The pathogen produces conidia and chlamydospores both on the inside and outside of the infected tissues. Disease development favours warm weather, with soil temperatures between 27-29 °C. The pathogen is inhibited at temperatures below 16 °C and above 32 °C. The fungus can survive in the soil for many years. Short distance spread occurs via surface water, wind blown soil and farm equipment.

Pest Management

Chemical Controls: None available.

Cultural Controls: The use of infested seedlings or seed should be avoided.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Fusarium Wilt

None identified.

Grey Leaf Spot and Black Leaf Spot (*Alternaria brassicae* and *A. brassicola)*

Pest Information

Damage: The two *Alternaria* species cause yellow and brown spotting on broccoli and cabbage leaves. *Alternaria brassicae* lesions are small and light brown or grey (grey leaf spot), while *A. brassicicola* lesions are larger and darker (black leaf spot). The spots eventually grow larger and turn black. If untreated, the infection can progress to the head, resulting in large brown spots with a coating of spores. In broccoli, the fungi cause damage almost every fall

and winter whereas in cabbage the leaf spot diseases can be severe during the winter and spring months.

Life Cycle: A. brassicae and *A. brassicicola* survive as spores on seed coat or as mycelium in seed as well as in infected plant debris. Infected seeds, with spores on the seed coat or mycelium under the seed coat, are likely the main source of transport for these pathogens. Spores are disseminated by wind, water, tools and animals.

Pest Management

Chemical Controls: Registered compounds include zineb, copper sulfate, chlorothalonil and fosetyl-al.

Cultural Controls: Seeds should be treated with hot water, while fungicidal treatments are recommended for seeds with visible spores on the seed surface. Plants should be spaced to allow for adequate air circulation and minimize splashing of water droplets between plants. Long crop rotations, field sanitation, weed elimination and avoidance of irrigation during head development all help in the control of these diseases.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Grey Leaf Spot and Black Leaf Spot

1. There is a need for the registration of new chemistries for the control of these diseases.

Head Rot (*Erwinia* spp. and *Pseudomonas* spp.)

Pest Information

Damage: Infections by these bacteria are associated with the stomata of the sepals and pedicels of the florets. The disease can frequently cause major losses in broccoli (>30%). Symptoms initially appear as water soaked areas on florets after long wetting periods. Small black lesions appear raised and a dark discolouration spreads to the surrounding tissues. Long periods of wetness cause rapid decay.

Life Cycle: The bacteria survive in soil and may be present in ponds and other irrigation sources. During heavy rainfalls, the pathogen is spread by splashing water. Insects such as tarnished plant bug or flea beetle may cause wounds on the florets that allow the bacteria to enter more easily. Once on the heads, the pathogen releases a biosurfactant, viscosin, which allows the pathogen to break the waxy surface and enter the stomata of the florets. Under dry conditions, the progress of infections halts, but once wetting or high humidity occurs, it is spread rapidly. The bacteria grow best at temperatures around 28 °C.

Pest Management

Chemical Controls: None available.

Cultural Controls: Excessive applications of nitrogen should be avoided, as they produce lush growth, that decreases air movement within the canopy and increases the drying time for plant tissue. Wider row spacing should be used to increase air circulation, with successive crops planted away from or up wind of previous plantings. Excessive applications of insecticides and fungicides that contain surfactants should be avoided, as they can enhance bacterial infection.

Alternative Controls: None identified.

Resistant cultivars: Varieties that produce heads well above the canopy should be chosen.

Issues for Head Rot

1. There is a need for the registration of control products for this disease.

Rhizoctonia diseases (Damping-off, wirestem, root rot, bottom rot, and head rot) (*Rhizoctonia solani, teleomorph Thanetophorus cucumeris*)

Pest Information

Damage: Depending on the time of infection, the pathogen can cause different diseases on broccoli and cabbage such as:

Damping-off: The disease is characterized by decaying seeds (especially in cold, wet soils) that fail to germinate. Affected seedlings quickly wilt, topple over, and die.

Wirestem: It is the most common and destructive phase of Rhizoctonia diseases. Wirestem may result from an extension of damping-off and causes the discolouration and constriction of seedling stems at the soil line, resulting in a thin, wiry stem. Seedlings with wirestem are unlikely to survive transplantation to the field, those that survive are stunted and have poor yields.

Bottom rot: This is a disease of mature cabbage and occurs when the outer leaves touch damp, infested soil. Bottom rot is a midseason disease is often a carryover from wirestem. The specific symptom of the disease is that the lower leaves droop, decay, and turn black, but remain attached to the plant. Some plants may recover and produce heads.

Head rot: Often, during damp weather, bottom rot develops into head rot. The pathogen attacks the bases of the wrapper leaves, causing them to drop off, exposing the stem. A firm to slimy dark decay of the bases of the outer leaves and heads develops between early head formation and maturity. The outer leaves of the head wilt, become pale, and turn brown to black near the main stem.

Root rot: Lesions of the rot are usually dark brown, slightly sunken, and semi-watery to spongy. The fungus may enter through leaf scars, injuries, or rootlets.

Life Cycle: The pathogen can survive in crop debris indefinitely. *R. solani* produces sclerotia that can survive in the soil during unfavourable conditions. The fungus is spread by any means that moves soil from one place to another.

Pest Management

Chemical Controls: Thiram is registered as a soil treatment for the seedling beds.

Cultural Controls: Hot water treatments should be used on seed. Plants should be spaced to allow for adequate air circulation. Seedlings exhibiting symptoms of wirestem should not be transplanted into the field. Practices used to prevent downy mildew will also aid in wirestem reduction.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Rhizoctonia diseases

None identified.

Sclerotinia Rot (*Sclerotinia sclerotiorum*)

Pest Information

Damage: Sclerotinia rot (otherwise referred to as cottony soft rot) appears as water soaked areas on the lower stems and leaves that have come into contact with the soil. As the lesions

expand, the infected leaves wilt and the fungus spreads to other parts of the plant. The development of white, cottony mycelium is typical. The disease does not cause significant damage to broccoli in storage as the crop is not stored for very long.

Life Cycle: The pathogen overwinters in the soil as sclerotia for many years and may survive in wooden storage bins that can be a source of inoculum.

Pest Management

Chemical Controls: None available.

Cultural Controls: Fields that have been infested by *S. sclerotiorum* are difficult to manage. Tillage practices do not bury sclerotia deep enough to prevent disease outbreak. Rotation for three-four years with non susceptible crops, such as corn, cereal or grasses, will significantly decrease the number of viable sclerotia in the soil. Susceptible crops should be planted on well-drained soil and care should be taken to eliminate cruciferous weed species from fields. Cleaning harvested plants and storage bins of soil will reduce the spread of inoculum.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Sclerotinia Rot

1. Research is needed on improving field control with the use of root exudates that can initiate sporulation in the absence of the host and reduce inoculum in the soil.

Minor Diseases

Powdery Mildew (*Erysiphe polygoni*)

Pest Information

Damage: Powdery mildew is a minor disease for cole crop growers. White, powdery, superficial patches appear on the upper surface of leaves. Infections grow together and eventually cover the undersides of leaves as well. Leaves change colour from light green to yellow and then to tan, with abscission occurring on the most heavily infected tissue. Plants are stunted and yields are reduced.

Life Cycle: The pathogen is spread by wind-blown spores. The fungus overwinters on plant residues and is favoured by mild temperatures, low relative humidity, water stress and long periods of plant wetness.

Pest Management

Chemical Controls: None available.

Cultural Controls: Control practices include crop rotation, eradication of cruciferous weeds and the removal of volunteer crucifers.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Powdery Mildew

None identified.

Table 4. Disease control products, classification and performance for Canadian broccoli and cabbage production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Disease, pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Chlorothalonil				Downy mildew	A	
				Black leaf spot	A	
Copper sulfate				Downy mildew	A^P	
				Black leaf spot	A^P	
Fosetyl-al				Downy mildew	A	
				Black leaf spot	A	
Iprodione				Black leaf spot	A	
Quintozene				Clubroot	A^P	
Thiram				Rhizoctonia rot	A	
Zineb				Downy mildew	A	
				Black leaf spot	A	

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-biological, RR-reduced risk, OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF; Tom Ferencevic-Sweet Earth Crop Management Services; PMRA; OMAF Publication 363 Vegetable Production Recommendations 2004-2005

Table 5. Availability and use of disease pest management approaches for Canadian broccoli and cabbage production

	Practice \ Pest	Black rot	Blackleg	Clubroot	Downey mildew	Fusarium wilt (yellows)	Gray & black leaf spot	Head rot	Rhizoctonia rot	Sclerotinia rot
Prevention	tillage									
	residue removal / management									
	water management									
	equipment sanitation									
	row spacing / seeding depth									
	removal of alternative hosts (weeds/volunteers)									
	mowing / mulching / flaming									
Avoidance	resistant varieties									
	planting / harvest date adjustment									
	crop rotation									
	trap crops - perimeter spraying									
	use of disease-free seed									
	optimizing fertilization									
	reducing mechanical damage / insect damage									
	thinning / pruning									
Monitoring	scouting - trapping									
	records to track pests									
	field mapping of weeds									
	soil analysis									
	weather monitoring for disease forecasting									
	grading out infected produce									
Suppression	use of thresholds for application decisions									
	biological pesticides									
	pheromones									
	sterile mating technique									
	beneficial organisms & habitat management									
	pesticide rotation for resistance management									
	ground cover / physical barriers									
	controlled atmosphere storage									
	forecasting for applications									

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Information in the crop profile for individual pests

Insects and Mites

Key Issues

- There is a need for the registration of new control products for tarnished plant bug and leafminer. These pests are increasing in prevalence due to the decrease in the use of broad spectrum insecticides.
- New products with new modes of action are required to decrease the potential for development of insect resistance, specifically alternatives to pyrethroids for diamondback moth.
- There is a need for the registration of systemic insecticides for the control of swede midge to limit resistance development. Currently, only one systemic insecticide, acetamiprid, is available with a temporary registration.
- An integrated control program is needed for swede midge. Currently, preventative sprays are used because scouting for the insect is extremely difficult (due to insect size) and once damage is noted in the field, it is too late. A pheromone currently under development in Switzerland, is a promising tool for timing insecticide applications.
- There is a need for more qualified, trained personnel.

Table 6. Degree of occurrence of insect pests in Canadian cabbage production

CABBAGE	Degree of occurrence							
Major Insects	**BC**	**MB**	**ON**	**QC**	**NB**	**NS**	**PE**	**NL**
Aphids		DNR	E	E	DNR		DNR	DNR
Cabbage looper		DNR	E	E	DNR		DNR	DNR
Cabbage maggot		DNR	E	E	DNR		DNR	DNR
Diamondback moth		DNR	E	E	DNR		DNR	DNR
Flea beatles		DNR	E	E	DNR		DNR	DNR
Imported cabbageworm		DNR	E	E	DNR		DNR	DNR
Leafminers		DNR	E	E	DNR		DNR	DNR
Swede midge		DNR	D	D	DNR		DNR	DNR
Thrips		DNR	E	E	DNR		DNR	DNR
Minor Insects	**BC**	**MB**	**ON**	**QC**	**NB**	**NS**	**PE**	**NL**
Cutworms		DNR	E	E	DNR		DNR	DNR
Slugs		DNR	E	E	DNR		DNR	DNR
Tarnished plant bugs		DNR	E	E	DNR		DNR	DNR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

NDR - No data reported

E – established

D – invasion expected or dispersing

Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF, other provincial crop specialists.

Table 7. Degree of occurrence of insect pests in Canadian broccoli production

BROCCOLI	Degree of occurrence				
Major Insects	**BC**	**ON**	**QC**	**NB**	**NL**
Aphids		E	E	NDR	NDR
Cabbagelooper		E	E	NDR	NDR
Cabbage maggot		E	E	NDR	NDR
Diamondback moth		E	E	NDR	NDR
Flea beatles		E	E	NDR	NDR
Imported cabbageworm		E	E	NDR	NDR
Swede midge		D	D	NDR	NDR
Minor Insects	**BC**	**ON**	**QC**	**NB**	**NL**
Cutworms		E	E	NDR	NDR
Leafminers		E	E	NDR	NDR
Slugs		E	E	NDR	NDR
Tarnished plant bug		E	E	NDR	NDR
Thrips		E	E	NDR	NDR

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
NDR - No data reported
E – established
D – invasion expected or dispersing

Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF, other provincial crop specialists.

Major Insects and Mites

Cabbage Aphid (*Brevicoryne brassicae*) and other aphids

Pest Information

Damage: Cabbage aphids are a serious pest of cole crops. Although cabbage aphids occasionally spread viruses, they are mainly of concern as contaminants at harvest. Prior to head formation, relatively high levels of aphid populations can be tolerated. Feeding damage due to aphids can result in deformed heads, so when heading begins, aphid populations must be at low levels. When the head forms, there is near zero-tolerance for aphids. Green peach aphids occur sporadically, but they are well-controlled by natural enemies. Therefore, chemical sprays are mainly aimed at cabbage aphids.

Life Cycle: The cabbage aphid overwinters as eggs on plant debris. During most of the year, females are able to reproduce without males. Development from birth to reproductive size takes just six days. Males are produced in the fall only. Each female lays up to 100 eggs in the crevices on cabbage leaf undersides. They may reproduce year-round in warm climates.

Pest Management

Chemical Controls: Acetamiprid, dimethoate, methamidophos, naled, acephate and imidacloprid are registered as foliar sprays.

Cultural Controls: Excessive nitrogen applications should be avoided, as they result in accelerated plant tissue growth. Irrigation should be done regularly to minimize drought stress. Areas of unsprayed cover crops should be maintained in order to support beneficial insect populations.

Alternative Controls: Natural enemies are not usually sufficient to provide complete control of cabbage aphids.

Resistant cultivars: None available.

Issues for Cabbage Aphids

None identified.

Caterpillars: Imported Cabbageworm (*Pieris rapae*), Diamondback Moth (*Plutella xylostella*), Cabbage Looper (*Trichoplusia ni*) and Alfalfa Looper (*Autographa californica*)

Pest Information

Damage: Caterpillars are common pests of all cole crops. High levels of feeding damage by caterpillars can cause severe defoliation, resulting in stunted growth. Lower levels can render heads unmarketable if they are stained with frass (insect excrement), or if frass is visible. Caterpillars are unlikely to cause damage pre-head formation, but during head development their presence is unacceptable.

Life Cycle: Caterpillar larvae are present continuously throughout the season due to the overlapping generations of various species. There are usually three generations of the imported cabbageworm and all generations can be damaging. Of the two to six diamondback moth generations, the first is most damaging because the crop is in the seedling stage and less likely to have the stored resources needed to make a full recovery. The second generation rarely causes economic damage. There may be up to three generations per year of the cabbage looper, and damage from each of the generations can cause severe defoliation if left unchecked. Alfalfa looper tends to be a sporadic pest of cole crops. Cabbage loopers have two generations per year, each of which may be economically damaging.

Pest Management

Chemical Controls: Permethrin, deltamethrin, cypermethrin, cyhalothrin-lambda, methomyl, carbaryl, endosulfan, naled, methamidophos, azinphos-methyl, acephate and spinosad are registered as foliar treatments.

Cultural Controls: Cull piles and cruciferous weeds (such as wild mustard and shepherd's-purse) serve as alternate hosts for these pests and should be destroyed.

Alternative Controls: Bacillus thuringiensis var. *kurstaki* may be applied in conjunction with chemical rotations to control caterpillars. The use of the biological insecticide before head formation allows other naturally occurring beneficial insects to reduce caterpillar populations. Pheromone traps are available to attract male diamondback moths, but visual inspections are a more accurate and more commonly employed monitoring technique. There

are various types of thresholds for caterpillars, with the most accurate being the average number of larvae per plant. The most commonly used technique is a presence/absence system, which classifies a plant as "infested" if there is any caterpillar damage on the plant. The action threshold for this system is 20-30% of plants infested before heading or 5-10% of plants infested after heading. Although slightly less accurate than counting individual caterpillars, this method is far less time-consuming. These caterpillars have several natural enemies, most notable are the parasitic wasps.

Resistant cultivars: None available.

Issues for Caterpillars

1. There is a need to develop tools for managing pest resistance to pyrethroids.
2. There is concern over the limited effectiveness of pyrethroids during intense summer heat.
3. There is concern over the phasing out of organophosphate and carbamate products.

Cabbage Maggot (*Delia radicum*)

Pest Information

Damage: Cabbage maggot is a major pest of all cole crops. This pest feeds on seedlings at the soil line and causes the plants to wilt. The attacked seedlings are highly susceptible to infection by secondary, soil-borne pathogens and rarely survive transplanting.

Life Cycle: By the time the plant has developed 4 to 5 true leaves, it has a good tolerance to maggot damage and economic loss is minimal. There are 2 to 3 generations per year, but only the first is economically damaging.

Pest Management

Chemical Controls: To protect seedlings, a drench may be applied pre- or post-emergence. Spot treatments can reduce pesticide use when scouting is adequate. Registered compounds include azinphos-methyl and chlorpyrifos.

Cultural Controls: A two -three year crop rotation out of cole crops is key to control. Tillage prior to seeding can reduce the level of emergence of adult flies by moving pupae nearer to the soil surface where they are more susceptible to attack by natural enemies. Minimizing surface residues, keeping cull piles away from fields and disking/ploughing under residues to depths greater than 5 cm is required. The use of floating row covers has been shown to be quite effective in some areas. Egg laying should be monitored and planting time should be adjusted based on monitoring to avoid seedling damage. Thresholds have been established for cabbage but are not available for broccoli. Scouting is done by counting the number of infested plants out of 25 to 30 plants per 6 acres. The threshold is 20% of cabbage plants infested. When soil conditions are dry, many eggs abort and chemical control is not required. The use of kale as a trap crop can be effective on small fields if managed properly.

Alternative Controls: Nematodes (*Steinernema* sp.) are efficient in Europe. Tested in Quebec, they are efficient if adequate moisture is present, requiring the use irrigation.

Resistant cultivars: None available.

Issues for Cabbage Maggot

1. There is concern that older chemistries are being phased out while newer active ingredients are not available.

Flea Beetle *(Phyllotreta* spp.*)*

Pest Information

Damage: Flea beetles feed on the undersides of leaves, causing typical 'shot hole' damage. If populations are heavy, this will decrease the photosynthetic capacity of the plants, decreasing marketable yield. Monitoring of this pest is most critical up to the 6 leaf stage as feeding may damage the growing point. Larger plants have a much greater leaf surface area and can tolerate more feeding damage.

Life Cycle: The most common flea beetle attacking cruciferous crops is the crucifer flea beetle, *Phyllotreta cucriferae*. All flea beetles are similar in shape, colour and size, and have a similar life cycle, one generation per year. Adults are active and jump when disturbed. Adults overwinter in leaf litter and emerge in early spring. They initially feed on cruciferous weeds, and canola and other volunteer crops as they emerge. Adults lay eggs near the roots of host plants. Larvae develop on the roots. By late July adults emerge from soil, feed and then hibernate in the fall.

Pest Management

Chemical Controls: Endosulfan, carbaryl, cypermethrin, deltamethrin, cyhalothrin-lambda and permethrin are registered as foliar treatments.

Cultural Controls: Use of a trap crop, such as Indian mustard, will help reduce the incidence of feeding. Transplants are less susceptible to feeding damage affecting yield than are seedlings. The removal of volunteer crucifers and cruciferous weeds decreases alternate hosts that can harbour populations, especially if they are not sprayed.

Alternative Controls: Sampling is done using a random sample of 25 plants. Up to the 6 leaf stage, the threshold is 1 flea beetle per plant. If black rot is present in the field, then the threshold should be decreased, as flea beetles may spread the pathogen through feeding.

Resistant cultivars: None available.

Issues for Flea Beetle

1. There is concern that during extreme summer heat there is a significant reduction in the performance of pyrethroids, making their use somewhat unreliable.
2. There is concern over the phasing out of organophosphate and carbamate insecticides. This will reduce the number of chemical alternatives for rotation.

Swede Midge (*Contarinia nasturtii*)

Pest Information

Damage: Swede Midge is a relatively new pest in Canada and is found in a number of provinces. The pest has caused heavy losses in broccoli in Ontario. Feeding causes a disruption or lapse in growth at the terminal growing point of the plant. When larvae feed on older plants, they can cause a twisting of the head, split terminals, crinkled heart leaves and other distortions.

Flower buds can be prevented from opening and the main stem can be deformed and split into extra stems. Infested plants produce no marketable yield.

Life Cycle: The insect overwinters as pupae and the first generation of adults emerges in the spring. The female lays 2–50 eggs in clusters on the growing vegetative tissue of the host (members of the Cruciferae family). Hatching larvae begin to feed on plant tissue and when mature, they drop to the ground, tunnelling below the soil surface to spin cocoons and pupate. Adults will emerge from the soil in about two weeks depending on climatic conditions. Preliminary studies in Ontario indicate there are three-four overlapping generations.

Pest Management

Chemical Controls: Cyhalothin-lambda and acetamiprid are registered as foliar treatments.

Cultural Controls: Recommendations from European experts that have been dealing with this pest for some time are to disc or plough crop residues deeper than 5 cm into the soil and to rotate out of cole crops for three-five years. In addition, crops of the same family should not be planted in adjacent fields during the period of the rotation. Cruciferous weeds should be controlled to remove alternate hosts. Greenhouse transplant growers in affected areas must follow the Canadian Food Inspection Agency's Swede Midge Certification Protocol to ensure pest-free transplants for buyers.

Alternative Controls: Degree day models are being tested in Ontario. A pheromone is currently under development in Switzerland as a tool for timing insecticide applications.

Resistant cultivars: None available.

Issues for Swede Midge

1. More information is required on the life cycle, biology, and behaviour of Swede midge in Canada in order to develop integrated pest management techniques for this pest.
2. New insecticides need to be registered for the control of this pest early in the season in greenhouses.

Thrips (*Thrips tabaci*)

Pest Information

Damage: Thrips are an important pest of cabbage and can cause serious economic losses associated with the decreased marketability of the heads. However, the pest is only a minor problem on broccoli. Plant tissue is damaged by thrips feeding with their rasping and sucking mouth parts on leaves. The damaged tissues are open to secondary fungal or bacterial infections.

Life Cycle: Early in the season, thrips prefer grasses, alfalfa and clover, but as these are cut and dry up thrips then migrate to cole crop fields. They return to winter wheat and alfalfa to overwinter. Females are winged, but males and young are wingless. In cabbage fields, thrips are located on the surface of outer leaves, but as plants form heads, they remain between leaves. This habit is of concern for stored cabbage, as thrips can survive at low temperatures and continue to cause feeding damage.

Pest Management

Chemical Controls: Cypermethrin is registered as a foliar treatment.

Cultural Controls: Monitoring cabbage fields that are closest to preferred host crops (grasses, alfalfa and clover) gives time to respond to population increases. Irrigation with larger water droplet size can knock the thrips off the plants.

Alternative Controls: Several natural enemies such as the minute pirate bug (*Orius insidious*) and *Ceranisus menes* are voracious predators of thrips.

Resistant cultivars: There are varieties with some degree of tolerance to feeding.

Issues for Thrips

1. There is concern over the development of insect resistance to pyrethroids in Ontario and the poor control and low residual effect of using the registered product in very hot weather.

Minor Insects and Mites

Cutworm (*Agrotis ipsilon*)

Pest Information

Damage: The cutworm is an occasional pest of broccoli and cabbage and does not cause serious economic losses. Damage is caused by feeding on transplant stems. This girdling cuts off vascular tissue flow to the rest of the plant which either dies by lodging or as a result of secondary infection.

Life Cycle: Since cutworms do not overwinter in the northern regions, they are dependent on spring weather conditions, primarily south-easterly winds, to bring them into the region. Eggs are laid on grasses and weeds before broccoli and cabbage are planted. When weeds are destroyed by cultivation or herbicides, the cutworm larvae migrate to newly emerged broccoli and cabbage.

Pest Management

Chemical Controls: Permethrin, cypermethrin and chlorpyrifos are registered as soil treatments to be applied shortly after transplanting.

Cultural Controls: Winter annual weeds, such as chickweed, should be controlled.

Alternative Controls: None identified.

Resistant Cultivars: None available.

Issues for Cutworm

None identified.

Slug

Pest Information

Damage: Slug damage is most common in mid to late summer when the crop canopy is the heaviest. Signs of slug damage are skeletonized leaves, large ragged holes and trails of dried slime. Slugs may feed at the base of plants often damaging the roots of crops.

Life Cycle: The slug reproduces by laying eggs that hatch into miniature adults. Slugs need a moist environment to survive, thriving under cool, wet conditions. They feed at night and hide in soil and under debris during the day.

Pest Management

Chemical Controls: Methomyl is registered as a foliar treatment.

Cultural Controls: Weeds should be controlled and leaving excessive amounts of plant debris on the soil surface should be avoided. Cultivation and proper field drainage help to control the slug. A perimeter of 3 meters around the field should be kept free of slugs by harrowing with disks every week and after each rainfall to keep the soil loose and free of weeds.

Alternative Controls: Soaps can be efficient controls. In the Netherlands, application of salt (NaCl) to the soil is recommended to control *Fusarium* spp. and *Phytophthora* spp. This results in higher yields due to disease control and, as a side effect, salt also controls slugs. However, soil salinity may affect subsequent crops.

Resistant Cultivars: None available.

Issues for Slug

None identified.

Tarnished Plant Bug (*Lygus lineolaris*)

Pest Information

Damage: The bug is an occasional pest of broccoli, but because it damages the marketable portion of the crop, detection is very important. Damage occurs on the broccoli florets. Feeding damage is indicated by dry, shrivelled, greyish to brown florets scattered across the head. Bacterial and fungal rots may invade these damaged tissues.

Life Cycle: Certain weeds such as mints, chickweed, pigweed and alfalfa are favourite hosts. The tarnished plant bug over-winters as an adult in hedgerows, weedy areas and woods. In the spring the bug migrates to preferred hosts to lay eggs. The adults are opportunistic and infest fields for short periods of time where preferred hosts are present.

Pest Management

Chemical Controls: None available.

Cultural Controls: Weed populations should be controlled, as they can be a refuge for early season populations. Nearby alfalfa fields should be monitored for populations that potentially will move into broccoli and cabbage crops, once the alfalfa has been cut.

Alternative Controls: None identified.

Resistant Cultivars: None available.

Issues for Tarnished Plant Bug

1. There is a need to register products for the control of this pest.

Table 8. Insect control products, classification and performance for Canadian broccoli and cabbage production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Acetamiprid				Aphids, Lepidoptera	A	
Azinphos-methyl				Root maggot, Lepidoptera	A^P	
Bacillus thuringiensis				Lepidoptera	A^P	
Carbaryl				Flea Beetles, Lepidoptera	A	
Chlorpyrifos				Root maggot, cutworms	A^P	
Cyhalothrin-lambda				Flea Beetles, Lepidoptera	A^P	
Cypermethrin				Lepidoptera Flea Beetles,thrips,cutworms	A^P	
Dimethoate				Aphids	A	
Endosulfan				Flea Beetles Lepidoptera	A	
Methamidophos				Aphids, Lepidoptera	A	
Methomyl				Cutworms	A^P	
Naled				Aphids, Lepidoptera	A	
Parathion				Thrips,Lepidoptera	A	
Permethrin				Flea Beetles,cutworms, Lepidoptera	A	
Spinodad				Aphids, Lepidoptera	A	

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html

[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*

[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-biological, RR-reduced risk, OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp

[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

Source(s): PMRA EDDENet database; OMAF Publication 363-Vegetable production recommendations 2004-2005; Tom Ferencevic-Sweet Earth Crop Management Services

Table 9. Availability and use of insect pest management approaches for Canadian broccoli and cabbage production

	Practice \ Pest	Aphids	Caterpillars	Cabbage maggot	Flea beatles	Swede midge	Thrips
Prevention	tillage						
	residue removal / management						
	water management						
	equipment sanitation						
	row spacing / seeding depth						
	removal of alternative hosts (weeds/volunteers)						
	mowing / mulching / flaming						
Avoidance	resistant varieties						
	planting / harvest date adjustment						
	crop rotation						
	trap crops - perimeter spraying						
	use of disease-free seed						
	optimizing fertilization						
	reducing mechanical damage / insect damage						
	thinning / pruning						
Monitoring	scouting - trapping						
	records to track pests						
	field mapping of weeds						
	soil analysis						
	weather monitoring for disease forecasting						
	grading out infected produce						
Suppression	use of thresholds for application decisions						
	biological pesticides						
	pheromones						
	sterile mating technique						
	beneficial organisms & habitat management						
	pesticide rotation for resistance management						
	ground cover / physical barriers						
	controlled atmosphere storage						
	forecasting for applications						

no indication that the practice is available/used
available/used
available/not used
not available
Source(s): Information in the crop profile for individual pests

Weeds

Key Issues

- There is a need to register new herbicides for annual, biennial and perennial cruciferous weeds that are difficult to control. Ethametsulfuron-methyl is currently under evaluation for registration as a control option for mustard.
- There is a need for more trained personnel.

Table 10. Degree of occurrence of weed pests in Canadian broccoli and cabbage production

	Degree of occurrence				
Annual Grasses	**BC**	**ON**	**QC**	**NB**	**NF**
Foxtail, green	DNR	E	E	DNR	DNR
Foxtail, yellow	DNR	E	E	DNR	DNR
Proso millet	DNR	E	E	DNR	DNR
Wild oats	DNR	E	DNR	DNR	DNR
Annual Broadleaves	**BC**	**ON**	**QC**	**NB**	**NF**
Buckwheat, wild	DNR	E	E	DNR	DNR
Chickweed, common	DNR	E	E	DNR	DNR
Mouse-eared chickweed	DNR	E	E	DNR	DNR
Fleabane, Canada	DNR	E	E	DNR	DNR
Hairy galinsoga	DNR	E	E	DNR	DNR
Goosefoot (oak, maple)	DNR	E	E	DNR	DNR
Groundsel	DNR	E	E	DNR	DNR
Hemp-nettle	DNR	E	E	DNR	DNR
Prostrate knotweed	DNR	E	E	DNR	DNR
Lady's-thumb	DNR	E	E	DNR	DNR
Lamb's-quarters	DNR	E	E	DNR	DNR
Mustard, wormseed	DNR	E	E	DNR	DNR
Night-flowering catchfly	DNR	E	E	DNR	DNR
Nightshade, black	DNR	E	E	DNR	DNR
Nightshade, hairy	DNR	E	E	DNR	DNR
Pigweed	DNR	E	E	DNR	DNR
Pigweed, redroot	DNR	E	E	DNR	DNR
Pineapple-weed	DNR	E	E	DNR	DNR
Prickly lettuce	DNR	E	E	DNR	DNR
Purslane	DNR	E	E	DNR	DNR
Radish, wild	DNR	E	E	DNR	DNR

	Degree of occurrence				
Annual Broadleaves	**BC**	**ON**	**QC**	**NB**	**NF**
Ragweed, common	DNR	E	E	DNR	DNR
Ragweed, giant	DNR	E	E	DNR	DNR
Shepherd's purse	DNR	E	E	DNR	DNR
Smartweed, green	DNR	E	E	DNR	DNR
Sowthistle, annual	DNR	E	E	DNR	DNR
Spurry, corn	DNR	E	E	DNR	DNR
Stinkweed	DNR	E	E	DNR	DNR
Thistle (Russian)	DNR	E	E	DNR	DNR
Velvetleaf	DNR	E	E	DNR	DNR
Perennial Grass and Sedge	**BC**	**ON**	**QC**	**NB**	**NF**
Nutsedge, yellow	DNR	E	E	DNR	DNR
Peppergrass, field	DNR	E	DNR	DNR	DNR
Quackgrass	DNR	E	E	DNR	DNR
Perennial Broadleaves	**BC**	**ON**	**QC**	**NB**	**NF**
Bindweed, field	DNR	E	E	DNR	DNR
Burdock, common	DNR	E	E	DNR	DNR
Carrot, wild	DNR	E	E	DNR	DNR
Clover , alsike	DNR	E	E	DNR	DNR
Dandelion	DNR	E	E	DNR	DNR
Horsetail, field	DNR	E	E	DNR	DNR
Mallow, round-leaved	DNR	E	E	DNR	DNR
Milkweed, common	DNR	E	E	DNR	DNR
Plaintain, broad-leafed	DNR	E	E	DNR	DNR
Rocket, yellow	DNR	E	E	DNR	DNR
Sheep sorrel	DNR	E	E	DNR	DNR
Sowthistle, perennial	DNR	E	E	DNR	DNR
Thistle, Canada	DNR	E	E	DNR	DNR
Wormwood, biennial	DNR	E	E	DNR	DNR

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
NDR - No data reported
E – established
D – invasion expected or dispersing

Source(s): Kristen Callow, Provincial Vegetable Specialist, OMAF.

Major Weeds

Annual Grasses

Pest Information

Damage: Importance of annual grass species vary greatly across regions.

Life Cycle: Annual weeds complete their life cycle within one growing season, going from seed to maturity to seed production of seeds. The weeds die during the winter, but their seeds produce the next generation of plants in the spring. Annual weeds that emerge with the crop or shortly after can have a great influence on yields.

Annual Broadleaves

Pest Information

Damage: The most serious weed problems in broccoli are shepherd's purse (*Capsella bursa-pastoris* L) and other weeds in the mustard (Cruciferae) family. There are no herbicides for the control of shepherd's purse in cole crops. Weeds in the sunflower family, such as ragweed (*Ambrosia artemisiifolia L.*) and galinsoga (*Galinsoga ciliata*) are also difficult to control. Weeds in the sunflower family are not controlled effectively trifluralin, the main herbicide used for control of broadleaves in broccoli. Lamb's quarters (*Chenopodium album L*) is also very difficult to control. Redroot pigweed (*Amaranthus retroflexus L*) is becoming much more prevalent and herbicide rotation may be ineffective, as resistance to some group 2 herbicides is being reported.

Life Cycle: See annual grasses life cycle.

Perennial Grasses

Pest Information

Damage: The importance of perennial grass species varies greatly across regions.

Life Cycle: Perennials are plants that live for many years. They can spread by seed, but also can spread vegetatively through their root systems. The plants usually flower every year and continually expand their root system. Perennial weeds are usually controlled using herbicides when they are actively growing.

Perennial Broadleaves

Pest Information

Damage: The importance of perennial broadleaf species varies greatly across regions.

Life Cycle: See perennial grasses life cycle section.

Weed Pest Management

Pest Management

Chemical Controls: Cole crops should not be planted into land that has had imazethapyr applied within the last 2 years. Weeds can be controlled pre-emergence with chlorthal dimethyl, trifluralin, s-metolachlor/benoxacor. Annual grasses can be controlled post-emergence with sethoxydim, fluzifop-p-butyl and fenoxaprop-p-ethyl. Annual broadleaves can be controlled post-emergence with clopyralid. Perennial grasses and broadleaves can be controlled post-emergence by glyphosate.

Cultural Controls: Site selection should be based on the degree of weed occurrence in the previous season. Planting into land that is infested with weeds should be avoided if possible. Weeds should be controlled before they become established. Shallow cultivation can be used as a mechanical means of destroying weeds. Early control of weeds allows cole crops to successfully out compete and suppress weeds that emerge later. A good fertility program should be observed to maintain the crop's competitive advantage. Soil moisture and row width should be adjusted as well. Earlier plantings have greater pressure from perennial and annual broadleaves, as the first early flush of weeds in later planting can be controlled by reworking the land. This approach will shift weed populations towards annual grasses, which are easier to control with available herbicides. The use of transplants makes weed control much easier, as the crop is given a head start over the weeds. Transplants are also more tolerant to herbicide applications than emerging seedlings and produce more uniform stands, allowing a better choice of weed management techniques. Crop rotation is essential, allowing for the control of weed species favoured by one crop.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Weeds

1. There is concern over the limited effectiveness of currently registered herbicides for annual broadleaf control.
2. There is a need to register new products for the control of annual and perennial weeds.

Table 11. Weed control products, classification and performance for Canadian broccoli and cabbage production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Clopyralid				Post emergence - broadleaf		
Fenoxaprop-p-ethyl				Post emergence - grass		
Fluazifop-p-butyl-				Post emergence - grass		
Napropamide				Soil applied grass & broadleaf		
Sethoxydim				Post emergence - grass		
s-metolachlor or s-metolachlor/ benoxaclor				Soil applied grass & broadleaf		
Trifluralin				Soil applied grass & broadleaf		

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-biological, RR-reduced risk, OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
Source(s): PMRA EDDENet database

Table 12. Availability and use of weed pest management approaches for Canadian broccoli and cabbage production

	Practice \ Pest	Annual grass	Annual broadleaf	Perennial grass	Perennial broadleaf
Prevention	tillage				
	residue removal / management				
	water management				
	equipment sanitation				
	row spacing / seeding depth				
	removal of alternative hosts (weeds/volunteers)				
	mowing / mulching / flaming				
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	trap crops - perimeter spraying				
	use of disease-free seed				
	optimizing fertilization				
	reducing mechanical damage / insect damage				
	thinning / pruning				
Monitoring	scouting - trapping				
	records to track pests				
	field mapping of weeds				
	soil analysis				
	weather monitoring for disease forecasting				
	grading out infected produce				
Suppression	use of thresholds for application decisions				
	biological pesticides				
	pheromones				
	sterile mating technique				
	beneficial organisms & habitat management				
	pesticide rotation for resistance management				
	ground cover / physical barriers				
	controlled atmosphere storage				
	forecasting for applications				

no indication that the practice is available/used
available/used
available/not used
not available
Source(s): Information in the crop profile for individual pests

References used in this document

Diseases and Pest of Vegetable Crops in Canada. 1994. R.J.Howard, J.A.Garland, W.L. Seaman, eds.

Vegetables of Canada. 1997. D.B. Munro & E. Small, NRC Research Press

Common Sense Pest Control. 1991. Olkowski, Daar & Olkowski. Taunton Press,

Destructive and Useful Insects, 5th ed. 1993. Metcalfe & Metcalfe.

Color Atlas of Post-Harvest Diseases & Disorders of Fruits & Vegetables, Vol.2: Vegetables. 1992. A.L Snowdon, CRC Press ISBN 084937734 x

Natural Enemies of Vegetable Insect Pests. 1993. M.P. Hoffman & A.C. Frodsham, Cornell Coop Extension Public, Resource Centre, 7 Business/Technology Park Cornell Univ., Ithaca, NY, USA 14850 (607) 255-2080

American Phytopathological Society (APS) Compendiums (lettuce, beet, cucurbit, onion, garlic and tomato).

Mineral Nutrition of Higher Plants. 2nd ed. Academic Press. 1995. Marschner, Horst.

Petoseed Publications (Crucifer Diseases, Onion Diseases) Petoseed, Saticoy, California USA (805) 647-1188 ext 1333.

Ontario Ministry of Agriculture and Food
Growing Vegetable Transplants in Plug Trays. Order No. 96-023, Agdex No.250/22.
Bacterial Diseases of Cruciferous Crops. Order No. 88-046, Agdex No. 252/635.
Black Rot of Crucifer Crops. Order No. 02-025, Agdex No. 252/635.
Fungal Diseases of Cruciferous Crops. Order No. 85-043, Agdex No. 252/635.
Swede Midge http://www.gov.on.ca/OMAFRA/english/crops/facts/03-035.htm
Vegetable Production Recommendations 2002-2003-363
Integrated Pest Management for Crucifers in Ontario, Publication 701.
Guide to Weed Control, 2002. OMAF Publication 75.
Managing Cutworms in Vegetable Crops. Order No. 00-055, Agdex 250/625
Managing Wireworms in Vegetable Crops. Order No. 00-047, Agdex 250/625
Thrips on Onions and Cabbage. Order No. 99-027, Agdex 250/612
Caterpillar Pests of Cruciferous Crops. Order No. 99-035, Agdex 252/625
Leafminers Attacking Field Vegetables and Greenhouse Crops. Order No. 00-039, Agdex 290/620

British Columbia Ministry of Agriculture Food and Fisheries
BCMAFF Vegetable Production Guide for Commercial Growers 2001/2002 Edition
BCMAFF Major Insect and Allied Pests of Vegetables in British Columbia, 1994
BCMAFF Fact sheet: Diamondback Moth (Plutella xylostella)
BCMAFF Fact sheet: Integrated Pest Management

Canadian Food Inspection Agency
www.inspection.gc.ca/english/plaveg/hort/swede.shtml
www.inspection.gc.ca/english/plaveg/protect/dir/d-02-06e.shtml
www.inspection.gc.ca/english/plaveg/protect/dir/smidgee.shtml
www.inspection.gc.ca/english/corpaffr/newcom/2002/20020529e.shtml
www.inspection.gc.ca/english/sci/surv/2002maps/connas2002.jpg
www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6connas.htm

IPM / ICM resources for production of broccoli in Canada

University of Guelph
http://www.uoguelph.ca/plant/
http://tdg.uoguelph.ca/www/CRSC/mainpath.html
http://tdg.uoguelph.ca/omafra/start.html

University of British Columbia
http://unixg.ubc.ca:780/~plantsci/index.html

Canada - Other
http://www.umanitoba.ca/Agriculture/Agriculture.html
http://lilas.grr.ulaval.ca/
http://home.cc.umanitoba.ca/~frist/
http://www.agrenv.mcgill.ca/
http://www.usask.ca/agriculture/cropsci/

Cornell University
http://www.hort.cornell.edu/
http://www.hort.cornell.edu/extension/commercial/vegetables/index.html
http://www.cce.cornell.edu/topics/agriculture.html

Oregon State University
http://oregonstate.edu/dept/hort/

Purdue University, Horticulture
http://www.hort.purdue.edu/hort/

University of California
http://aggie-horticulture.tamu.edu/
http://envhort.ucdavis.edu/

Iowa state University extension
http://hancock134.exnet.iastate.edu/ref.page.html

USDA Research centers
Horticulture crops quality lab. (Beltsville):
http://www.ars-grin.gov/ars/Beltsville/barc/psi/hcql/hcqlhome.html

Vegetable lab. (Beltsville)
http://www.ars-grin.gov/ars/Beltsville/barc/psi/vl/home.htm

Horticultural crops research units (Corvallis):
http://www.ars-grin.gov/ars/PacWest/Corvallis/hcrl/hcrl.html

Horticultural research lab (Orlando):
http://www.ars-grin.gov/ars/SoAtlantic/Orlando/orlando.html

Other
http://hort.ifas.ufl.edu/
http://www.extension.umn.edu/Hort/
http://hort.unl.edu/
http://www2.ncsu.edu/ncsu/cals/hort_sci/
http://taipan.nmsu.edu/aght/agronomy.html
http://www.hcs.ohio-state.edu/hcs/EM/OnlineCropDatabase.html
http://140.254.84.23:8080/
http://129.93.226.104/
http://gnv.ifas.ufl.edu/www/agator_home.htm
http://hortweb.cas.psu.edu/extension/vegcrp.html
http://www.hort.iastate.edu/
http://hcs.osu.edu/
http://www.cas.psu.edu/docs/CASDEPT/IPM/index.html
http://www.oznet.ksu.edu/dp_hfrr/
http://www.hrt.msu.edu/
http://www.okstate.edu/OSU_Ag/asnr/hortla/
National agricultural library (USDA): http://www.nalusda.gov/
Agriweb Canada: http://aceis.agr.ca/agriweb/agriweb.htm
Counsel Canadienne de l'horticulture: http://www.hortcouncil.ca/
Cole Crop IPM Poster, 2002, Agriculture Environment Partnership Initiative

Table 13. Research contacts related to pest management in Canadian broccoli and cabbage production

Name	Organization	Pest type	Specific pests	Type of research
Hallett, R.	University of Guelph, Guelph, ON	Insect	Swede Midge	Host resistance/susceptibility insecticide efficacy
Rimmer, S.R.	Saskatoon Research Center, AAFC, SK	Disease	Blackleg	Host resistance to disease