Crop Profile for Carrot in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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Crop Profile for Carrot in Canada

The carrot (*Daucus carota*) is a member of the Apiaceae (formerly Umbelliferae), the parsley family). Carrots are biennial plants, but they are grown as an annual crop and harvested for the enlarged taproot. Wild carrots were consumed in prehistoric times, and are believed to have originated in the area around what is now Afghanistan. They were put to medicinal and herbal uses, but were not generally eaten for food because of their poor flavour. Described in Greek and Roman literature, by 900 AD carrots were grown from India to the Eastern Mediterranean. By 1300 the range of cultivation had extended to include China and Western Europe. Today there are hundreds of varieties but orange carrots were not known until the 17th century, when they were developed in Holland. Orange carrots are now the predominant type on the world market, but coloured varieties are making a comeback. Carrots are an excellent source of beta-carotene (pro-vitamin A). Carrots can also be used to produce food colouring, for example, used in colouring dairy products. Other nutrients include vitamin C, vitamin B6, and folic acid as well as potassium. Carrots may be consumed fresh, cooked, or juiced.

General Production Information

Canadian Production (2002)	286,496 metric tonnes 8,622 hectares
Farm gate value (2002)	$57 million
Domestic consumption (2001)	236,130 metric tonnes (fresh) 69,688 metric tonnes (processed)
Export (2002)	$29 million (fresh)
Imports (2002)	$101 million (fresh)

Source(s): Statistics Canada

Production Regions

Carrots are grown in all regions of Canada, being a cool season vegetable adapted to long, cool growing seasons. The majority of carrot production occurs in Ontario (44%) and Quebec (35%), both for fresh market and processing.

Cultural Practices

The best soils for growing carrots are well-drained, stone-free, organic, peat and sandy loam soils with good water holding capacity. Most of the Canadian carrot crop is grown in organic soils. In Ontario, carrot acreage grown in highland or non-organic soils is rapidly increasing and almost equalling muck production. Carrots are grown in temperate regions of the world and in tropical areas where high elevations give cool night temperatures. Optimum growing temperatures for carrots are 15^{o} to 20^{o} C, with a minimum of 5^{o} C and a maximum of 24^{o} C. In Canada, carrots are planted from mid-March to June. Carrots take from 6-21 days to germinate, and from 70 to 120 days to fully mature. The optimum temperature for germination ranges from 10^{o} to 25^{o}C. Carrot foliage is frost sensitive, but this does not usually damage the roots. Prolonged frost over 24 hours may injure the crowns and the carrots will not keep in storage.

Carrots are grown for both the fresh market and processing industries and are a crop of high per capita consumption. Fresh carrots can be sold as either “bunched" (with tops) or “topped" (without tops). Increasingly popular in the late 90’s are “baby carrots”, which took over large

parts of the traditional topped carrot market. The market for this type of carrot and the topped carrot market appears to have stabilized in the last 2 years. Many of these pre-packaged, washed, ready to eat baby carrots may be cut from undersized carrots or pieces of larger carrots, but they generally are grown from selected cultivars at high density. Since they undergo minimal change to the actual carrot, baby carrots are not considered to be processed. Processing includes canning and freezing.

Carrot harvest begins with the bunched crop in mid-July. Roots for topping and packaging are harvested later, starting in early to mid August. Carrots harvested from mid-September to November can yield a gross weight of 40 tonnes to 80 tonnes per hectare. However, marketable yields average 25 tonnes per hectare (fresh or processed). Carrots are mechanically harvested by undercutting roots and lifting them out of the soil and into the machine by grasping the leaves. It is important to maintain healthy leaves until the carrots are harvested.

Production Issues

Weed populations can compete with the crop and greatly affect yield and quality, as well as harbour insects and diseases. Herbicides may be applied to control early annual weeds. Shallow cultivation is used in conjunction with herbicides to control escaped weeds. Perennial weeds should be controlled prior to planting. Pre-emergence herbicides usually provide good weed control. Carrots can be severely injured by pre-emergence herbicides when heavy rainfall or a high water table coincides with carrot emergence. Post emergence treatments are also suitable for annual broadleaf weeds and grasses. Small numbers of weeds that escape herbicide treatment may be removed by hand to reduce future growth. Good crop rotation can also reduce the general weed seed reservoir in the soil.

Several insect pests and diseases can affect carrot crop growth, yield and quality. Insecticides and fungicides are important as seed treatments and foliar sprays to maintain yield, quality, and marketability of the crop. Concern over pesticide uses is becoming a serious issue with growers and the general public.

Table 1. Canadian carrot production and pest management schedule

Time of year	Activity	Action
November - April	-	Nothing done
May	Plant care	Seeding (earlier in some areas)
	Soil care	Fertilization and cultivation
	Disease management	Seed treatment
	Insect & mite management	Seed treatment
	Weed management	Cultivation and pre-emergence sprays
June	Plant care	Irrigation and monitoring
	Disease management	Monitoring and spraying when necessary
	Insect & mite management	Monitoring and spraying when necessary
	Weed management	Post emergence sprays
July - August	Plant care	Irrigation and monitoring
	Disease management	Monitoring and spraying when necessary
	Insect & mite management	Monitoring and spraying when necessary
	Weed management	Limited
September - November	Plant care	Harvesting (later in some areas) and storage
	Disease management	Limited so late in the season
	Insect & mite management	Monitoring and spraying when necessary
November - February	-	Storage

Abiotic Factors Limiting Production

Key Issues

- High temperatures and drought are the most important abiotic factors limiting carrot production.

High Temperatures

Carrots are best adapted to long cool growing seasons. Carrots have a low tolerance for high temperatures. During hot, bright, sunny days, young plants can be badly injured or killed by high temperatures that develop at or just below the soil surface. Prolonged hot weather later in the development of the plants may not only retard growth and depress yield, but also may cause undesirable strong flavour and coarseness in the roots.

Drought

Carrots have a low tolerance to drought. Carrots are most sensitive to moisture stress during root enlargement and seed germination. Irrigation can improve emergence, reduce wind erosion and lower temperatures at the soil line during germination.

Diseases

Key Issues

- There are new products registered for blight control, but there is little information available on effective application timing. Studies are required to determine effective timing in order to reduce trims across the field and the number of applications.
- In Ontario, there is a need for province wide blight forecasting systems and an increase in resources to scout all acreages for the established thresholds.
- There is a need for the further development of the blight forecasting technology (CIPRA) for the Maritime Provinces. Early detection of the first disease pressure is critical for maintaining low disease pressure throughout the growing season.
- There is a need for the development and registration of a fungicide to reduce storage losses.

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

	Degree of occurrence									
Major diseases	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
White mould	E			E	E	E	DNR	E	E	E
Grey mould			DNR	E	E	E	DNR	E	E	
Cercospora blight	E		DNR		E	E	DNR	-	E	DNR
Alternaria blight	E		DNR	E	E	E	DNR	E	E	E
Minor diseases	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Violet Root Rot			DNR		D	-	DNR		E	
Aster yellows	E		DNR	E	E	E	DNR	D	E	E
Rusty root	E		DNR		E	E	DNR		E	
Cavity spot	E		DNR	E	E	E	DNR	E	E	D
Crown rot			DNR	E	E	E	DNR	D	E	
Black root rot (*Chalara elegans*)	E	DNR	DNR	DNR	DNR	DNR	DNR	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

E – established

D – invasion expected or dispersing

DNR - Data not reported

Source(s): Provincial crop and pest management specialists, BC Crop Profile

Major diseases

White Mould (*Sclerotinia sclerotiorum*)

Pest Information

Damage: Infected tissue becomes soft and watery. Infections may not be apparent at harvest but can show up in storage where it is spread rapidly from infected carrots to healthy ones. Significant yield losses are possible when growing seasons are cool and wet.

Life Cycle: The fungus has a wide host range, including most vegetable crops. The fungus is soil-born and can survive in the soil for many years in the form of sclerotia. Sclerotia germinate after being conditioned by cool, moist conditions for several weeks and germinate when exposed to adequate soil moisture and moderate temperatures. The carrot crop canopy creates an excellent environment for the conditioning and germination of sclerotia, with dense foliage that blocks out sunlight and keeps the soil moist. Germination produces apothecia which release ascospores into the air. The ascospores are carried by wind to host plants where they can infect leaves and roots. Infections give rise to fungal mycelium which grows on senescent leaves. The mycelium, through contact, can infect other leaves and is another mode of transmission. In storage, the disease spreads from infected carrots to adjacent healthy roots by mycelial growth.

Pest Management

Chemical Control: Benomyl is effective, with a maximum of three applications per season. Field spraying is effective only if the spray contacts lower leaf petioles and crowns.

Cultural Control: Other susceptible crops should not be grown in proximity to carrot fields. Areas with poor drainage and frequent light watering should be avoided. A 3-4 year crop rotation is important, avoiding beans, cucurbits, celery and cabbage. Soil should be well drained and watering should be done early in the day. Weed control is important and the removal and destruction of infected plant material can help reduce the spread. If late season carrot varieties are used, row spacing should be increased.

Alternative Controls:

Resistant Cultivars: There are several varieties that are less susceptible, however none are resistant.

***Issues for White Mould**:*

1. A replacement for benomyl is a priority for both control in the field and storage. Reduced risk or biological products to control white mould in storage are especially needed.

Grey Mould (*Botrytis cinerea*)

Pest Information

Damage: Affected tissue can develop an extensive soft rot.

Life Cycle: Conidia, produced in infected crop residue and plants and from sclerotia, are the primary means the disease is spread. Mycelium can also infect healthy plant tissue. Conidia are produced in infection sites, 2-3 days after primary infection and are the means of secondary spread..

Pest Management

Chemical Controls: Benomyl was effective when sprays reached lower petioles, but it is no longer registered for use.

Cultural Controls: Areas of poor air circulation and frequent light watering should be avoided. A 3-4 year crop rotation is beneficial, avoiding beans, cucurbits, celery and cabbage. Plants should be seeded into well drained soil and any watering should be done early in the day. Weed control is very important to minimize disease. The removal and destruction of infected plant material can help reduce the build-up of inoculum in the soil. Row spacing should be increased when late season varieties are used.

Alternative Controls:

Resistant Cultivars:

Issues for Grey Mould

1. A replacement for benomyl is a priority for control both in the field and storage. In particular, Reduced risk or biological products are especially needed to control grey mould in storage.

Cercospora Blight (*Cercospora carotae*)

Pest Information

The disease is also known as leaf spot and early blight.

Damage: The pathogen causes a serious foliage disease of carrot. Yield losses can be significant as the disease weakens carrot tops, making harvesting by machinery impossible.

Pest Life Cycle: The pathogen affects only the leaves and not the edible carrot root. The fungus overwinters in infected plant debris and wild hosts or is seed borne. Spores are produced on debris and are carried by wind or water to young carrots. The fungus enters the leaves through the stomata, with lesions appearing 3-5 days after infection. Lesions produce new spores in a short period of time, which cause secondary infection. Long periods of leaf wetness provide ideal conditions for infection, but spores are able to germinate over a wide range of conditions.

Pest Management

Chemical Controls: Mancozeb, chlorothalonil, pyraclostrobin and metiram are effective fungicides registered for control of the pathogen on carrots.

Cultural Controls: Only disease free seed should be used and resistant cultivars should be chosen. A 2-3 year rotation helps reduce inoculum build-up in the soil. In the fall, residue left after harvest should be ploughed under to speed up decomposition. Over-watering should be avoided and row spacing should be increased for late season varieties.

Alternative Controls: A forecasting system is being developed for Eastern Canada. The system is being tested in Quebec by Agriculture and Agri-Food Canada. The system integrates data such as inoculum levels, temperature, humidity and leaf wetness, to determine if the carrots are at risk of a severe infestation.. In B.C., an IPM program recommends applying fungicides when 25% of mid-age leaves have one or more blight lesions, which corresponds to about 1-2% of the entire field's leaf area.

Resistant Cultivars: Resistant varieties include Delite, Delux, Fancy, Bonus, Classic, Winner and Premium.

Issues for Cercospora Blight

1. There is a need for the development of blight forecasting technology in most areas. Early detection of first disease pressure is critical for maintaining low disease pressure throughout the growing season.

Alternaria Blight (*Alternaria* dauci)

Pest Information

Damage: Petioles and leaves of infected plants become weakened and brittle, breaking off during harvest. Mechanical harvesting is becomes difficult due to the weakening of the leaves. The pathogen also causes damping-off of seedlings, blight of seed stalks and a black decay of the roots.

Life Cycle: Alternaria overwinters in infected debris in the soil and may also be spread by contaminated seed. During the growing season, *Alternaria* spores and mycelium are spread by wind, water, splashing rain and farm equipmentThe pathogen attacks older foliage and occurs somewhat later in the season than *Cercospora* blight. . Infections progress slowly until conditions are favourable. In warm, moist weather, leaf-spotting can progress very rapidly as the pathogen spreads. Damaged plants and nitrogen deficient plants are more susceptible to infection.

Pest Management

Chemical Controls: Fungicides registered include chlorothalonil, iprodione, mancozeb and metiram.

Cultural Controls: Treated, disease free seed of resistant varieties should be used if possible. A 3 year crop rotation in well drained soils can help reduce inoculum build-up. Equipment should be cleaned before moving between fields to reduce the spread of inoculum. Fall ploughing will help infected debris decompose more quickly.

Alternative Controls: A disease forecasting system, which takes inoculum levels, weather data and leaf wetness into account, is being developed by the University of Guelph's Ridgetown College.

Resistant Cultivars: Resistant varieties include Orlando Gold and Hi-color.

Issues for Alternaria Blight

None identified

Minor Diseases

Violet Root Rot, Storage Rots, Crater Rots (*Rhizoctonia carotae*)

Pest Information

Damage: Crater rot can cause up to 100% crop loss.

Life Cycle: Once the pathogen is in the soil, it remains there indefinitely, overwintering as mycelium in the soil or in infected plant material. Contaminated soil facilitates the spread of the pathogen from one field to another. Foliar symptoms, such as wilting and dying, are not always obvious until the disease is very serious.

Pest Management

Chemical Control: Seed treatments with thiram, captan and iprodione, provide some level of control.

Cultural Controls: Planting in fields with a history of violet root rot should be avoided. Sanitation practices are very important to prevent the spread of the disease to other fields. Disease free seed should be planted as soon as possible in the spring to allow for early emergence and a long crop rotation should be followed.

Alternative Controls:

Resistant Cultivars: None

Issues for Violet Root Rot, Storage Rot, Crater Rots

None identified

Aster Yellows

Pest Information

Damage: The disease is characterized by a yellowing of the leaves and vein clearing at the center of the crown. Crown growth is short, bunchy and brittle. Carrots become deformed and dwarfed and have poor flavour. The pathogen also pre-disposes plants to other diseases, such as soft rot. Severe yield losses are possible, as the disease affects both above and below ground parts of the plant.

Pest Life Cycle: The pathogen that causes the disease is a phytoplasma. Various species of leafhoppers spread the pathogen and the phytoplasma can overwinter in leafhoppersr. Overwintering can also take place in perennial host plants, such as weeds and ornamentals. After acquiring the pathogen, 10 days is required before leafhoppers are able to transmit the disease to new plants. An insect may remain active and continue to spread the disease for more than 100 days after acquiring the pathogen. Symptoms become visible 10-21 days after infection. The occurrence of the disease in carrots is directly related to the flight of leafhopper insects from areas with diseased plant to new plantings of carrots.

Pest Management

Chemical Controls: Carbaryl and parathion are registered for the control of leafhopper. There are no registered products to control the disease once a plant is infected.

Cultural Controls: Weed control is very important in the field, as well as in adjacent fields and ditches. Carrots should not be planted near lettuce or other susceptible crops. Early planting is important to establish plants before infection is a concern.

Alternative Controls: Monitoring of insects and their migrations from field to field is important for early season vectors. Scouting is done using sweep nets and sticky traps.

Resistant Cultivars: Less susceptible varieties can be chosen to minimize damage.

Issues for Aster Yellows

None identified

Rusty Root (*Pythium* sp), Root Dieback (*Pythium* sp.)

Pest Information

Damage: Pythium is one of the many fungi responsible for pre and post-emergence damping off. Infection rates can be high, particularly during periods of cool, wet weather and can lead to germination failure.

Life Cycle: The pathogen develops as white mycelium, branching off and forming reproductive structures. Spores are produced that are transported by water to the host. The pathogen survives best on dead plant and animal matter, but is also able to survive on living plants in wet soils. The fungus enters plant cells, consumes cellular material and kills the cells. Mature plants are better able to resist infection, however, seeds and young seedlings are much more susceptible.Young roots can be attacked at any stage of plant growth.

Pest Management

Chemical Controls: Seed can be treated with thiram or iprodione.

Cultural Controls: Dense seeding and planting into severely infested fields should be avoided. Poorly drained soils and over watering of seedlings should be avoided. Seeds should be planted when soil has warmed and resistant cultivars should be used whenever possible. A three year crop rotation including potato, onion, corn and cabbage can reduce infection.

Alternative Controls:

Resistant Cultivars: Among the several cultivars that have high tolerance to the pathogen are Spartan Fancy, Canada Super X, Orlando Gold and Paramount.

Issues for Rusty Root, Root Dieback

1. The disease can be a problem during wet years on muck soils.

Cavity Spot (*Pythium* spp.)

Pest Information

Damage: The disease rarely reduces yield, but can have significant effects on quality. Roots have elliptical lesions on the surface that are horizontally elongated and darken with age. There are no foliar symptoms.

Life Cycle: This disease is caused by several *Pythium* species. Symptoms are normally seen on carrots that have been growing for at least 12 weeks.

Pest Management

Chemical Controls: Seeds can be treated with metalaxyl.

Cultural Controls: Carrots should not be planted in soils with a history of cavity spot. Excessive moisture and over watering should be avoided. Resistant cultivars should be used and seeds should be planted on raised beds to reduce excessive soil moisture.

Alternative Controls:

Resistant Cultivars: Among the many resistant cultivars are Orlando Gold, Six Pak and Spartan Premium.

Issues for Cavity Spot

1. The disease can be a problem during wet years on muck soils.

Crown Rot (*Rhizoctonia solani*)

Pest Information

Damage: Infected plants are stunted and wilted in patches in the field. The disease causes horizontal, dark brown lesions to develop near the top of the root that may penetrate several millimetres deep.

Life Cycle: The pathogen survives for many years in soil.

Pest Management

Chemical Controls: Fungicide treatments to prevent damping off can be used.

Cultural Controls: Crop rotations and good drainage are both important. Avoiding late harvests and grading carrots before storage can reduce losses.

Alternative Controls:

Resistant Cultivars: None

Issues for Crown Rot

None identified

Table 3. Disease control products, classification and performance for Canadian carrot 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
benomyl	Benzimidazole fungicide	B	DI	White mould	I	Product withrawn
				Gray mould		
captan	Phthalimide fungicide (microbial)	Multi-site contact activity	R	Rots		
chlorothalanil	Chloronitrile fungicide	Multi-site contact activity	RE	Cercospora blight	A	
				Alternaria blight	A	
iprodione	Imidazole fungicide	F	R	Alternaria blight		
				Rots	A	Seed treatment
				Rusty root	A	Seed treatment
mancozeb	Polymeric dithiocarbamate fungicide	B	R	Cercospora blight	A^P	MRL issues for the processing market
				Alternaria blight	A^P	Inadequate in PEI
metalaxyl	Anilide fungicide (acylalanines)	A	R	Cavity spot	A^P	Inadequate in PEI
metiram	Polymeric dithiocarbamate fungicide	Multi-site contact activity	R	Cercospora blight	A	
				Alternaria blight	A^P	Inadequate in PEI
pyraclostrobin	Quinine outside inhibitor fungicide	C	R	Cercospora blight		

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
thiram	Dithiocarbamate fungicide	F	R	Rots	A	Seed treatment
				Rusty root	A	Seed treatment
Tri-basic copper sulphate				Alternaria blight	A	Used by organic growers
				Cercospora blight	A	
zineb	Polymeric dithiocarbamate fungicide	Multi-site contact activity	R	Cercospora blight	A^P	MRL issues for the processing market
				Alternaria blight	A^P	

[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-full registration (biological), RR- full registration (reduced risk), OP-full registration (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. 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)

Sources: Provincial crop and pest management specialists; Pest Management Regulatory Agency

Table 4. Adoption of disease management approaches for Canadian carrot production

	Practice \ Pest	White mould	Grey mould	Cercospora blight	Alternaria blight
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/weed-free seed				
	optimizing fertilization				
	reducing mechanical damage / insect damage				
	thinning / pruning				
	choice of planting site				
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				
	innovative techniques				
	limited sprays				
	pest specific pesticides / consideration of beneficials				

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 target specific insecticides. There is a reliance on older chemistries that are currently under review (carbaryl and organophosphates), which will leave the industry with very few insecticide options for certain pests.
- There is concern over U.S. maximum residue limits (MRLs), which make many products unavailable for the processing market.
- There is a need for less toxic pesticides for the control of aster leafhopper. New products that are available in the U.S. are less toxic and are used preferentially by growers.
- There is a need for an aster leafhopper infectivity level in Ontario to help reduce the number of sprays used. Currently information is used from the U.S. to determine when to spray. A method has been developed, but it is not profitable for labs to provide the service to growers.
- There is a need for research into crop rotations and antagonistic crops for nematode suppression.
- There is a need for research into cultural practices for the control of the carrot rust fly, such as row covers and exclusion fences.
- There is a need for harmonization of product registration with the U.S., particularly bio-control agents and reduced risk products.

Table 5. Degree of occurrence of insect pests in Canadian carrot production

	Degree of occurrence									
Major pests	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Aster leafhopper				E	E	E	DNR	D	E	E
Carrot weevil			DNR		E	E	DNR		E	E
Carrot rust fly			DNR		E	E	DNR	D	E	E
Minor pests	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Cutworms				E	E	E	DNR	D	E	E
Nematodes	E		DNR	E	E	E	DNR	D	E	

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

E – established

D – invasion expected or dispersing

DNR - Did not report data

Source(s): Provincial crop and pest management specialists, BC Crop Profile

Major Insects and Mites

Aster leafhopper (*Macrosteles quadrilineatus*)

Pest Information

Damage: The pest is important annually in some areas, but not in Quebec, damaging carrot leaves by transmitting the phytoplasma that causes aster yellows.

Life Cycle: Adults are very active, jumping, flying and crawling sideways or backward when disturbed. Both adults and nymphs have piercing mouthparts that they use to extract sap from leaves. The phytoplasma is transmitted in saliva. The pest winters in weedy areas along field margins and generally moves into carrot fields in early July. The leafhoppers can carry the aster yellows pathogen from plant to plant as they feed.

Pest Management

Chemical Controls: Carbaryl and parathion are registered for the control of aster leafhopper.

Cultural Controls: Weeds should be removed in surrounding ditches and hedgerows. Other susceptible crops, such as lettuce, should not be planted near the carrot crop. Early seeding increases plant vigour and reduces the chances of infection. Weeds and winter grasses should be controlled in the carrot field.

Alternative Controls: Thresholds, based on the number of leafhoppers present (and not on the number of leafhoppers present that are contaminated with the phytoplasma) have been set at 5 leafhoppers per sample of 25 sweeps.

Resistant Cultivars: Resistant cultivars are available.

Issues for Aster Leafhopper

1. There is a need for a scientifically based threshold that can determine the percentage of leafhoppers that carry the phytoplasma responsible for aster yellows. If the insect is present, but is not carrying the phytoplasma, control may not be necessary.

Carrot Weevil (*Listronotus oregonensis*)

Pest Information

Damage: The pest can cause serious economic damage, but infestations are localized. Damage, which may be extensive, results from larval tunnelling in roots. Adults also cause injury when they excavate areas for egg laying in young carrots.

Life Cycle: Adults overwinter in fields, field margins and ditch banks in the upper 6-8 cm of the soil. Larvae bore down to the roots where they feed for 2-4 weeks before pupating in the surrounding soil. There is only one generation per year in Atlantic Canada, but there may be a second generation in Quebec in some years.

Pest Management

Chemical Controls: Phosmet is an effective insecticide for control of carrot weevil.

Cultural Controls: Good weed control throughout the year can help control the pest. Planting late will avoid the first generation of weevils in the spring. Removing all carrots and carrot pieces from the field at the end of the season removes breeding sites.

Alternative Controls: Nematodes applied with a broom sprayer or through irrigation have been effective in controlling weevils. There are also many naturally occurring beetles and wasps that prey on the on the weevil in the egg, larval and adult stages.
Resistant Cultivars: None

Issues for Carrot Weevil

1. There are trade problems due to the lack of an MRL for phosmet in the United States. Carrots treated with this product cannot be exported to the U.S., making chemical control of carrot weevil difficult if carrots are destined for export markets. The registration of a product with reduced toxicity is required.

Carrot Rust Fly (*Psila rosae*)

Pest Information

Damage: Larvae of the carrot rust fly create tunnels in the roots of carrots, making them unmarketable. Roots may be reduced in size, distorted, scarred and riddled with rust-red burrows of the larvae. Attacks also result in the stunting of carrot plants and seedlings may be killed if the growing tips are severely injured.
Life Cycle: Adult flies appear twice, in early summer and in mid-August. The insect is a poor flier and does not do well in wind swept fields. Leaving infected carrots in the field at harvest can result in greater numbers of overwintering pupae in the soil.

Pest Management

Chemical Controls: Cypermethrin, diaznon and parathion are effective controls.
Cultural Controls: Planting close to fields in which carrots were planted the previous year, should be avoided. A 3 year crop rotation should be used. Planting should be delayed until mid-June if possible to avoid the first generation of the pest. Harvesting can be done in late September before damage is incurred in the fall.
Alternative Controls: There are some parasites of the carrot rust fly, however they have not become established in Canada.
Resistant Cultivars: None

Issues for Carrot Rust Fly

1. There is a need to register new pyrethroids with longer residual activity in order to better control this pest.

Minor Insect and Mite Pests

Cutworm (*Agrostis ipsilon*)

Pest Information

Damage: The cutworm is occasionally a pest in carrot. The cutworm feeds at or below the soil surface at night. It is an active feeder of young foliage and stem tissue and can cut off many young seedlings.
Life Cycle: Preferred egg laying sites are low growing vegetation, including chickweed, mustards or plant residue. Heavy spring weed growth, broken sod and crop debris will favour cutworm

infestations. There are 3-4 generations per year, with the first generation causing the most damage. The pest is most problematic in low, wet, grassy areas.

Pest Management

Chemical Controls: Effective chemicals used for control include permethrin, chlorpyrifos and cypermethrin.

Cultural Controls: Crop rotation should be used, avoiding susceptible crops. Planting should not be done in wet, grassy areas. Grassy weeds should be kept under control. Ploughing in the fall will reduce overwintering populations.

Alternative Controls: There are a number of braconid parasites and predaceous ground beetles that can help keep cutworm numbers down.

Resistant Cultivars: None

Issues for Cutworm

None identified

Root Knot Nematode (*Meloidogyne hapla)*

Pest Information

Damage: Larvae feed on root tips and rootlets, affecting foliage growth and weight and length of roots. The pest causes malformation of the edible root, including forking, galling and hairiness. Severe infections may result in decomposition by secondary pathogens. A loss in stand will occur if seedlings are attacked. Older, infected plants will appear stunted and chlorotic and have a tendency to wilt. Damage levels can be high even when nematode populations are low.

Life Cycle: The pest is a microscopic plant parasitic roundworm found in the soil. It is particularly common in muck soils, where it is a pest to many crops. The pest must feed on susceptible plants to reproduce and complete it's life cycle. Nematodes spread mainly by surface water drainage, blowing soil and farm equipment. The nematodes are most active during hot summer months.

Pest Management

Chemical Controls: Soil fumigation is effective.

Cultural Controls: Crop rotation using non-host crops, such as corn, cereals and marigolds, is important.

Alternative Controls:

Resistant Cultivars: None

Issues for Root Knot Nematode

1. Nematodes are of concern as there are few controls available and they can be a serious problem for carrot production, especially in muck soils.

Table 6. Insect control products, classification and performance for Canadian carrot 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
carbaryl	Carbamate insecticide	1A	RE	aster leafhopper	A[P]	Inadequate in PEI
chlorpyrifos	Pyridine organothiophosphate insecticide	1B	RE	carrot weevil	A[P]	Inadequate in PEI
				cutworm	A	
cypermethrin	Pyrethroid ester insecticide	3	R	carrot rust fly	A[P]	Inadequate in Quebec
				carrot weevil	A[P]	Inadequate in PEI
				cutworm	A	
diazinon	Pyrimide organothiophosphate insecticide	1B	RE	carrot rust fly	A[P]	Inadequate in Quebec
malathion			R	aster leafhopper	I	
metam sodium	Dithiocarbamate insecticide	Unclassified	RE	nematodes	A	
parathion	Phenyl-organothiophosphate insecticide	1B	DI	aster leafhopper	A[P]	Inadequate in PEI

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
permethrin	Pyrethroid ester insecticide	3	R	carrot weevil	A^P	Inadequate in PEI
				cutworm	A	
phosmet	Phthalimide insecticide	1B	RE	carrot weevil	A^P	No alternative product, old chemistry, toxic

[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-full registration (biological), RR- full registration (reduced risk), OP-full registration (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. 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): Provincial Crop and Pest Management Specialists; Pest Management Regulatory Agency

Table 7. Adoption of insect pest management approaches for Canadian carrot production

	Practice \ Pest	Aster leafhopper	Carrot weevil	Carrot rust fly
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/weed-free seed			
	optimizing fertilization			
	reducing mechanical damage / insect damage			
	thinning / pruning			
	choice of planting site			
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			
	innovative techniques			
	limited sprays			
	pest specific pesticides / consideration of beneficials			

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 concern about the resistance developing to some types of herbicides, such as linuron. Herbicides with different modes of action need to be registered to prevent resistance development.
- There is a need for research into cultural practices for controlling weeds, such as tillage, crop rotation and flaming.
- There are no efficient herbicides registered for the control of yellow nutsedge.

Table 8. Degree of occurrence of weed pests in Canadian carrot production

	Weed Occurrence								
Annual grasses	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**PE**	**NS**	**NF**
Barnyard grass	E			E	E	E	E	E	E
Green foxtail	DNR			E	E		D	E	DNR
Volunteer wheat	DNR			E	E			E	DNR
Wild buckwheat	DNR			DNR	E		DNR	E	DNR
Wild oats	DNR			E	E			E	DNR
Seedling grasses	E	DNR	DNR	DNR	DNR	DNR	DNR	DNR	DNR
Annual broadleaf	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**PE**	**NS**	**NF**
Common ragweed				E	E	E		E	DNR
Corn spurry	E			E			D	E	E
Hairy nightshade	E			D	E				DNR
Hempnettle	E			E	E		D	E	E
Kochia	E			E				4	
Lady's thumb	E			E	E		E	E	E
Lambs quarters	E			E	E	E	E	E	E
Low cudweed	E				E		D	E	E
Redroot pigweed	E			E	E	E	D	E	DNR
Wild radish	E			E	E			E	DNR
Volunteer potatoes	E	DNR	DNR	E	DNR		DNR	DNR	DNR
Pinapple weed	E	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Common groudsedge	E	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Wild parsnip	E	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Canada fleabane	E	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Annual weeds	E	DNR	DNR	DNR	DNR	DNR	DNR	DNR	DNR

	Weed Occurrence								
Perennial grasses	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**PE**	**NS**	**NF**
Quackgrass	DNR			E	E	E	E	E	DNR
Yellow nutsedge	DNR	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Perennial broadleaf	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**	**PE**	**NS**	**NF**
Canada thistle	DNR			E	E			E	DNR
Field mint	DNR						E	E	DNR
Narrow-leaved goldenrod	DNR			E		E	E	E	E

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
E – established
D – invasion expected or dispersing
DNR - Data not reported
Source(s): Provincial crop and pest management specialists, BC Crop Profile

Annual and Biennial Weeds

Pest Information

Damage: Crop losses can be very high if annual weeds are not controlled. Broadleaf weeds can reach heights similar to the carrot crop and compete for light, water and nutrients. If not controlled effectively, they will reduce carrot growth and yield. Annual grasses also cause significant problems in carrot production because of their fast growth and ability to compete for necessary resources. Additionally, grass weeds are very tolerant to extremes in moisture and temperature once established. They can be very difficult to eliminate from infested fields and they require management/control prior to seed-set due to their prolific seeding.

Life Cycle: Annual grass and broadleaf weeds complete their life cycle from seed germination through to new seed production, in a single season. Spring annuals germinate in the early spring and produce seed in the summer or fall of the same year. Winter annuals grow to the rosette stage in the fall, and maturing and producing seed early the following year. Annual weeds produce large numbers of seeds by which they easily spread. Most arable land is infested with annual weed seeds at all times and some weed seeds can remain viable in the soil for many years, germinating when conditions are suitable. Biennial weeds are plants that germinate in the spring, producing a rosette of leaves and remain vegetative during the first summer. They overwinter as rosettes and in the next season, they flower and produce seed. The plant dies at the end of the second growing season. Biennial weeds only disseminate through the seeds produced every other year and so their dissemination potential is slightly less than that of annuals.

Pest Management

Chemical Controls: Herbicides currently labelled for control in carrots work well on annual grasses and a few small seeded broadleaf weeds. Most annual broadleaf and grass weeds can be controlled in carrots with a soil applied pre-emergent residual herbicide. This can provide season long protection against germinating weeds and seedlings. Once the carrots emerge, there are limited herbicide options for controlling broadleaf weeds in the crop. Using selective systemic herbicides can control grass that emerges after the crop plants.

Cultural Controls: A primary preventative measure to control weeds is site selection. Carrots should not be planted in a field for which the weed history is unknown. Fields must be scouted the previous season to determine what weeds might be present and whether they can be controlled in the carrot crop. Difficult to control weed infestations must be reduced to a manageable level before planting the carrot crop. Purchased seed should be certified to ensure that it contains the lowest possible quantities of weed seed. The removal of weeds from fence lines, ditches, and roadways will also help to prevent weed establishment in cropping areas. Weed seeds can be transported from field to field by equipment, wind, water, and animals. To reduce this transport, clean soil and debris from equipment when leaving each field. Manure applications can also introduce weeds to a field. Weed seeds in forages may not be destroyed through digestion by livestock or from composting. Repeated tilling, prior to planting and cultivation after planting, can help reduce the number of germinating weeds that survive. Monitoring for annual weeds should be done during the first 2-3 weeks after weed emergence if post emergence controls are to be applied. Vigorous carrot stands are important to shade out germinating weed seed. Row spacing should be chosen so that row closure is quick. Crop rotation is a very effective method to control all pests including weeds. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimise erosion and nutrient uptake over the winter.

Alternative Controls:

Resistant Cultivars: Carrot varieties that give quick emergence and vigorous crop stands will help shade out germinating weed seeds.

Issues for Annual and Biennial Weeds

1. In some areas of Canada, annual weeds have developed resistance to herbicides; triazine-resistant lambsquarters now infests many fields across the country.

Perennial Weeds

Pest Information

Damage: Perennial weeds can grow very large and be very competitive, especially if they have been established for several years. This can reduce growth and yield of the crop.

Pest Life Cycle: Perennial grass and broadleaf weeds can live for several to many years. They are generally established from root systems, although many will also spread by seeds. Perennials usually flower and produce seeds every year as well as expand their root system, so can spread effectively by both methods. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds. The critical stage for crop damage is early in the growing season, as for the other groups of weeds.

Pest Management

Chemical Controls: Many perennial broadleaf and grass weeds cannot be effectively controlled once established in the carrot crop.

Cultural Controls: Management of perennials is difficult in carrots, especially after the crop has been planted. Prevention is the most important component of any weed management program. The primary preventative measure to control weeds is field selection. It is important to avoid planting carrots into a field that has a history of serious perennial weed problems. Purchased seed should be certified to ensure that it contains the lowest possible quantities of weed seed. The removal of weeds from fence lines, ditches, and roadways will also help to prevent weed establishment in cropping areas. Cultivation is less effective in controlling perennial weeds as compared to annual weeds. Cultivation may actually break up the underground portions of the plant and increase the weed problem. Weed seeds and other reproductive parts such as roots and rhizomes can be transported from field to field by equipment, wind, water, and animals. Equipment should be cleaned of all soil and debris when leaving each field, to reduce spread. Crop rotation is a very effective method to control weeds. Crop rotation can disrupt perennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimise erosion and nutrient uptake over the winter

Alternative Controls:

Resistant Cultivars: Carrot varieties that give quick emergence and vigorous crop stands will help shade out germinating weed seeds.

Issues for Perennial Weeds

See “key issues” at the start of the weed section.

Table 9. Weed control products, classification and performance for Canadian carrot 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
diclofop-methyl	Aryloxyphenoxy-propoinate herbicide	A	R	Annual grasses		
diquat	Bipiridylium herbicide	D	R	Annual grasses	I	
				Annual broadleaves	I	
				Perennial grasses	I	
				Perennial broadleaves	I	
fenoxaprop-p-ethyl	Aryloxyphenoxy-propoinate herbicide	A	R	Annual grasses	A^{P}	Inadequate in PEI
fluazifop-p-butyl	Aryloxyphenoxy-propoinate herbicide	A	R	Annual grasses	A	
				Perennial grasses	A	
glufosinate	Phosphinic acid herbicide	H	R	Annual grasses	A^{P}	Inadequate in PEI
				Annual broadleaves	A^{P}	
				Perennial grasses	A^{P}	
				Perennial broadleaves	A^{P}	
glyphosate	Glycine herbicide	9G	R	Annual grasses	A	
				Annual broadleaves	A	
				Perennial grasses	A	
				Perennial broadleaves	A	
linuron	Urea herbicide	C2	R	Annual grasses	A^{P}	Inadequate in Quebec
				Annual broadleaves	A	

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
monolinuron	Urea herbicide	7	R	Annual grasses		
				Annual broadleaves		
paraquat	Bipiridylium herbicide	22	R	Annual grasses	I	
				Annual broadleaves	I	
				Perennial grasses	I	
				Perennial broadleaves	I	
prometryne	Triazine herbicide	5	R	Annual grasses	A^P	Inadequate in Quebec
				Annual broadleaves	A	
sethoxydim	Cyclohexandion herbicide	1	R	Annual grasses	A	
				Annual broadleaves		
				Perennial grasses	A	
				Perennial broadleaves		
trifluralin	Dinitroanaline herbicide	3	R	Annual grasses	A^P	Inadequate in PEI, can be toxic to the crop
				Annual broadleaves	A^P	

[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-full registration (biological), RR- full registration (reduced risk), OP-full registration (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. 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): Provincial Crop and Pest Management Specialists; Pest Management Regulatory Agency

Table 10. Adoption of weed pest management approaches for Canadian carrot production

	Practice \ Pest	annual and biennial weeds	perennial weeds
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/weed-free seed		
	optimizing fertilization		
	reducing mechanical damage / insect damage		
	thinning / pruning		
	choice of planting site		
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		
	innovative techniques		
	pest specific pesticides / consideration of beneficials		

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

Vertebrate Pests

There are a few vertebrate pests than can affect carrots. Groundhogs can destroy seedlings in the spring and deer can eat roots, being very destructive in fall.

References used in this document

Atlantic Provinces Agricultural Services Co-ordinating Committee. 1997. *Vegetable Crops Production Guide for the Atlantic Provinces.* Publication 1400 Atlantic Provinces Agricultural Services Co-ordinating Committee.

Bélanger, M. and D.L. Benoît. 2003. Inventaire 2003 des mauvaises herbes en sol organique. Cahier de conférences, Journées horticoles régionales « Terre noire », St-Rémi (QC), Décembre 2003.

British Columbia Ministry of Agriculture, Food and Fisheries. 2002. *Annual BC Horticultural Statistics: 2000*. Statistical Services Unit, Policy and Economics Branch, British Columbia Ministry of Agriculture Food and Fisheries.

British Columbia Ministry of Agriculture, Food and Fisheries. 2001. *Vegetable Production Guide for Commercial Growers, 2001/2002 Edition.* Lower Mainland Horticulture Improvement Association.

British Columbia Ministry of Agriculture, Food and Fisheries. *BC Farm Products A-Z: Carrots*. British Columbia Ministry of Agriculture, Food and Fisheries. Available at: http://www.agf.gov.bc.ca/aboutind/products/plant/carrots.htm.

Brodeur, C. and G. Bourgeois. *Cercospora Leaf Blight of Carrot: Control Strategies*. Horticulture Research and Development Centre, Research Branch, Agriculture and Agri-Food Canada.

Carrots Atlantic Canada Vegetable Crops
Guide to Pest Management 2002-2003
Publication No.1400A, Agdex No.250/600 Published January 2002
http://www.gov.pe.ca/af/agweb/library/vegetables/carrots02_new.php.3

Chaput, J. 2000. *Carrot Integrated Crop Management Guidelines*. Ontario Ministry of Agriculture, Food and Rural Affairs. Available at: http://www.gov.on.ca/OMAFRA/english/crops/resource/carricm.htm.

Chaput, J. 2000. *Identification and Management of Carrot Root Diseases*. Ontario Ministry of Agriculture, Food and Rural Affairs. Available at: http://www.gov.on.ca/OMAFRA/english/crops/facts/98-001.html.

Chaput, J. 2000. *Management of Carrot Leaf Diseases*. Ontario Ministry of Agriculture, Food and Rural Affairs. Available at: http://www.gov.on.ca/OMAFRA/english/crops/facts/00-045.html.

Chaput, J. 1996. *Integrated Pest Management for Onions, Carrots, Celery and Lettuce in Ontario*. Muck Research Station, Pest Management Section, Ontario Ministry of Agriculture, Food and Rural Affairs.

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

Crop Profile for Carrot in Virginia, 1999.
Available at: http://pestdata.ncsu.edu/cropprofiles/docs/nycarrots.html

Gunner, A. 1996. *Planning for Profit: Topped Carrots, Fraser Valley*. British Columbia Ministry of Agriculture, Food and Fisheries. Available at: http://fbminet.ca/bc/pfp/Ent.pdf/top_carrot.pdf. Accessed o

Howard, J.R., Garland J.A., Seaman W.J.1994 *Disease and Pests of Vegetable Crops in Canada.* The Canadian Phytopathological Society and Entomological Society of Canada.

Industry Canada. *Trade by Product*. Industry Canada. Available at: http://strategis.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php.

Manitoba Ministry of Agriculture and Food. 2001. *Crops and Plants: Carrots*. Manitoba Ministry of Agriculture and Food. Available at: http://www.gov.mb.ca/agriculture/crops/vegetablecrops/bme00s00.html.

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.

Markle, G., J. Baron, and B. Schneider. 1998. *Food and Feed Crops of the United States, 2nd Edition, Revised.* Rutgers, The State University. Meister Publishing Co. Willoughby, Ohio.

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

Sorenson, E. 2000. *Crop Profile for Carrots in Washington*. Washington State Co-operative Extension.

Statistics Canada. Carrots - Fresh imports from all countries.

Statistics Canada. Carrots - Processed imports from all countries.

Statistics Canada, Agriculture Division, Horticultural Crops Unit. *Fruit and Vegetable Production 2003.*

Statistics Canada. Canada's carrots, fresh or chilled – Exports to all countries.

Statistics Canada. Part 1 2002. Catalogue no. 32-229-XIB. *Food consumption in Canada*

Strong, W. 1990. *Field Scout's Manual for Monitoring Carrot and Onion Pests in the Fraser Valley, British Columbia*. East Chilliwack Agricultural Co-op.

Vegetables of Canada. 1997. D.B. Munro & E. Small, NRC Research Press, ISBN 066016708

IPM / ICM resources for production of carrot in Canada

Agriculture and Agri-Food Canada, Department of Electronic Publications. Diseases of Carrots in Canada, http://www.agr.gc.ca/cal/epub/1615e/1615-0001_e.html

Atlantic Provinces Agricultural Services Coordinating Committee. 1997. *Vegetable Crops Production Guide for the Atlantic Provinces*. Publication 1400 Atlantic Provinces Agricultural Services Coordinating Committee.

Crop Profile for Carrots in Michigan. Available at:
http://pestdata.ncsu.edu/cropprofiles/doc/micarrots.html

Crop Profile for Carrot in Virginia, 1999. Available at:
http://pestdata.ncsu.edu/cropprofiles/docs/nycarrots.html

Horticulture 2001-2002 Canadian Vegetable Situation and Trends- Excluding Potatoes
Agriculture and Agri-Food Canada
http://www.agr.gc.ca/misb/hort/2001_2002/vegetales_e.html

Howard, J.R., Garland J.A., Seaman W.J.1994 *Disease and Pests of Vegetable Crops in Canada.* The Canadian Phytopathological Society and Entomological Society of Canada.

OMFRA. 2000-2001.*Vegetable production recommendations*

Strong, W. 1990. *Field Scout's Manual for Monitoring Carrot and Onion Pests in the Fraser Valley, British Columbia*. East Chilliwack Agricultural Co-op.

Table 11. Research contacts related to pest management in Canadian carrot production

Name	Organization	Pest type	Specific pests	Type of research
S. Banizza	University of Saskatchewan	Diseases	All	IPM
G.J. Boland	Univeristy of Guelph	Diseases	Sclerotinia, others	Storage diseases
Y. Gan	Agriculture and Agri-Food Canada	Weeds, diseases and insects	All	IPM - systems
B. Gossen	Agriculture and Agri-Food Canada	Diseases	All	IPM, breeding
R. Holm	University of Saskatchewan	Weeds, diseases	Agronomy	IPM, general agronomy
R. Lada	Nova Scotia Agricultural College	Abiotic factors		Natural product protection against abiotic stress
M.R. Mcdonald	University of Guelph	Diseases		Muck soil trials, pesticide testing, IPM
R. McVicar	Saskatchewan Agriculture, Food and Rural Revitalization	Weeds, diseases and insects	Extension	IPM
P. Pearse	Saskatchewan Agriculture, Food and Rural Revitalization	Diseases	Extension	IPM
V. Toussaint	Agriculture and Agri-Food Canada	Diseases	Sclerotinia, others	Post-harvest disease control, IPM