Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Crop Profile for Rutabaga in Canada, 2012

Prepared by:

Pesticide Risk Reduction Program
Pest Management Centre
Agriculture and Agri-Food Canada

Canada

First Edition – 2005
Crop Profile for Rutabaga in Canada
Catalogue No.: A118-10/23-2005E-RDF

Second Edition – 2011
Crop Profile for Rutabaga in Canada, 2010
Catalogue No.: A118-10/23-2011E-PDF
ISBN: 978-1-100-19524-7
AAFC No.: 11649E

Third Edition - 2014
Crop Profile for Rutabaga in Canada, 2012
Catalogue No.: A118-10/23-2014E-PDF
ISBN: 978-1-100-23577-6
AAFC No.: 12198E

Electronic version available at www.agr.gc.ca/pmc-cropprofiles

Paru également en français sous le titre: « Profil de la culture du Rutabaga au Canada, 2012 »

For more information reach us at www.agr.gc.ca or call us toll-free 1-855-773-0241.

Preface

National crop profiles are developed under the Pesticide Risk Reduction Program (PRRP), a joint program of Agriculture and Agri-Food Canada (AAFC) and the Pest Management Regulatory Agency (PMRA). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticide or pest control technique, discussed, is implied. Product names may be included and are meant as an aid for the reader, to facilitate the identification of pesticides in general use. The use of product names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

For detailed information on growing rutabaga, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

Agriculture and Agri-Food Canada gratefully acknowledges the contributions of provincial crop specialists, industry specialists and growers in the gathering of information for this publication.

For inquiries regarding the contents of the profile, please contact:

Pesticide Risk Reduction Program
Pest Management Centre
Agriculture and Agri-Food Canada
Building 57, 960 Carling Ave
Ottawa, ON, Canada K1A 0C6
pmc.cla.info@agr.gc.ca

Contents

List of Tables and Figure

Crop Profile for Rutabaga in Canada

The rutabaga (*Brassica napus* var. *napobrassic*a), is a member of the Brassicaceae family. The plant is a cross between turnips (*Brassica rapa*) and cabbage (*Brassica oleracea*) and originated in Scandanavia or Russia in the 17th century. Rutabaga was introduced into North America by European immigrants in the early 19th century. The rutabaga root consists of both a true root and true stem. The upper portion of the stem forms a neck, which distinguishes rutabagas from turnips. The rutabaga is a biennial plant, requiring two years to complete its entire life cycle, from seed to seed. However, only one growing season is required for the production of the edible root, which is the commercial product.

Crop Production

Industry Overview

The root of the rutabaga is used as a vegetable for human consumption and has historically also been used for animal feed. Rutabaga stores well and is available year round and for this reason is becoming more popular among consumers. Rutabagas are used in everyday recipes from muffins to Christmas cake, as a side dish, in dips, mashed, in casseroles and as baked fries/chips. Rutabaga is relatively low in calories and is a good source of vitamin C, folacin and fibre. Figures on national production and value of the crop are presented in table 1.

Table 1. National production statistics for rutabaga

Canadian Production (2012)[1,2]	50,056 metric tonnes 1,863 hectares
Farm gate value (2012)[1,2]	$21.5 million
Fresh rutabaga available for consumption in Canada 2012[2,3]	1.0 kg/ person
Exports (2012)	nil
Imports (2012)	nil

[1]Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database). (Accessed: 2014-01-24)

[2]Includes rutabaga and turnips

[3]Source: Agriculture and Agri-Food Canada. Statistical Overview of the Canadian Vegetable Industry 2012. AAFC No. 12162E-PDF

Production Regions

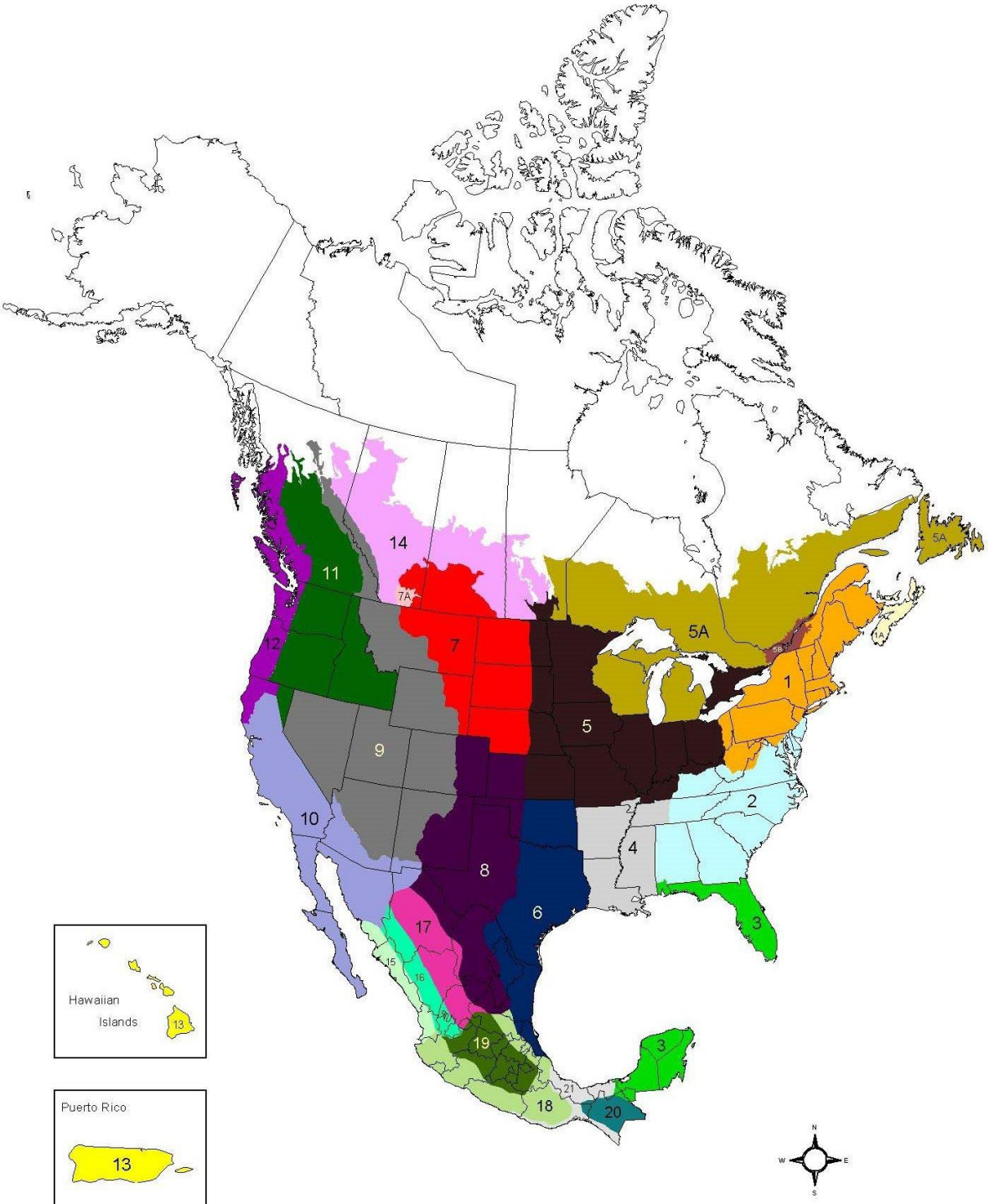
Rutabaga is grown commercially in a number of provinces in Canada. The majority of production takes place in Ontario, Quebec and Prince Edward Island (refer table 2).

Table 2. Distribution of rutabaga production in Canada (2012)[1]

Production Regions	Planted Area 2012 (hectares)	Percent National Production
British Columbia	89	5%
Alberta	70	4%
Ontario	748	40%
Quebec	495	27%
New Brunswick	26	1%
Nova Scotia	64	3%
Prince Edward Island	245	13%
Newfoundland	83	4%
Canada	1,863	100%

[1]Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database). (Accessed: 2014-01-24)

North American Major and Minor Crop Field Trial Regions



Scale 1 : 28 000 000

250 0 250 500 Kilometers

Lambert Conformal Conic Projection

Major and Minor Crop Field Trial Regions

Zone 1	Zone 5	Zone 7A	Zone 12	Zone 17
Zone 1A	Zone 5A	Zone 8	Zone 13	Zone 18
Zone 2	Zone 5B	Zone 9	Zone 14	Zone 19
Zone 3	Zone 6	Zone 10	Zone 15	Zone 20
Zone 4	Zone 7	Zone 11	Zone 16	Zone 21

Produced for: Asociación Mexicana de la Industria Fitosanitaria, A.C.

Produced by: Spatial Analysis and Geomatics Applications, Agriculture Division, Statistics Canada, Februrary, 2001.

Figure 1. Common zone map: North American major and minor field trial regions[1,2]

The major and minor crop field trial regions were developed following stakeholder consultation and are used by the Pest Management Regulatory Agency (PMRA) and the Environmental Protection Agency of the USA to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate but they do not correspond to plant hardiness zones. For additional information, please consult the PMRA Regulatory Directive 2010-05 Revisions to the Residue Chemistry Crop Field Trial Requirements (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir2010-05/index-eng.php).

[1]Produced for: *Asociación Mexicana de la Industria Fitosanitaria, A.C.*

[2]Produced by: Spatial Analysis and Geomatics Applications, Agriculture Division, Statistics Canada, February 2001.

Cultural Practices

Rutabaga grows best on moderately acidic, well-drained clay loam soil with good tilth and organic matter. Soils that have good drainage are essential for fall or winter harvest. The crop will also grow well on moderately acid loams and sandy loams. On sandy loams, roots tend to elongate, especially in dry weather and with high plant populations. Rutabaga is rarely grown in sandy soils because the coarse sand grains can be abrasive and cause injury to the root tissues. Wounded roots do not keep well during long-term storage. Soil crusting can be a problem on heavy soils in fields with poor rotation (i.e. a rotation which does not provide sufficient organic matter) because the crust can prevent the cotyledons from breaking through the soil surface.

A minimum of four to five years of crop rotation away from cole crops is necessary for acceptable insect and disease control. At least a seven-year rotation may be required in fields infested with the clubroot pathogen. During this period, cruciferous weeds should also be controlled, as they can serve as hosts for clubroot. Rutabaga should follow stubble (cereal crop plough down) instead of sod from perennial legumes such as alfalfa or clover, to reduce the potential for the development of diseases and damage from pests that thrive in sod (e.g. wireworms and slugs). Only limited nitrogen is required for rutabaga growth, and this is easier to manage following stubble than following legumes that fix nitrogen. Using legumes in the rotation for two or more years will improve the soil structure and is beneficial, as long as the rutabaga crop does not immediately follow the legume crop.

When choosing fields for rutabaga production, it is also important to consider the possibility of herbicide carryover. Fields where herbicides applied in previous years, persist in the soil, should be avoided, as crop injury may occur.

A soil test is required before seeding or planting to determine fertilizer requirements. The soil must not contain too much nitrogen. Limited nitrogen supply results in slow and steady growth, and improves the shape, size and storage-ability of the root. Fertilizers are best broadcast and incorporated prior to planting. Fertilizer placed too close to the root results in excessive root formation, misshapen roots and consequently high cull rates. Major nutrients to be applied include phosphorus, boron, magnesium and gypsum (sulphur). When necessary, lime should be applied to maintain the soil pH in the range of 6.0 to 6.8.

Rutabaga can be directly seeded in the field or grown from transplants. It is important that growers use high quality certified seed. Seeding can begin as soon as the soil can be worked in the spring. Rutabaga that is intended for storage is planted in early to mid-June, allowing the plants to develop during the cool fall weather. Early-seeded crops may not be suitable for fall harvest and storage as they can develop woody parts and have poor quality. The optimum soil temperature for germination is 16 to 19^{o}C; however, seeds can germinate in soil temperatures as low as 5^{o}C. A fine smooth seedbed is required for uniform seeding depth. Seeding is done at a rate of 225-500 grams/ha and depth of 0.6-1.5 cm. Seeds are spaced 11-15 cm apart in rows that are spaced 50-90 cm. Wide in-row spacing is used for early production and close spacing is used for producing smaller roots. Spacing affects the root size and the harvest date. Precision seeders are used to space seeds at accurate intervals, eliminating thinning and producing a very uniform crop. Thinning, if required, is normally done when plants are 4-8 cm high.

Transplants can be used for early-market rutabaga production. Transplants are started in late March and set in the field in late April. Short, sturdy transplants should be grown without too much cold, which may promote bolting to seed later in the season. Plastic row covers or floating row covers can be used to increase early growth. There is little difference in terms of maturation in rutabaga varieties, although *Thomson Laurentian* tends to be more vigorous. When growing transplants, they must not be subjected to low light conditions and large differences between day and night temperatures.

Rutabaga is well adapted to cool and humid growing conditions. Temperatures between 15°C and 20ºC favour growth. Although frost tolerant, the plants are not usually left in the ground later than the end of October. Rutabagas can tolerate a limited period of temperatures as low as –3^{o}C; however if a significant frost occurs over a prolonged period (longer than 24 hours), the root may freeze, develop a glazed appearance and be unsuitable for storage or sale. Rutabaga can withstand dry periods with a minimal amount of soil moisture, but will have a slower growth rate in these conditions. Excess water also reduces growth. Cracking of the root may occur with a fast growth rate due to excessive fertilization, wide spacing and hot humid weather. Cracks act as potential entry sites for soft rot bacteria. Weeds can be controlled with frequent shallow (2.5-5 cm) cultivation when the crop is dry. This helps conserve moisture and nutrients for the crop and improves soil aeration.

Harvesting is done only when the plant is mature, as the quality and flavour are best when the roots are fully mature and have been exposed to frosts before harvest. Immature roots have a bitter taste and, if early-seeded rutabagas are left in the field until late fall, the roots tend to become fibrous and woody. Rutabagas are very susceptible to bruising, which leads to the development of rot in storage. Bruising may not be apparent until the crop has been stored for three to four months. Harvesting in warm or wet conditions, or putting wet roots into storage can reduce storage quality by making the crop more susceptible to post-harvest diseases. Roots harvested during dry weather tend to shrivel and soften if the level of humidity is not sufficient in storage. Harvesting can be done by hand or mechanically. Mechanical harvesting can cause bruising to the roots. Therefore, care must be taken to minimize injury, especially for roots intended for long-term storage. Storage of roots for up to nine months over the winter and spring months is possible, but special care must be taken to maintain the quality of the rutabaga during this period. The storage facility and storage containers should be cleaned and disinfected in order to prevent the spread of pathogenic micro-organisms that may cause rot during storage. Optimal storage conditions are air temperatures around 0^{o}C and relative humidity greater than 95%.

The following table (table 3) describes production practices and worker activities for rutabaga throughout the season.

Table 3. Rutabaga production and pest management schedule in Canada

Time of Year	Activity	Action
March	Plant care	Transplants are started in late March
April	Plant care	Transplants are set in the field in late April
May	Plant care	Planting of crops destined for early season markets
	Soil care	Fertilization and liming before planting, based on soil tests; application of required phosphorous, potassium and boron
	Disease management	Seed treated with fungicides in some provinces
	Insect & mite management	Seed treated with insecticides in some provinces
	Weed management	Cultivation and pre-emergence sprays
June	Plant care	Planting of crops (early-mid June) intended for storage to enable roots to size during cool fall temperatures, yielding a better quality root
		Monitoring and irrigation (if used)
	Soil care	Topdressing
	Disease management	Monitoring and spraying (if necessary)
	Insect & mite management	Monitoring and spraying (if necessary)
	Weed management	Post-emergent spraying
July	Plant care	Monitoring and irrigation (if used)
	Soil care	Limited activities
	Disease management	Monitoring and spraying (if necessary)
	Insect & mite management	Monitoring and spraying (if necessary)
	Weed management	Limited activities
August	Plant care	Monitoring and irrigation (if used), early harvest
	Soil care	Limited activities
	Disease management	Monitoring and spraying (if necessary)
	Insect & mite management	Monitoring and spraying (if necessary)
	Weed management	Limited activities
September/ October	Plant care	Harvest and storage
	Soil care	Cultivation

Source(s): Ontario Vegetable Production Recommendations, 2010-2011 OMAFRA Publication 363. Turnip and Rutabaga Production Guide, Atlantic Provinces Vegetable Crops Guide to Pest Management 2005.Agriculture Services Co-ordinating Committee. 1400A, Agdex No. 250/600. April 2005.

Abiotic Factors Limiting Production

Herbicide Sensitivity

Rutabaga is extremely sensitive to the drifting of phenoxy herbicides from nearby applications, such as field crop weed control. Seedling crops of rutabaga may show little, if any, visible sign of phenoxy herbicide damage. However, trace or even undetected levels of phenoxy herbicide residue can result in an unmarketable crop. Rutabagas are also sensitive to herbicide carryover from previous crops. Fields where herbicides from previous years persist in the soil must be avoided as crop injury may occur. In particular, if herbicides with the active ingredient metribuzin (used on potato and soybean, among other crops) were applied the year before, there is a very strong possibility of crop injury occurring if rutabaga is grown in the same field the following year.

Brown Heart

Brown heart (also known as water-core) is a disorder of the rutabaga root that occurs when there is a deficiency in soil boron available to the plant. Affected roots have brown, discoloured areas that may appear soft and water-soaked. The discolouration varies from light to dark brown, and can occur as a single area or several smaller areas scattered throughout the centre of the root. Rutabaga first needs boron at about the five-leaf stage, when the root is just beginning to swell. Granular boron must be applied before or at seeding and be followed by foliar applications. By the time brown heart develops, it is usually too late to correct with boron applications. Rutabagas grown in soils with less than 0.5 ppm soluble boron are more likely to have brown heart. The cultivar *York* tends to be less susceptible to brown heart than *Thomson Laurentian*.

Plants take up boron more easily when there is adequate soil moisture. During dry periods, boron may not be readily available to the plant. Soil organic matter, which improves moisture retention may be a source of boron in acidic soils. However, a pH of greater than 7.0 can also interfere with boron uptake.

Temperature Extremes and Low Light

Bolting or flowering can be a problem with very early-seeded or transplanted crops. Rutabaga is a biennial plant. It forms a swollen root during the first year of growth and flowering stems in the second year of growth after a cold period. The exposure of transplants to low temperatures, below 5^{o}C, when they are less than 10 weeks old, will trigger the development of flowering stems. The duration of the low temperature period that triggers flowering, varies with the variety being grown. However, as little as 3 to 5 nights with temperatures around 3^{o}C are

believed to result in the development of flowering stems. Field plantings or seedlings can be affected by low temperatures, but transplants more than 10 weeks old require several nights of freezing temperatures to induce flowering.

Misshapen (long cylindrical shaped) roots result from transplants being grown under low light conditions and with large differences between day and night temperatures. It is essential to provide good ventilation during the day to help reduce temperatures when the days are bright and sunny. It would be beneficial to raise temperatures to above 10ºC at night with supplementary heating, but the feasibility and economics of this practice are questionable. Delaying seeding may be useful in growing a crop that is less likely to bolt and will produce better-shaped roots.

Diseases

Key Issues

- There is a need to register new fungicides for the management of diseases including clubroot, rhizoctonia diseases and downy mildew and for resistance management.
- It would be beneficial to develop new varieties with resistance to all races of clubroot.

Table 4. Occurrence of diseases in rutabaga production in Canada[1,2]

Disease	Ontario[3]	Quebec	Nova Scotia	Prince Edward Island	Newfoundland & Labrador
Black rot					
Clubroot					
Downy mildew					F
Powdery mildew					F
Root rot (crater rot), wirestem					
Soft rot/ neck rot					
Turnip Mosaic Virus					

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Rutabaga stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

[3]Data from Crop Profile for Rutabaga in Canada, 2010.

F - Disease is widespread with low pressure; data on frequency not reported.

Table 5. Adoption of disease management practices in rutabaga production in Canada[1]

Practice / Pest		Clubroot	Root rot (crater rot), wirestem	Downy mildew	Powdery mildew
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	choice of planting site				
	optimizing fertilization				
	reducing mechanical damage or insect damage				
	thinning / pruning				
	use of disease-free seed, transplants				
Prevention	equipment sanitation				
	mowing / mulching / flaming				
	modification of plant density (row or plant spacing; seeding rate)				
	seeding / planting depth				
	water / irrigation management				
	end of season crop residue removal / management				
	pruning out / elimination of infected crop residues				
	tillage / cultivation				
	removal of other hosts (weeds / volunteers / wild plants)				

…continued

Table 5. Adoption of disease management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Clubroot	Root rot (crater rot), wirestem	Downy mildew	Powdery mildew
Monitoring	scouting - trapping				
	records to track diseases				
	soil analysis				
	weather monitoring for disease forecasting				
	use of portable electronic devices in the field to access pest identification /management information				
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests				
Decision making tools	economic threshold				
	weather / weather-based forecast / predictive model				
	recommendation from crop specialist				
	first appearance of pest or pest life stage				
	observed crop damage				
	crop stage				

…continued

Table 5. Adoption of disease management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Clubroot	Root rot (crater rot), wirestem	Downy mildew	Powdery mildew
Suppression	pesticide rotation for resistance management				
	soil amendments				
	biological pesticides				
	controlled atmosphere storage				
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)				

This practice is used to manage this pest by at least some growers.

This practice is not used by growers to manage this pest.

This practice is not applicable for the management of this pest.

Information regarding the practice for this pest is unknown.

[1]Source: Rutabaga stakeholders in reporting provinces (Quebec, Prince Edward Island and Newfoundland and Labrador).

Table 6. Fungicides and biofungicides registered for disease management in rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
azoxystrobin	methoxy-acrylate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Rhizoctonia diseases
bacillus-subtilis strain QST 713	Bacillus subtilis and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	Downy mildew, white mould (*Sclerotinia sclerotiroum*)
bacillus-subtilis strain QST 713 (soil treatment)	Bacillus subtilis and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	Rhizoctonia diseases, phytophthora root rot, fusarium and pythium root rots
captan	phthalimide	Multi-site contact activity	-	M4	RE	Damping off diseases, root rot (general)
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D: amino acids and protein synthesis + E2 signal transduction	D1: methionine biosynthesis (proposed) (cgs gene) + MAP/Histidine-kinase in osmotic signal transduction (os-2, HOG1)	9 + 12	R + RE	Botytis gray mould (*Botrytis cinerea*)
fludioxonil (seed treatment)	phenylpyrrole	E2: signal transduction	MAP/Histidine- kinase in osmotic signal transduction (os-2, HOG1)	12	RE	Seed decay, damping off, seedling blights
fluopicolide	pyridinyl methyl benzamide	mitosis and cell division	delocalisation of spectrin-like proteins	43	R	Botytis gray mould (*Botrytis cinerea*)
fosetyl-Al	ethyl phosphonate	Unknown mode of action		33	RE	Downy mildew (*Hyaloperonospora parasitic*a)
metalaxyl-M (seed treatment)	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	*Pythium* spp. (damping-off)

…continued

Table 6. Fungicides and biofungicides registered for disease management in rutabaga production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
penthiopyrad	pyrazole carboxamide	C2. respiration	complex II: succinate-dehydrogenase	7	R	Botytis gray mould (*Botrytis cinerea*)
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Powdery mildew
pyraclostrobin	methoxy-carbamate	C3. Respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Alternaria leaf spot, *Cercospora* spp., Powdery mildew
sulphur	inorganic	Multi-site contact activity	-	M4	R	Powdery mildew
trifloxystrobin	oximino acetate	C. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Leaf blight (*Alternaria* sp.)

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 3, 2014. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2013: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed January 2014).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note REV2013-06, Special Review Initiation of 23 Active Ingredients, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Black rot (*Xanthomonas campestris pv. campestris*)

Pest information

Damage: Black rot is a very serious disease of cruciferous crops. Infected leaf tissue develops V-shaped, yellow lesions at the leaf margins and chlorosis can progress toward the leaf center. Veins in these areas become dark brown or black. As the infection becomes systemic, symptoms may appear anywhere on the plant and stunting occurs. Blackened vascular tissues may develop in roots.

Life cycle: The bacterial pathogen can over-winter in plant debris for up to 2 years and be carried internally within the plant and externally on seed. The bacterium infects a range of crucifer crops and weeds. It may be spread in the field by water, insects, equipment, humans and animals. Free water from dew, rain or irrigation is necessary for spread. The pathogen enters water pores at leaf margins or through mechanical injuries. Many outbreaks can be attributed to disease spread in the seedbed. Infested seed is the main vector of black rot, and a seed lot with as few as 5 infected seeds per 10,000 can cause a high incidence of black rot in the field.

Pest management

Cultural controls: Work should not be done in the field when plants are wet. Cruciferous weeds should be controlled. A 4 year rotation should be followed. Equipment used in an infested field should be cleaned and disinfected before being used in other fields. A hot-water seed treatment (50 °C for 15 minutes) will limit spread of the disease. Only certified, disease free seed should be used. Diseased plants should be removed from the field and destroyed.

Resistant cultivars: None available.

Chemical controls: None available.

Issues for black rot

None identified.

Clubroot *(Plasmodiophora brassicae)*

Pest information

Damage: Diseased plants become chlorotic, are slow to grow and develop, and may partially wilt during warm days. Large, spherical, club-like growths develop below the enlarged area of the root (hypocotyl), which become infected with secondary bacteria, resulting in rot.

Life cycle: The fungus survives in the soil as resting spores. Land will remain infested for seven years or longer after a diseased crop. Certain weeds of the mustard family, such as wild radish and wild mustard will maintain or increase the level of infestation year after year. Soils that are cool, wet and acidic (pH less than 7.2) favour the disease. The fungus is soil-borne and is spread by infected seedlings, contaminated manure, water, farm equipment, animals, human footwear and in soil blown by the wind. It invades roots through wounds and root hairs and causes swelling and distortion. Motile spores are released from infected roots and swim in moisture films to other roots.

Pest management

Cultural controls: Plants should be scouted regularly. A rotation of at least 7 years, that does not include cruciferous crops, should be used once an infestation has been encountered in a particular field. A three year rotation between cruciferous crops can be used on "clean" land. Manure from animals fed infected crops should not be used on land intended for any cruciferous crop. Soil tests should be conducted to ensure that high soil calcium and magnesium levels are maintained along with a pH over 7.2. Planting in fields with a known history of clubroot should be avoided. Care must be taken not to introduce the pathogen into new fields through the movement of infested transplants, soil and equipment. Field equipment should be cleaned and disinfected when moved from field to field. Infested land should be seeded to a sod crop, such as hay or pasture, for at least seven years, to prevent the movement of soil. Susceptible weeds should also be controlled.

Resistant cultivars: Resistant cultivars are available; *York* is resistant to most races of clubroot, while *Kingston* is resistant to all races.

Chemical controls: The seedbed can be fumigated if pathogen-free soil is not used.

Issues for clubroot

1. There is a need for the registration of pesticides for the management of clubroot.
2. It would be beneficial to develop new varieties with resistance to all races of clubroot.

Downy mildew *(Peronospora parasitica)*

Pest Information

Damage: Symptoms include distinct, angular yellow areas on the upper surface of leaves and fluffy, white patches of mycelial growth on the lower surface. Rutabaga roots can be invaded systemically, resulting in internal darkening of the root and in advanced cases, cracks or splitting.

Life cycle: The disease is favoured by cool moist weather and is a problem on rutabaga in the spring and fall. Temperatures in the range of 10 – 15^{o}C and free moisture on the leaves are optimal for spore production and initiation of new infections. Spores are spread by wind and splashing rain. The fungus overwinters on seed, in cruciferous weed hosts and likely in soil.

Pest Management

Cultural controls: Excessive watering of transplants should be avoided. A minimum 3 year crop rotation using grains and grasses should be followed. Seedlings and leaves should be kept as dry as possible. Proper spacing to allow airflow is important. As nutrient deficiencies increase the susceptibility of plants to diseases, fertilization may help seedlings outgrow infection.

Resistant cultivars: None available.

Chemical controls: Refer to table 6. "Fungicides registered for disease management in rutabaga production in Canada" for fungicides registered for the control of downy mildew.

Issues for downy mildew

1. Rotational products are required for resistance management.

Powdery mildew (*Erysiphe polygoni*)

Pest information

Damage: The disease appears as a white, powdery fungal growth on the upper surfaces of leaves which can eventually grow to cover the entire leaf surface and spread to lower leaf surfaces. In advanced stages, leaves turn yellow and die and prematurely drop. This may result in reduced growth and yields and make mechanical harvesting of the crop difficult.

Life cycle: E. polygoni is a fungal pathogen that occurs in several physiologic races and attacks a wide range of plants. The fungus is spread by wind-blown spores. The fungus over-winters on cruciferous plant debris, weeds and seeds. The disease is more severe under conditions of low relative humidity and water stress within the plant.

Pest management

Cultural controls: Dense seeding should be avoided and crop residue should be ploughed under following harvest. Rutabaga fields should be isolated from other crucifers and cruciferous weeds should be controlled. If infections are severe, rotations out of the crucifer family should be used. Monitoring of plants for signs of infection should be done during the growing season.

Resistant cultivars: None available.

Chemical controls: Refer to table 6. "Fungicides registered for disease management in rutabaga production in Canada" for fungicides registered for the control of powdery mildew.

Issues for powdery mildew

None identified.

Rhizoctonia diseases (*Rhizoctonia solani*)

Pest information

Damage: Rhizoctonia solani causes damping-off, wirestem and root rots of rutabaga and other cruciferous crops. Seeds may rot before germination or seedlings may die and fail to emerge from the soil. Stem infections on small, young plants may result in a dark decay and sloughing off of the outer cortex, a symptom commonly called wirestem. On mature roots, root rot lesions (crater rot) may be sunken, spongy and brown with purplish rims that may develop into large irregular black craters with a scabby appearance. Infection may occur in the field or during storage.

Life cycle: The pathogen is soil-borne and survives the winter as mycelium or sclerotia in soil and plant residues. Infection occurs through wounds and directly through the cuticle. Slow growing seedlings are more susceptible to disease. Field infections may be more severe when the control of root maggot is not adequate. Soil contamination of storage bins can increase the spread and severity of disease in storage.

Pest management

Cultural controls: Deep planting and planting into excessively cold or wet soils should be avoided. Poorly-drained fields or fields with a history of crater rot should not be used. Adequate air movement between plants and rotation with grass or cereal green manure crops is important. Insects should be controlled adequately and care must be taken to minimize mechanical injury to the roots during growth. Regular clean up and sterilization of tools and storage bins is important.

Resistant cultivars: None available.

Chemical controls: There are no fungicides available for field application to control rhizoctonia rot. However, several seed treatments are available. Seed treatments are usually carried out by the seed companies and can keep rhizoctonia problems to a minimum.

Issues for rhizoctonia rot

1. There is a need for the registration of additional fungicides for rhizoctonia diseases for resistance management.

Soft rot/ neck rot (*Erwinia carotovora* subsp. *carotovora, Pseudomonas spp.*)

Pest information

Damage: The tops of affected plants appear weak or are easily pulled from the root. Root tissues become soft, rotted and smelly with the exterior of the root remaining intact.

Life cycle: Soft rot bacteria are present in soil, rotten vegetables and on parts of host plants. They are introduced into rutabagas through wounds caused by insect feeding, dry rot and physiological injuries such as growth cracks or mechanical injury. High temperatures and soil moisture favour soft rot. Severe injury to foliage caused by powdery mildew may also predispose the neck tissues to soft rot. The disease can spread rapidly in storage.

Pest Management

Cultural controls: The management of soft rot is dependent on preventative measures including following good cultural practices and strict sanitation measures. Cultural practices such as using a 4 to 5 year rotation with non-cruciferous crops and non-host crops will help prevent infections in rutabaga. Damaged or infected roots must not be placed into storage. Storages and boxes must be thoroughly cleaned and disinfected prior to being used for a new crop.

Resistant cultivars: None identified.

Chemical controls: None available.

Issues for soft rot/ neck rot

None identified

Turnip mosaic virus (TuMV)

Pest information

Damage: Turnip mosaic virus causes premature yellowing and loss of older leaves on affected rutabaga plants, resulting in a "goose-necked" appearance. Younger foliage may become distorted and mottled. Early season infections result in reduced size of the roots. The loss of leaves makes mechanical harvesting difficult.

Life cycle: The virus over-winters in living tissues including winter canola crops, some cruciferous weeds, volunteer rutabaga plants and infected rutabaga roots from storage warehouses that are dumped in early spring. The virus is transmitted only by aphids and many species of aphids serve as vectors. The virus is not seedborne.

Pest management

Cultural controls: Crops should not be grown near fields of winter canola. Planting should not be done late in the season. Volunteer rutabaga should be controlled and culls should be removed from storage early. Late seeded fields should be isolated from early seeded fields.

Resistant cultivars: None available.

Chemical controls: As aphids can acquire and transmit the virus in a relatively short period of time, insecticides to manage the aphid population are ineffective at preventing spread of the virus.

Issues for turnip mosaic virus

None identified.

Insects and Mites

Key Issues

- There is a need for the registration of new, reduced risk insecticide products to control many insect pests of rutabaga.
- There is a critical need for the registration of reduced risk insecticides for the management of cabbage maggot to replace organophosphate insecticides and for resistance management.
- There is an urgent need for the development of alternative management strategies for cabbage maggot in rutabaga.
- Improved pest control strategies, including biological and cultural approaches to the management of wireworm, are needed.
- Resistance to insecticides is a concern with diamondback moths due to this insect's ability to quickly develop resistance.

Table 7. Occurrence of insect pests in rutabaga production in Canada[1,2]

Insect	Ontario[3]	Quebec	Nova Scotia	Prince Edward Island	Newfoundland & Labrador
Aphids					
Cabbage maggot					
Cabbage looper					
Diamondback moth					
Imported cabbage worm					
Cutworms					
Flea beetles					
Crucifer flea beetle					
Striped flea beetle					
Wireworm					

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest not present.

Data not reported.

[1]Source: Rutabaga stakeholders in reporting provinces.

[2]Please refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

[3]Data from "Crop Profile for Rutabaga in Canada, 2010".

Table 8. Adoption of insect pest management practices in rutabaga production in Canada[1]

Practice / Pest		Aphids	Cabbage maggot	Flea beetles	Diamond-back moth	Imported cabbage worm
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	reducing mechanical damage					
	thinning / pruning					
	trap crops / perimeter spraying					
	physical barriers					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding rate)					
	seeding depth					
	water / irrigation management					
	end of season crop residue removal / management					
	pruning out / removal of infested material					
	tillage / cultivation					
	removal of other hosts (weeds / volunteers / wild plants)					
Monitoring	scouting – trapping					
	records to track pests					
	soil analysis					
	use of portable electronic devices in the field to access pest identification /management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					
	grading out infected produce					

…continued

Table 8. Adoption of insect pest management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Aphids	Cabbage maggot	Flea beetles	Diamond-back moth	Imported cabbage worm
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model (eg. degree day modelling)					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	beneficial organisms and habitat management					
	ground cover / physical barriers					
	pheromones (eg. mating disruption)					
	sterile mating technique					
	trapping					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Crop specific practices	Fencing					
	Row covers (mesh net)					

This practice is used to manage this pest by at least some growers.

This practice is not used by growers to manage this pest.

This practice is not applicable for the management of this pest

Information regarding the practice for this pest is unknown.

[1]Source: Rutabaga stakeholders in reporting provinces (Quebec, Prince Edward Island, and Newfoundland and Labrador).

Table 9. Insecticides and bioinsecticides registered for the management of insect pests in rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status [3]	Targeted Pests[1]
carbaryl	Carbamate	Acetylcholinesterase inhibitors	1A	RES*	Armyworm, cabbage looper, corn earworm, diamondback moth, imported cabbageworm, lygus bug, meadow spittlebug, six spotted leafhopper, stink bugs
chlorantraniliprole	Diamide	Ryanodine receptor modulators	28	R	Armyworm, beet armyworm, black cutworm, cabbage looper, corn earworm, diamondback moth, European corn borer, fall armyworm, imported cabbageworm, leafminers, Swede midge, tobacco hornworm, tomato hornworm, variegated cutworm
chlorpyrifos	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	Black cutworm, cabbage maggot, dark sided cutworm, redbacked cutworm
cypermethrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	Crucifer flea beetle
diazinon	Organophosphate	Acetylcholinesterase inhibitors	1B	Phase-out Dec. 31, 2016	Aphids, dipterous leafminers, flea beetles, root maggots
flonicamid	Flonicamid	Selective homopteran feeding blockers	9C	R	Aphids
imidacloprid	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonists	4A	RE	Aphids, flea beetles, leafhoppers
malathion	Organophosphate	Acetylcholinesterase inhibitors	1B	R	Aphids, cabbage looper, imported cabbageworm, pepper weevil (maggot), spider mites
mineral oil	Diverse	Not classified	NC	R	To deter feeding of aphids which spread turnip mosaic virus
spinetoram	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Cabbage looper, diamondback moth, imported cabbageworm

...continued

Table 9. Insecticides and bioinsecticides registered for the management of insect pests in rutabaga production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Cabbage looper, diamondback moth, imported cabbageworm
sulfoxaflor	Sulfoxaflor	Nicotinic acetylcholine receptor (nAChR) agonists	4C	R	Aphids
thiamethoxam	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonists	4A	RE	Aphids, aster leafhopper

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 3, 2014. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (April 2012)* (www.irac-online.org) (accessed January 2014).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note REV2013-06, Special Review Initiation of 23 Active Ingredients, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Aphids: cabbage aphid (*Brevicoryne brassicae*), green peach aphid (*Myzus persicae*) and turnip aphid (*Lipaphis erysimi*)

Pest information

Damage: Aphids feed by sucking plant sap. Saliva injected while feeding may introduce plant viruses or may be toxic to the host plant. Feeding by large numbers of aphids causes foliar discolouration, curls leaves and damages developing buds. A sticky substance, called honeydew, is excreted by the aphids and may cover the leaves and crown and result in sooty mould growth.

Life cycle: In late spring, aphids move from their overwintering hosts to crop plants. The population consists primarily of female aphids that can reproduce without mating and bear live young. At certain times of the year male aphids arise, mating occurs and eggs are produced. Low populations of some species can quickly increase during warm, dry weather and completely colonize the upper parts of the plant.

Pest management

Cultural controls: Early and late rutabaga crops should not be grown in close proximity. Rutabaga should be grown as far as possible from corn fields, as corn is an important host of aphids. Naturally occurring predators may suppress aphid numbers, particularly later in the season.

Resistant cultivars: None available.

Chemical controls: Chemical sprays are used only if aphids are in high enough numbers to cause wilting of leaves during dry weather or if there is concern about the transmission of viruses. Insecticides registered for the control of aphids are listed in table 9.

Issues for aphids

1. There is a need for the registration of new pesticides to control aphids.

Cabbage maggot (*Delia radicum*)

Pest information

Damage: This insect is the most serious pest of rutabaga in Canada. Larvae or maggots feed by tunnelling into the roots. Plants may be killed, weakened or stunted and yields reduced. Severely infected plants wilt and remain in place in the row, unlike those severed at ground level by cutworms. A small amount of tunnelling in rutabaga roots renders the crop unmarketable.

Life cycle: There are two to three generations of cabbage maggot per year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring and lay oval shaped, white eggs at the base of the stem of host plants or in nearby crevices in the soil. Eggs hatch in three to seven days.

Pest management

Cultural controls: The rutabaga crop should not be grown near other cruciferous crops. Early and late rutabaga crops should not be grown in close proximity to each other. Crop rotation should be used. Many naturally occurring beneficial insects can help to control populations of cabbage maggot. In Newfoundland and Labrador, the beetle, *Aleochara bilineata*, kills a large number of pupae and feeds on eggs. The Pesticide Risk Reduction Program of AAFC has an active risk reduction strategy underway to address pest management and pesticide risk reduction issues for cabbage maggot in brassica crops (www.agr.gc.ca/eng/?id=1288805416537).

Resistant cultivars: There are a few less susceptible varieties on the market.

Chemical controls: Refer to table 9: "Insecticides registered for the management of insect pests in rutabaga production in Canada".

Issues for cabbage maggot

1. There is a need for the development of an alternative, cost effective approach to the management of cabbage maggot in rutabaga.
2. There is a critical need for the registration of reduced risk insecticides for the management of cabbage maggot to replace organophosphate insecticides and for resistance management.

Cabbage looper (*Trichoplusia ni*)

Pest information

Damage: Feeding by the cabbage looper results in the leaves being riddled with ragged-edged holes. The growth of severely infested plants is stunted.

Life cycle: Since the cabbage looper prefers warmer climates, it is only a serious pest in southern regions of Canada where the pest can have as many as three generations per season, as compared to only one in the Atlantic Provinces. Eggs are laid on lower leaf surfaces, close to the edge of the foliage and following larval feeding, pupation occurs on the foliage.

Pest management

Cultural controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga crops should not be grown in close proximity. There are several parasitic wasps, ants, beetles and flies which feed on the larvae and eggs of the cabbage looper. Viruses can be important for control, as the pest is susceptible to many different types. Larvae may be infected by a nuclear polyhedrosis virus, however this virus is not commercially available. *Bacillus thuringiensis* is commercially available and effective.

Resistant cultivars: None available.

Chemical controls: Chemical sprays can be effectively used. Registered insecticides are listed in table 9: "Insecticides registered for the management of insect pests in rutabaga production in Canada".

Issues for cabbage looper

None identified.

Diamondback moth (*Plutella xylostella*)

Pest information

Damage: Diamondback moth larvae feed on the leaves of rutabaga with early instars mining the leaves and older larvae feeding on lower leaf surfaces. With severe damage, leaves may develop a silvery appearance. Crowns may occasionally be damaged.

Life cycle: In most years, this insect does not overwinter in Canada and new infestations result from insects that are blown northward from the United States. Larvae of the first generation feed on cruciferous weeds prior to moving onto planted crops. Eggs are laid on foliage of host crops. When feeding is complete, the larvae spin cocoons and pupate on the host crop. This insect can have 3-6 generations per year. Hot, dry conditions can cause populations to explode although under cold, wet conditions this pest is not much of a problem. This pest can appear suddenly in epidemic levels, especially if cabbage fields are nearby.

Pest management

Cultural controls: Rutabaga should not be grown near other cruciferous crops. Early and late rutabaga crops should not be grown in close proximity. Crop rotation and planting the crop as far away from plantings in previous years helps in control. Deep ploughing of field debris late in the season reduces numbers of potentially over-wintering adults. The diamondback moth is preyed upon by several species of wasps, including *Diadegma insulare* and *Microplitis plutaellae*. The bacterial insecticide, *Bacillus thuringiensis* is effective, but moth resistance has been recorded in other countries. The use of pheromone baited traps can help predict the presence of larvae.

Resistant cultivars: None available.

Chemical controls: Registered insecticides are listed in table 9: "Insecticides registered for the management of insect pests in rutabaga production in Canada".

Issues for diamondback moth larva

1. Resistance to registered products is a concern as this pest has the ability to quickly develop resistance to pesticides.

Imported cabbageworm (*Pieris rapae*)

Pest information

Damage: Injury caused by larvae occurs as large irregular holes chewed in the leaves. Foliage is dirtied with pellets of dark-green excrement.

Life cycle: Eggs are laid singly on the underside of leaves and give rise to velvety-green larvae. Larvae feed on foliage and when feeding is complete (two to three weeks), pupate on the plant or plant debris. Various stages may be seen on the foliage at the same time. There are three to five generations a year. Pupae over-winter attached to old plants or debris.

Pest management

Cultural controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga crops should not be grown in close proximity. There are a number of wasps and flies that prey on the imported cabbageworm. *Bacillus thuringiensis* is a preferred bacterial insecticide. A granulosis virus will cause high mortality rates in the larval stage, but it is not commercially available in Canada.

Resistant cultivars: None available.

Chemical controls: Insecticides may be used if larvae are causing severe leaf damage. Registered insecticides are listed in table 9: "Insecticides registered for the management of insect pests in rutabaga production in Canada".

Issues for imported cabbageworm

None identified.

Cutworm: black cutworm (*Agrotis ipsilon*) and variegated cutworm (*Peridroma saucia*)

Pest information

Damage: Black and variegated cutworms may cause considerable damage to rutabaga. They attack very young plants that have recently emerged from the soil. Later, they also feed on the crown and leave deep scars or burrow into the root. Damage may occur in the spring and also later in the growing season. Late season infestations are difficult to detect and often are not noticed until harvest time.

Life cycle: Cutworms pass through egg, larval, pupal, and adult stages and depending on the species, can have one or more generations per year. The spring generation is the most damaging because its occurrence coincides with seed germination. The variegated cutworm overwinters as pupae in warmer parts of Canada. The black cutworm is wind-blown northward from the US.

Pest management

Cultural controls: Fields known to have high numbers of cutworm should be avoided. Fields recently converted from meadowlands have greater risks of infestation. Pheromone baited traps can be used to forecast the presence of larvae.

Resistant cultivars: None available.

Chemical controls: Cutworms are normally kept under control by chemicals used for cabbage maggot. Refer table 9 for insecticides registered for cutworm control.

Issues for cutworms

1. There is a need for the registration of new pesticides.

Crucifer flea beetle (*Phyllotreta cruciferae*) and striped flea beetle (*Phyllotreta striolata*)

Pest information

Damage: Adult beetles feed on cotyledons and young leaves of emerging seedlings creating small "shot holes". Heavy feeding will kill seedlings and if extensive in the field, may result in the crop having to be re-seeded. The larvae feed on the root and are capable of causing scarring of the root surface. Flea beetles are prevalent mostly in the spring and will attack most crucifers.

Life cycle: The pest overwinters as adult beetles in leaf litter of hedgerows and headlands around fields. Adults feed on cruciferous weeds and volunteer crops until the host crop emerges. There is generally one generation per year. Hot sunny weather favours the adult beetles and damage is most severe during such periods. The adult beetles lay eggs in soil near the roots of host plants and larvae feed on plant roots. Pupation occurs in the soil. Emergence of the next generation of adults begins in July. Adults feed on cruciferous crops at that time and seek overwintering sites in the fall.

Pest management

Cultural controls: Early planting should be avoided. High seeding rates can be used to reduce the impact of the beetles. Irrigation can be used during warm periods to drown adults. There are few natural predators of the flea beetle. Some wasps will feed on the beetle but not enough for complete control.

Resistant cultivars: The variety "*American Purple Top*" has some resistance to the flea beetle.

Chemical controls: Please refer to table 9: "Insecticides registered for the management of insect pests in rutabaga production in Canada", for products registered against flea beetles. Drenches applied for cabbage maggot will also help to control flea beetles and additional foliar sprays are often not necessary.

Issues for flea beetles

1. Flea beetles are present every year and their populations seem to be increasing. Plants are very susceptible from the cotyledon to the 2-3 leaf stage. Currently registered pesticides have good efficacy, however there is a need for the registration of a systemic insecticide for use at the first stages of crop growth.

Wireworm (*Melanotus communis)*

Pest information

Damage: The larvae feed on roots and seed in the soil.

Life cycle: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about a week and depending on the species, will live for 1 to 5 years in the ground feeding on roots and seeds. Wireworms require three or more years to complete their life cycle. Wireworms of all sizes and ages are present in the soil throughout the year as there is always an overlapping of generations. Mature larvae pupate in the fall and emerge in the spring as adult beetles. Wireworms are often numerous in soil that has been in sod for several years, however they are also becoming an increasing problem in fields that have been in cultivation for a number of years. They are also more abundant in heavy, poorly drained soil.

Pest management

Cultural controls: Fields known to have heavy infestations or fields coming out of sod should be avoided. Rotation with non-host crops should be done to help reduce populations. Bait stations set out in the spring or fall provide a method for checking to see if wireworms are present.

Resistant cultivars: None available.

Chemical controls: None available.

Issues for wireworm

1. There are no effective controls for wireworms.
2. Improved pest control strategies, including cultural and biological approaches to the management of wireworm, must be developed.
3. There is a need for continued registration of new products that will control wireworm, especially for long season root crops like rutabagas, potatoes, and carrots.

Weeds

Key Issues

- There is a need for herbicides that will control weeds of the crucifer family (shepherd's purse, wild radish, etc.)
- There is a need for the registration of herbicides to control annual broadleaf weeds and some grasses such as annual bluegrass and pigweed.
- There is a need for the registration of new, pre-plant herbicides.
- There is interest in the registration of a longer acting, pre-plant or pre-emergence herbicide to keep the weed population under control when row covers are used.

Table 10. Occurrence of weeds in rutabaga production in Canada[1,2]

Weed	Ontario	Quebec	Nova Scotia	Prince Edward Island	Newfoundland & Labrador
Annual broadleaf weeds					
Corn spurry					
Redroot pigweed					
Common ragweed					
Hairy nightshade					
Lady's-thumb					
Perennial broadleaf weeds					
Canada thistle					
Scentless chamomile (mayweed)					
Annual grasses					
Barnyard grass					
Perennial grasses					
Quackgrass					
Cruciferous weeds					
Shepherd's purse					
Yellow rocket					
Wild mustard					
Wild radish					
Stinkweed (pennycress)					
Wormseed mustard					

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Rutabaga stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 11. Adoption of weed management practices in rutabaga production in Canada[1]

Practice / Pest		Annual grasses	Annual broadleaf weeds	Perennial grasses	Perennial broadleaf weeds	Cruciferous weeds
Avoidance	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	use of weed-free seed					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding)					
	seeding / planting depth					
	water / irrigation management					
	weed management in non-crop lands					
	weed management in non-crop years					
	tillage / cultivation					
Monitoring	scouting - field inspection					
	field mapping of weeds / record of resistant weeds					
	soil analysis					
	use of portable electronic devices in the field to access pest identification/ management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of weed or weed growth stage					
	observed crop damage crop stage					

…continued

Table 11. Adoption of weed management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Annual grasses	Annual broadleaf weeds	Perennial grasses	Perennial broadleaf weeds	Cruciferous weeds
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	habitat / environment management					
	ground cover / physical barriers					
	mechanical weed control					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Crop specific practices	manual weeding (Quebec)					

This practice is used to manage this pest by at least some grower.

This practice is not used by growers to manage this pest.

This practice is not applicable for the management of this pest.

Information regarding the practice for this pest is unknown.

[1]**Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec, Prince Edward Island, and Newfoundland and Labrador).**

Table 12. Herbicides and bioherbicides registered for the management of weeds in rutabaga production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status [3]	Targeted Pests[1]
carfentrazone-ethyl	Triazolinone	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	Annual broadleaf weeds
clopyralid	Pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	R	Canada thistle (top growth), vetch, alsike clover, scentless chamomile, wild buckwheat, perennial sow-thistle (top growth), common groundsel, volunteer alfalfa, common ragweed, sheep sorrel (suppression), ox-eye daisy (suppression)
EPTC	Thiocarbamate	Inhibition of lipid synthesis - not ACCase inhibition	8	R	Annual weeds, quackgrass, yellow nutsedge
ethametsulfuron-methyl (for use on Laurentian rutabaga)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	Wild mustard
fluazifop-p-butyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	RES	Grass weeds
napropamide	Acetamide	Inhibition of cell division (Inhibition of VLCFAs	15	R	Annual weeds
quizalofop-p-ethyl (Ontario and Quebec)	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	Grass weeds
s-metolachlor	Chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs	15	R	American nightshade, eastern black night shade, crabgrass (smooth, hairy), barnyard grass, redroot pigweed (suppression only) fall panicum, foxtaile (green, yellow, giant) old witchgrass, yellow nutsedge
trifluralin	Dinitroaniline	Microtubule assembly inhibition	3	RES	Annual weeds

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 8, 2014. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Herbicide Resistance Action Committee (HRAC). *Classification of Herbicides According to Site of Action* (www.hracglobal.com) (accessed January 2014). Herbicide resistance groups are based on the Weed Science Society of America classification system as reported by HRAC.(www.hracglobal.com).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note REV2013-06, Special Review Initiation of 23 Active Ingredients, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Annual and biennial weeds

Annual grasses: barnyard grass (*Echinochloa crusgalli*), green foxtail (*Setaria viridis*), volunteer wheat, (*Triticum aestivum*), annual bluegrass (*Poa annua*)

Annual broadleaf weeds: corn spurry (*Spergula arvensis*), hairy nightshade (*Solanum sarachoides*), hemp nettle (*Galeopsis tetrahit*), kochia (*Kochia scoparia*), lady's thumb (*Polygonum persicaria*), low cudweed (*Gnaphalium uliginosum)*, wild radish (*Raphanus raphanistrum*), volunteer potatoes (*Solanum tuberosum*), wild buckwheat (*Polygonum convolvulus*), hairy galinsoga (*Galinsoga ciliata, G. quadriradiata*), wormseed mustard (*Erysimum cheiranthoides*), March yellow cress (*Rorippa islandica*), shepherd's purse (*Capsella bursa-pastoris*), scentless mayweed (*Matricaria maritima*)

Pest information

Damage: Broadleaf weeds can reach heights similar to rutabaga and compete with the crop for light, water and nutrients. If not controlled, they will reduce rutabaga growth and yield. Annual grasses have fast growth and the ability to compete for necessary resources, making them a serious problem. 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. In rutabagas, the critical stage for control of annual weeds is early in the growing season.

Life cycle: Annual grass and broadleaf weeds complete their life cycle in 1 year, going from seed germination through growth to new seed production. Spring annuals germinate in the early spring and grow to produce seed in the summer or fall of the same year. Winter annuals begin their growth in the fall, growing a rosette and producing their seeds early the following year. Annual weeds are very adept at disseminating through the production of large numbers of seeds. 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 favourable. Biennial weeds germinate in the spring producing a rosette of leaves and remain vegetative during the first summer. They over-winter as rosettes and then during the second summer send up a flower stock on which seeds are produced. The original plants then die at the end of the second growing season.

Pest management

Cultural controls: Weeds along road sides, ditches, and fence lines should be controlled by mowing or planting perennial grasses. A site that is as weed free as possible should be selected for growing rutabaga. Fields should be scouted in the previous season to determine what weeds might be expected and to determine if they can be controlled in the rutabaga crop. Purchased seed should be certified to ensure that it contains the lowest possible quantities of weed seed. To reduce the transport of weeds by equipment, soil and debris should be cleaned off when leaving each field. Manure applications may also introduce weeds to a field. Repeated tilling prior to planting and cultivation after planting, will reduce germinating weeds. Monitoring for annual weeds should be done during the first 2-3 weeks after weed emergence if post emergence controls are to be applied. Row spacing should be chosen that

favours row closure. Crop rotation can disrupt perennial and biennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Rotating between broadleaf and grassy crops provides a chance to control broadleaf weeds in grassy crops and grassy weeds in broadleaf crops with selective herbicides. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimize erosion and nutrient loss over the winter.

Resistant cultivars: Choose rutabaga varieties that will give quick emergence and vigorous crop stands that will help shade out germinating weed seeds.

Chemical controls: Herbicides currently labeled for control in rutabaga work well on annual grasses and a few small seeded broadleaf weeds. Most annual broadleaf and grass weeds can be controlled in rutabaga with a soil applied pre-emergent residual herbicide. This can provide season long protection against germinating weeds and seedlings. Once the rutabagas emerge, there are limited herbicide options for controlling broadleaf weeds in the crop. Selective systemic herbicides can be used to control grass that emerges after the crop plants. Refer to table 12: "Herbicides registered for the control of weeds in rutabaga production in Canada".

Perennial weeds

Perennial grasses: quackgrass (*Elitrigia repens*)

Perennial broadleaf weeds: field mint (*Mentha arvensis*), narrow-leaved golden rod (*Solidago graminifolia*)

Pest information

Damage: Refer to damage description under annual and biennial weeds. Perennial weeds can become very large and be very competitive, especially if they have been established for several years.

Life cycle: Perennial grass and broadleaf weeds can live for several to many years and generally establish from various types of root systems, although many will also spread by seeds. Most perennial weed seeds germinate in the spring and the plants grow throughout the summer. During this period they also expand their root systems, sending up new plants along the roots as well as expanding the size of existing plants. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds. The critical stage for damage is early in the growing season, as for the other groups of weeds.

Pest management

Cultural controls: See cultural controls for annual and biennial weeds; cultivation is less effective at controlling perennial weeds as compared to annual weeds, because of their large root systems.

Resistant cultivars: Rutabaga varieties that give quick emergence and produce vigorous crop stands will help shade out germinating weed seeds.

Chemical controls: Many perennial broadleaf and grass weeds cannot be effectively controlled once established in the rutabaga crop and must be controlled in the years preceding the crop.

Issues for weeds

1. There is a need for the registration of herbicides that will control weeds in the crucifer family (eg. shepherd's purse, wild radish, etc.).
2. There is a need for the registration of herbicides to control annual broadleaf weeds and some grasses such as annual bluegrass and pigweed.
3. There is interest in the registration of a longer acting pre-plant or pre-emergence herbicide to keep the weed population under control when row covers are used or a product that can be applied at high volumes through the "mesh" (row cover) to reduce weeds.
4. There is a need for the registration of new pre-plant products.

Resources

IPM/ICM resources for production of rutabaga in Canada

Websites

Agri-Reseau (http://www.agrireseau.qc.ca)

Ari-Reseau. Phytoprotection.
http://www.agrireseau.qc.ca/rap/navigation.aspx?sid=1186&pid=0&r=

Le Centre de référence en agriculture et agroalimentaire du Québec (http://www.craaq.qc.ca)

Ontario Crop IPM http://www.omafra.gov.on.ca/IPM/english/index.html

Sage Pesticides. http://www.sagepesticides.qc.ca/default.aspx

Health Canada, Pest Management Regulatory Agency http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

Publications

Bien identifier les problèmes sur des transplants de crucifères. MAPAQ
http://www.agrireseau.qc.ca/lab/documents/Crucif%c3%a8res-2001.pdf

Bien identifier les problèmes sur des transplants de crucifères. MAPAQ
http://www.agrireseau.qc.ca/lab/documents/Maladies%20transplants%20crucif%c3%a8res.pdf

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

Integrated Pest Management for Crucifers (2008) OMAFRA Publication 701; Agdex #252 available from http://www.omafra.gov.on.ca/english/crops/pub701/p701order.htm

Ontario Ministry of Agriculture and Foodcrop publications
http://www.omafra.gov.on.ca/english/crops/publications.html

Ontario Ministry of Agriculture and Food vegetable information : *OMAF Vegetables : Brassicas, broccoli, cabbage, cauliflower, horseradish, kale, kohlrabi, radish, rutabaga, specialty crucifers* www.omafra.gov.on.ca/english/crops/hort/cole_crops.html

Turnip and Rutabaga Management Schedule: A guide to weed, insect and disease management in turnip & rutabaga in Nova Scotia 2013[TUR@_13](updated June 4, 2013) Perennia.

http://www.perennia.ca/vegetables.php

Publication 75, Guide to Weed Control 2012-13. Ontario Ministry of Agriculture and .
http://www.omafra.gov.on.ca/english/crops/pub75/pub75toc.htm

Turnips and Rutabagas Production Guides 2005. Publication No. 1400A, Agdex No. 250/600. April 2005.

http://www.gov.pe.ca/agriculture/index.php3?number=79347&lang=E

Ontario Vegetable Production Recommendations (2010-11) OMAF Publication 363
http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Ontario Vegetable Crop Protection Guide (2012-13) Publication 838^{E}; 2013 Supplement (838S)

http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture and Food	Marion Paibomesai, marion.paibomesai@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministére d'Agriculture, Pêcheries et Alimentation du Québec	Denis Giroux d-giroux@videotron.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca
Nova Scotia	Nova Scotia Department of Agriculture and Fisheries	-	Steven Tattrie tattrisc@gov.ns.ca
	Perennia www.perennia.ca	Viliam Zvalo, Vzvalo@perennia.ca	-
		Rachael Cheverie Rcheverie@perennia.ca	-
Prince Edward Island	Prince Edward Island Department of Agriculture	Susan MacKinnon sdmackinnon@gov.pe.ca	Shauna Mellish smmellish@gov.pe.ca
Newfoundland and Labrador	Department of Natural Resources	-	Leah Madore leahmadore@gov.nl.ca

National and Provincial Vegetable Grower Organizations

Conseil Québecois de l'horticulture (CQH) (http://www.cqh.ca)

Horticulture Nova Scotia (http://hortns.com)

Newfoundland and Labrador Horticultural Producers Council Incorporated (http://www.hortnl.com)

Ontario Fruit and Vegetable Growers Association (http://www.ofvga.org)

Prince Edward Island Horticultural Association (http://www.peifarmcentre.com/tenants.cfm?t_id+39)

National

Canadian Horticultural Council (http://www.hortcouncil.ca)

Appendix 1

Definition of terms and colour coding for pest occurrence table of the crop profiles.

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 11 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="9">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="4">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="6">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**Not of concern:** The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">**Is of concern:** The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

References

Cutcliffe, J.A. and U.C. Gupta. November 1987. *Effect of foliar sprays of boron applied at different stages of growth on incidence of brown heart in rutabagas*. Canadian Journal of Soil Science 1987 67(3): 705-708

Gerber, H.S. 1994. *Major Insect and Allied Pests of Vegetables in British Columbia.* British Columbia Ministry of Agriculture, Victoria, BC. 78 pp

Howard, J., J.A. Garland and W.L.Seaman, eds. 1994. *Diseases and Pests of Vegetable Crops in Canada.* The Canadian Phytopathological Society and the Entomological Society of Canada. 554 pp.

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.

Turnip and Rutabaga Management Schedule, a guide to weed, insect and disease management in turnip and rutabaga in Nova Scotia. Updated June 4, 2013 http://www.perennia.ca/Pest%20Management%20Guides/Vegetables/2013/Rutabaga%202013.pdf

Integrated Pest Management for Crucifers (2008) OMAFRA Publication 701; Agdex #252 available from www.ServiceOntario.ca

Noms des maladies des plantes au Canada, Names of plant diseases in Canada, Société de protection des plantes du Québec, Québec, 1992

Pest Management Regulatory Agency, Health Canada. http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

Pest Management Regulatory Agency. 1998. *Residue Chemistry Guidelines*. Dir98-02 Pest Management Regulatory Agency, Health Canada. http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir98-02/index-eng.php

Turnip Mosaic Virus. OMAFRA Agdex 258/635 http://www.omafra.gov.on.ca/english/crops/facts/88-091.htm

Vegetable Production Guide 2012: Beneficial Management Practices for Commercial Growers in British Columbia http://www.agf.gov.bc.ca/cropprot/prodguide.htm

Vegetable Production Recommendations (2009-10) OMAFRA Publication 363); Publication 363SE, Supplement - Vegetable Production Recommendations 2010 - 2011 www.ServiceOntario.ca

Ontario Crop Integrated Pest Management –www.omafra.gov.on.ca/IPM/english/index.html

Rutabaga and Turnip – Vegetable Crops Production Guide for the Atlantic Provinces 2005. Agriculture Services Co-ordinating Committee. 1400A, Agdex No. 250/600. April 2005.

http://www.nr.gov.nl.ca/nr/agrifoods/crops/veg_pdfs/turnip.pdf