



# CROP PROFILE FOR RUTABAGA IN CANADA, 2015

PREPARED BY:  
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# Preface

National crop profiles are developed under the [Pesticide Risk Reduction Program](#) (PRRP), a program of [Agriculture and Agri-Food Canada](#) (AAFC). 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.

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# Contents

Crop Production.....	1
Industry Overview .....	1
Production Regions.....	2
North American Major and Minor Field Trial Regions .....	2
Cultural Practices .....	4
Abiotic Factors Limiting Production .....	7
Herbicide Sensitivity .....	7
Brown Heart .....	7
Temperature Extremes and Low Light .....	7
Water / Moisture Stress .....	8
Bruising / Mechanical Damage .....	8
Diseases .....	9
Key Issues .....	9
Blackleg ( <i>Phoma lingam</i> , sexual stage: <i>Leptosphaeria maculans</i> ) .....	16
Black Rot ( <i>Xanthomonas campestris</i> pv. <i>campestris</i> ) .....	17
Clubroot ( <i>Plasmodiophora brassicae</i> ) .....	17
Downy Mildew ( <i>Peronospora parasitica</i> ) .....	18
Powdery Mildew ( <i>Erysiphe polygoni</i> ).....	19
Rhizoctonia diseases ( <i>Rhizoctonia solani</i> ) .....	20
Root Rot ( <i>Fusarium</i> spp. and <i>Pythium</i> spp.) .....	21
Soft Rot / Neck Rot ( <i>Pectobacterium carotovorum</i> and <i>Pseudomonas</i> spp.).....	21
Turnip Mosaic Virus (TuMV) .....	22
Insects and Mites .....	23
Key Issues .....	23
Aphids: Cabbage Aphid ( <i>Brevicoryne brassicae</i> ), Green Peach Aphid ( <i>Myzus persicae</i> ) and Turnip Aphid ( <i>Lipaphis erysimi</i> ).....	31
Cabbage Maggot ( <i>Delia radicum</i> ).....	31
Cabbage Looper ( <i>Trichoplusia ni</i> ) .....	32
Diamondback Moth ( <i>Plutella xylostella</i> ) .....	33
Imported Cabbageworm ( <i>Pieris rapae</i> ).....	34
Cutworm: Black Cutworm ( <i>Agrotis ipsilon</i> ) and Variegated Cutworm ( <i>Peridroma saucia</i> ) .....	35
Crucifer Flea Beetle ( <i>Phyllotreta cruciferae</i> ) and Striped Flea Beetle ( <i>Phyllotreta striolata</i> ).....	35
Wireworm (Elateridae).....	36
Weeds .....	38
Key Issues .....	38
Annual and Biennial Weeds .....	46
Perennial Weeds .....	47
Resources .....	49
Integrated Pest Management/ Integrated Crop Management Resources for Production of Rutabaga in Canada.....	49
Provincial Crop Specialists and Provincial Minor Use Coordinators .....	51
Provincial and National Grower Organizations .....	51
Appendix 1 .....	52
References.....	53

# List of Tables and Figure

Table 1. General production information for rutabaga (2015).....	1
Table 2. Distribution of rutabaga production in Canada (2015) .....	2
Table 3. Rutabaga production and pest management schedule in Canada.....	6
Table 4. Occurrence of diseases in rutabaga production in Canada .....	9
Table 5. Adoption of disease management practices in rutabaga production in Canada .....	10
Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada .....	12
Table 7. Occurrence of insect pests in rutabaga production in Canada .....	24
Table 8. Adoption of insect pest management practices in rutabaga production in Canada .....	25
Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada .....	27
Table 10. Occurrence of weeds in rutabaga production in Canada.....	39
Table 11. Adoption of weed management practices in rutabaga production in Canada .....	40
Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada.....	42
Figure 1. Common zone map: North American major and minor field trial regions .....	3

# Crop Profile for Rutabaga in Canada

The rutabaga (*Brassica napus* var. *napobrassica*), also known as “swedes”, is a member of the Brassicaceae family. The plant is a cross between turnips (*Brassica rapa*) and cabbage (*Brassica oleracea*) and originated in Scandinavia 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 historically has been used for animal feed as well. Rutabaga stores well and is available year round and for this reason is becoming popular among consumers. Rutabagas are used in a wide variety of recipes from muffins to Christmas cake, as a side dish, in dips, mashed, in stews and casseroles and as baked fries/chips. Rutabaga is relatively low in calories and is a good source of vitamins A and C, potassium, folacin and fibre. A summary of Canadian crop production information including export and import data is presented in Table 1.

**Table 1. General production information for rutabaga (2015)<sup>1</sup>**

Canadian production <sup>2</sup>	46,148 metric tonnes 1,633 hectares
Farm gate value <sup>2</sup>	\$ 23.9 million
Fresh rutabaga available for consumption in Canada <sup>3</sup>	1.26 kg/ person
Exports <sup>4</sup>	390 metric tonnes
Imports <sup>4</sup>	1,630 metric tonnes

<sup>1</sup>Includes rutabaga and turnip.

<sup>2</sup>Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database) (accessed: 2017-09-06).

<sup>3</sup>Statistics Canada. Table 002-0011 - Food available in Canada, annual CANSIM (database) (accessed 2017-09-06).

<sup>4</sup>Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada, annual CANSIM (database) (accessed: 2017-09-06).

## ***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 (2015)<sup>1,2</sup>**

<b>Production Regions</b>	<b>Planted Area 2015 (hectares)</b>	<b>Percent National Production</b>
British Columbia <sup>3</sup>	61	3.7%
Alberta <sup>4</sup>	x	x
Saskatchewan <sup>3</sup>	1	0.1%
Manitoba <sup>4</sup>	x	x
Ontario	630	38.6%
Quebec	509	31.2%
New Brunswick	20	1.2%
Nova Scotia	53	3.2%
Prince Edward Island	181	11.1%
Newfoundland and Labrador	77	4.7%
Canada	1,633	100.0%

<sup>1</sup>Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database) (accessed: 2017-09-06).

<sup>2</sup>Includes rutabaga and turnip.

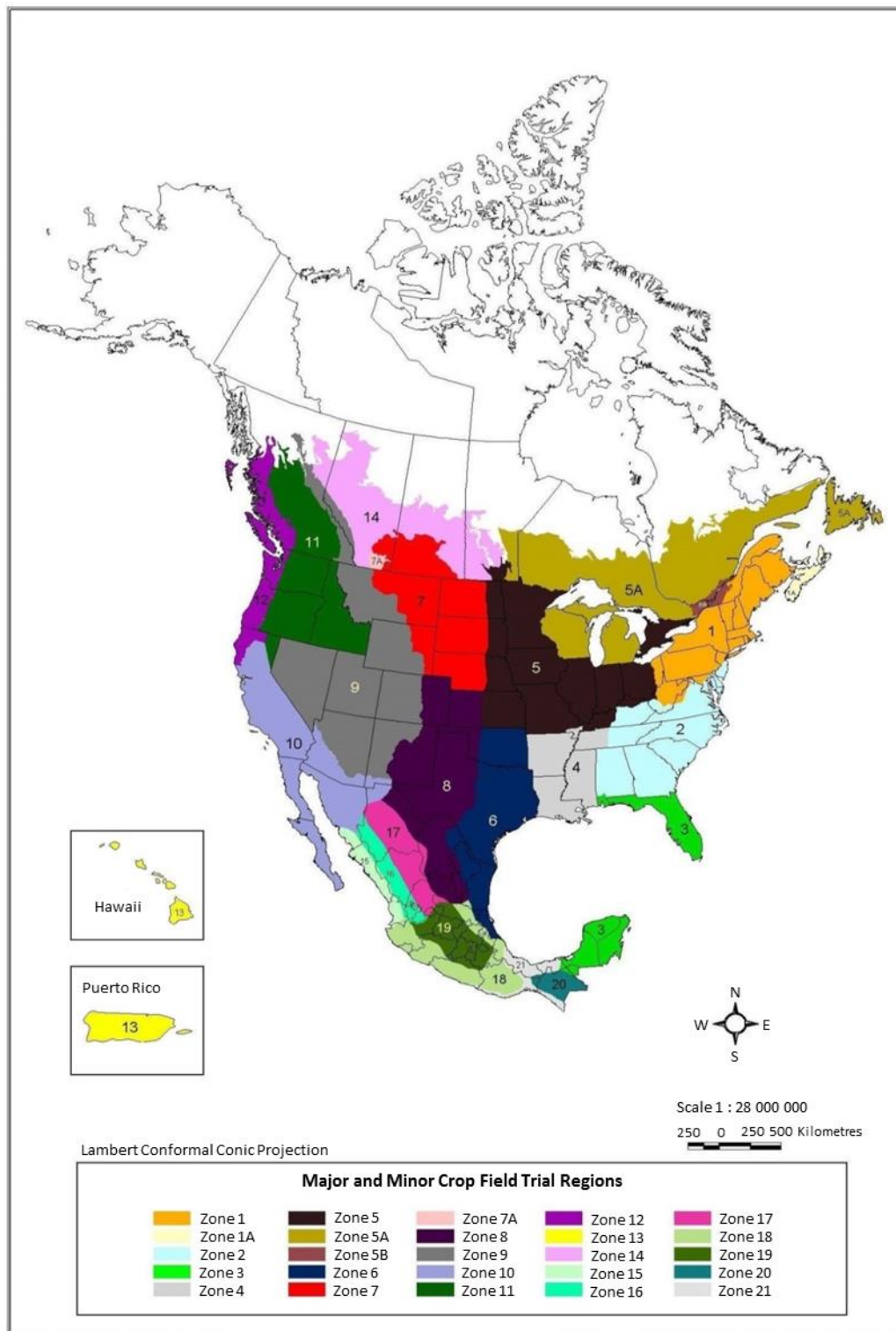
<sup>3</sup>Use with caution.

<sup>4</sup>x Suppressed to meet the confidentiality requirements of the Statistics Act.

## ***North American Major and Minor Field Trial Regions***

Major and minor crop field trial regions (see Figure 1) are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (EPA) 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 on field trial regions and requirements, 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](http://www.hc-sc.gc.ca/cps-spc/pubs/pest/pol-guide/dir2010-05/index-eng.php)).

**Figure 1. Common zone map: North American major and minor field trial regions<sup>1</sup>**



<sup>1</sup>Produced by: Spatial Analysis and Geomatics Applications, Agriculture Division, Statistics Canada, February 2001.

## Cultural Practices

While there are over a dozen varieties of rutabaga available in Canada, almost all commercially seeded rutabaga is the *Laurentian* variety. *York* is used for transplant rutabagas. Other varieties in use include *American Purple Top*, *Marian*, *Fortin*, and *Joan*.

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 crop rotation away from Brassica crops of from four to seven years is used by growers in order to obtain acceptable reductions in insect pest and disease pressures. Cruciferous weeds are controlled during this time, as they can serve as hosts for many insects and diseases that attack rutabaga. Planting rutabaga following stubble (cereal crop plough down) instead of sod from perennial legumes such as alfalfa or clover, will 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.

Since herbicides recommended for use on rutabagas do not provide total weed control, rutabagas are typically planted in rotation following crops in which weeds can be thoroughly controlled.

Soil tests to determine fertilizer requirements and soil pH are carried out before seeding, and adjustments are made to ensure a limited supply of nitrogen, for slow and steady growth of a well formed root, and to achieve a soil pH range of 6.0 to 6.8. Other major nutrients to be applied may include phosphorus, boron, magnesium and gypsum (sulphur).

Rutabaga can be directly seeded in the field or grown from transplants. 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°C; however, seeds can germinate in soil temperatures as low as 5°C. A fine smooth seedbed is required for uniform seeding depth. Seeding is done at a rate of 225 to 500 grams/ha and depth of 0.6 to 1.5 cm. Seeds are spaced 11 to 15 cm apart in rows that are spaced 50 to 90 cm. Spacing affects the harvest date and the root size. Wide in-row spacing is used for early production and close spacing is used for producing smaller roots. 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 four to eight 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. Plastic row covers or floating row covers can be used

to increase early growth after transplants are set out. Maturity of most rutabaga varieties ranges between 90 and 95 days, although *Marian* and *York* generally reach maturity between 40 and 60 days.

Rutabaga is well adapted to cool and humid growing conditions, with optimal temperatures for growth between 15°C and 20°C. Although frost tolerant, the plants are not usually left in the ground later than the end of October. Harvesting is done only when roots are fully mature and have been exposed to frosts before harvest, as this promotes best quality and flavour. 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. Optimal storage conditions include air temperatures around 0°C and relative humidity greater than 95%. A wax coating is applied to rutabaga being marketed to enhance their appearance and to prevent dehydration.

Production practices and worker activities for rutabaga throughout the season are described in Table 3.

**Table 3. Rutabaga production and pest management schedule in Canada**

Time of Year	Activity	Action
<b>March</b>	Plant care	Transplants started from seed in late March
<b>April</b>	Plant care	Transplants set in the field in late April
<b>May</b>	Plant care	Planting of crops destined for early season markets
	Soil care	Fertilization and pH adjustments (liming) before planting, based on soil tests; application of required phosphorous, potassium and boron
	Disease management	Seed treated with fungicides in some provinces
	Insect and mite management	Monitoring
	Weed management	Cultivation and pre-emergence pesticide treatments
<b>June</b>	Plant care	Planting of crops (early-mid June, later in some areas) 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 with organic matter
	Disease management	Monitoring and pesticide treatment (if necessary)
	Insect and mite management	Monitoring and pesticide treatment (if necessary)
	Weed management	Post-emergent pesticide treatment
<b>July</b>	Plant care	Monitoring and irrigation (if used)
	Soil care	Limited activities
	Disease management	Monitoring and pesticide treatment (if necessary)
	Insect and mite management	Monitoring and pesticide treatment (if necessary)
	Weed management	Limited activities
<b>August</b>	Plant care	Monitoring and irrigation (if used), early harvest
	Soil care	Limited activities
	Disease management	Monitoring and pesticide treatment (if necessary)
	Insect and mite management	Monitoring and pesticide treatment (if necessary)
	Weed management	Limited activities
<b>September/ October</b>	Plant care	Harvest and storage
	Soil care	Cultivation

Sources: Ontario Vegetable Production Recommendations, 2010-2011 OMAFRA Publication 363; Rutabaga and Turnip. Vegetable Crops Production Guide for the Atlantic Provinces (accessed July 26 2017).

## **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. In particular, herbicides containing the active ingredient metribuzin (used on potato and soybean, among other crops) applied the year before planting rutabagas in the same field can pose a very strong risk of crop injury.

### **Brown Heart**

Brown heart (also known as water-core) is a disorder of the rutabaga root that occurs when there is a deficiency in 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. By the time brown heart develops, it is usually too late to correct with boron applications. Rutabagas grown in soils containing less than 0.5 ppm soluble boron are more likely to develop brown heart. As well, plants grown under dry conditions or when the soil pH is higher than 7.0 may not absorb boron efficiently. The cultivar *York* tends to be less susceptible to brown heart than *Laurentian* (Thompson strain).

### **Temperature Extremes and Low Light**

Rutabaga is a biennial plant. It forms a swollen root during the first year and flowering stems in the second year of growth after a cold period. The exposure of very early-seeded or transplants to temperatures below 5°C, when they are less than ten weeks old, can trigger the development of flowering stems. The exposure of plants to temperatures around 3°C for as little as three to five nights is thought to result in the development of flowering stems. However, the duration of the low temperature period that triggers flowering will vary depending on the variety being grown.

Greenhouse transplants grown under low light conditions and subjected to large temperature differences between day and night may also suffer from misshapen roots (long cylindrical shape). The establishment of good ventilation during bright and sunny days and/or providing supplementary heating during cool nights will minimize these temperature differences within the greenhouse.

Prior to harvest, rutabagas can tolerate a limited period of temperatures as low as -3°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.

## **Water / Moisture Stress**

Rutabaga can withstand dry periods with minimal 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.

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. Optimal storage conditions include air temperatures around 0°C and relative humidity greater than 95%. A wax coating can be applied to rutabaga being marketed to enhance their appearance and to prevent dehydration in storage.

## **Bruising / Mechanical Damage**

Rutabagas are very susceptible to bruising, which can lead to the development of rot in storage. Bruising may not be apparent until the crop has been stored for three to four months. Harvesting can be done by hand or mechanically. Mechanical harvesting can cause bruising to the roots, and this requires producers to take extra care to minimize injury, especially for roots intended for long-term storage. Rutabaga lends itself well to extended cold storage for up to nine months over the winter and spring months.

## Diseases

### Key Issues

- There is a need for the registration of new fungicides for the management of a number of diseases of rutabaga, including clubroot, rhizoctonia diseases and downy mildew, and to enable rotation of chemicals for resistance management.
- There is a need for the development of new varieties with resistance to all races of clubroot.

**Table 4. Occurrence of diseases in rutabaga production in Canada<sup>1,2</sup>**

Disease	Ontario	Quebec	Prince Edward Island
Blackleg			
Black rot			
Downy mildew			
Powdery mildew			
Clubroot			
Common scab			
Root rot (crater rot), wirestem (rhizoctonia)			
Root rot			
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 pest 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.			

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces.

<sup>2</sup>Refer to Appendix 1 for further information on colour coding of occurrence data.

**Table 5. Adoption of disease management practices in rutabaga production in Canada<sup>1</sup>**

Practice / Pest		Clubroot	Rhizoctonia diseases	Downy mildew	Powdery mildew	Black rot ( <i>X. campestris</i> )
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 / removal of infected material throughout the growing season					
	Tillage / cultivation					
	Removal of other hosts (weeds/ volunteers/ wild plants)					
	Scouting / trapping					
Monitoring	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					

...continued

**Table 5. Adoption of disease management practices in rutabaga production in Canada<sup>1</sup> (continued)**

Practice / Pest		Clubroot	Rhizoctonia diseases	Downy mildew	Powdery mildew	Black rot ( <i>X. campestris</i> )
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					
Suppression	Pesticide rotation for resistance management					
	Soil amendments					
	Biopesticides					
	Controlled atmosphere storage					
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
New practices (by province)	Hilling of soil along plants (Québec)					
This practice is used to manage this pest by at least some growers in the province.						
This practice is not used by growers in the province to manage this pest.						
This practice is not applicable for the management of this pest.						
Information regarding the practice for this pest is unknown.						

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island).

**Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Target Site <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
<b>Seed treatment</b>						
azoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	seed rot and pre-emergence damping-off ( <i>Rhizoctonia solani</i> )
fludioxonil	phenylpyrrole	E2: signal transduction	MAP/histidine-kinase in osmotic signal transduction (os-2, HOG1)	12	RE	seed-borne and soil-borne diseases caused by <i>Fusarium</i> spp. (including seedling diseases due to <i>F. graminearum</i> ) and <i>Rhizoctonia</i> spp.
metalaxyl (for importation of treated seed only)	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	pythium damping-off
metalaxyl-M and S-isomer	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	pythium damping-off
<b>Soil treatment</b>						
<i>Bacillus subtilis</i> strain QST 713	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	rhizoctonia root rot, black scurf and stem canker, phytophthora root rot, pink rot, pythium root rot, cavity spot, fusarium root rot
captan	phthalimide	multi-site contact activity	multi-site contact activity	M4	RE	damping-off, root rot

...continued

**Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Target Site <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
<b>Foliar treatment</b>						
<i>Bacillus subtilis</i> strain QST 713	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	downy mildew, white mould
azoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	rhizoctonia root rot, crown rot, and stem canker
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	botrytis gray mold, white mold
fluopicolide	pyridinylmethyl-benzamide	B5: cytoskeleton and motor proteins	delocalisation of spectrin-like proteins	43	RES	downy mildew
fluopyram	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	alternaria blight, botrytis leaf spot
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	powdery mildew, alternaria leaf spot/blight (suppression)
fosetyl-AL	ethyl phosphonate	unknown mode of action	unknown	33	RE	downy mildew

...continued

**Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Target Site <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
<b>Foliar treatment (continued)</b>						
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	gray mold, powdery mildew
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew, blackleg ( <i>Leptosphaeria maculans</i> ) (suppression)
pyraclostrobin	methoxy-carbamate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	alternaria, cercospora leaf spot, powdery mildew
sulphur	inorganic	multi-site contact activity	multi-site contact activity	M2	R	powdery mildew
trifloxystrobin	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	leaf blight ( <i>Alternaria</i> spp.)
<b>Soil fumigant</b>						
chloropicrin	chloropicrin <sup>4</sup>	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8B <sup>4</sup>	RE	soilborne pests including root knot and root lesion nematodes, soil borne disease organisms including <i>Phytophthora</i> spp. (eg black shank), <i>Thielaviopsis</i> spp. (eg. black root rot), <i>Fusarium</i> spp. and <i>Pythium</i> spp.

...continued

**Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Target Site <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
<b>Soil fumigant (continued)</b>						
metam-potassium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8F <sup>4</sup>	RE	soil-borne diseases (rhizoctonia, pythium, phytophthora, verticillium, sclerotinia and club root of crucifers), nematodes
metam-sodium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8F <sup>4</sup>	RE	soil-borne fungal diseases (clubroot of crucifers, damping-off, root rot, oak root fungus, fusarium, pythium, phytophthora, rhizoctonia, verticillium, sclerotinia), nematodes, symphyllans (garden centipede)
oriental mustard seed meal (oil) ( <i>Brassica juncea</i> )	diverse	not classified	unknown	NC	R	suppression of root knot nematode, soil borne <i>Pythium</i> spp. and <i>Fusarium</i> spp., verticillium wilt

<sup>1</sup>Source: Pest Management Regulatory Agency label database ([www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php](http://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 December 8, 2017**. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

<sup>2</sup>Source: Fungicide Resistance Action Committee. *FRAC Code List 2017: Fungicides sorted by mode of action (including FRAC code numbering)* ([www.frac.info/](http://www.frac.info/)) (accessed September 13, 2017).

<sup>3</sup>PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES\* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2017-18, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2017-2022*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

<sup>4</sup>Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.3; July 2017)* ([www.irac-online.org](http://www.irac-online.org)) (accessed Sept. 14, 2017).

## **Blackleg (*Phoma lingam*, sexual stage: *Leptosphaeria maculans*)**

### ***Pest Information***

*Damage:* This disease can reduce vegetable and seed crop yields, and low levels of seed infection coupled with weather favourable for disease spread in seedbeds can lead to severe losses after transplanting by damping-off. Early symptoms of blackleg appear as small pale and irregular spots on leaves of young plants that become roundish or oval and ashy grey in colour. On stems, the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed, although new roots formed above the lesion may keep the plant alive. Plants can be stunted and may exhibit wilting during warm, sunny days. Eventually, plants may collapse from stem rot or fall over from poor root anchorage. During rainy weather, secondary diseases are common on plants infected with blackleg and may mask blackleg infections. Wounding, insect, or herbicide injury can result in greater disease severity.

*Life Cycle:* Blackleg is a destructive fungal pathogen that is often spread on seed. *Leptosphaeria* can survive for years in association with seed. It overwinters on plant debris and on alternate host plants and can survive up to four years on decomposing plant debris. The fungus infects a range of brassica crops and weeds and is especially prominent in canola. The disease can spread by splashing rain or irrigation water, workers, contaminated equipment and by ascospores that can be carried several kilometres by wind. The pathogen has the potential to spread very rapidly through a field.

### ***Pest Management***

*Cultural Controls:* Weed control in ditches and hedgerows around the field may help to minimize infection in the field. Delaying spring planting until fields are drier can reduce spread of disease, as can adjusting plant spacing to enable good air flow between plants. Disease incidence can be reduced by avoiding planting rutabaga adjacent to or downwind from fields that were cropped to crucifers or canola in the previous year or adjacent to or downwind from fields that were infected within the last three to four years. Rotation out of cruciferous crops for four to five years, avoiding use of manure from animals which have consumed infected plants, and removal of cruciferous weeds are all common practise used to minimise risk of blackleg infection. Use of certified disease-free seeds and hot-water seed treatment (50°C for 25 minutes) also helps limit the incidence of the disease.

*Resistant Cultivars:* None available.

*Control Products:* Refer to Table 6. *Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products registered for the control of blackleg.

### ***Issues for Blackleg***

None identified.

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

### ***Pest Information***

*Damage:* Black rot is a very serious bacterial disease of cruciferous crops, considered the most important worldwide disease of crucifers. 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 overwinter in plant debris for up to two 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 wind, 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, and infested seed is the main vector of black rot. A seed lot with as few as five infected seeds per 10,000 can cause a high incidence of black rot in the field.

### ***Pest Management***

*Cultural Controls:* Controlling cruciferous weeds and minimizing work in wet fields can help to minimize the spread of disease. A four year rotation can minimize pathogen presence. A reduction in seeding rates and densities to promote good air circulation can also help reduce the spread of black rot. It is good practice to clean and disinfect equipment used in an infected field before it is used in other fields. The use of certified, disease-free seed or applying a hot-water treatment (50°C for 15 minutes) to seed before planting will minimize risks of introducing the black rot pathogen. The removal and destruction of diseased plants from the field will help to limit the spread of the disease. Additional management practices for black rot are listed in *Table 5. Adoption of disease management practices in rutabaga production in Canada*.

*Resistant Cultivars:* None available.

*Control Products:* None available.

### ***Issues for Black Rot***

1. There is a need for the registration of bactericides for the control of black rot.

## **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. Infected rutabaga roots are unmarketable.

*Life Cycle:* The fungus survives in the soil as resting spores. Land will remain infected for seven years or longer after a diseased crop. The presence of certain weeds of the mustard family, such as wild radish and wild mustard will maintain or increase the level of infection 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, footwear and 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:* Maintaining a rotation of at least seven years out of cruciferous crops, and being vigilant in scouting for disease in the crop can help to reduce incidence and severity of clubroot. Planting in fields with a known history of clubroot and use of manure from animals fed clubroot infected crops are avoided to manage the risk. Careful adherence to field and machinery sanitation to minimize the potential movement of pathogen from field to field will help to contain clubroot problems. Planting of infested land to a sod crop, such as hay or pasture, for at least seven years, to prevent the movement of soil can help to prevent the spread of the pathogen from infected fields. Additional management practices for clubroot are listed in *Table 5. Adoption of disease management practices in rutabaga production in Canada*.

*Resistant Cultivars:* *Kingston, Laurentian, Marian, York* and *Joan* are resistant to some races of clubroot.

*Control Products:* Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products registered for the control of clubroot.

### ***Issues for Clubroot***

1. There is a need for the registration of pesticides for the management of clubroot.
2. There is a need for the development of new varieties of rutabaga with resistance to multiple races of clubroot and with resistance to races for which there are currently no resistant varieties.

## ***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 to 15°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:** Keeping transplant seedlings and leaves as dry as possible will help in minimizing the presence of the disease. A minimum three year crop rotation using grains and grasses will contribute to breaking an infection cycle, and plowing under crop residue following harvest in infected fields can speed the breakdown of disease inoculum. Proper spacing to allow airflow will avert conditions which are optimal for disease progression. As nutrient deficiencies increase the susceptibility of plants to diseases, fertilization may help seedlings outgrow infection. Additional management practices for downy mildew are listed in *Table 5. Adoption of disease management practices in rutabaga production in Canada.*

**Resistant Cultivars:** None available.

**Control Products:** Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products registered for the control of downy mildew.

### ***Issues for Downy Mildew***

1. The registration of new classes of reduced risk fungicides to be used in rotation for resistance management is required for downy mildew control.

## **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 overwinters 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:** Maintaining sufficient spacing between plants will reduce disease incidence and severity, and plowing under crop residue following harvest in infected fields can speed the breakdown of disease inoculum. Isolation of rutabaga fields from other cruciferous crops, and rotations away from crucifers are also appropriate methods to reduce the incidence of powdery mildew infections. Additional management practices for powdery mildew are listed in *Table 5. Adoption of disease management practices in rutabaga production in Canada.*

**Resistant Cultivars:** None available.

**Control Products:** Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products 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. The amount of decay increases rapidly as the temperature is raised above 4°C.

*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:* Avoidance of deep planting and planting into excessively cold or wet soils may reduce disease rates. Adequate air movement between plants and rotation with grass or cereal green manure crops can also reduce the severity of this disease. As the infections can be initiated in storage after harvest, regular clean up and sterilization of tools and storage bins are considered to be good practice. Additional management practices for rhizoctonia diseases are listed in Table 5. *Adoption of disease management practices in rutabaga production in Canada.*

*Resistant Cultivars:* None available.

*Control Products:* Refer to Table 6. *Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products registered for the control of rhizoctonia diseases.

### ***Issues for Rhizoctonia Diseases***

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

## Root Rot (*Fusarium* spp. and *Pythium* spp.)

### ***Pest Information***

*Damage:* Root rot diseases affect the root system and the lower portion of the stem at the soil line. Infected plants may be yellowed and stunted. Root rotting pathogens cause seed decay and seedling blight and infected seedlings often die. Plants affected by fusarium root rot display below-ground stem and root systems covered with reddish-brown lesions. Plants severely affected will produce numerous adventitious roots. This disease is also favoured under compacted soil or low soil fertility. Pythium root rot is more specifically expressed by decaying of young plant tissues on seed, seedlings and roots leading to premature death of the plant (damping-off).

*Life Cycle:* These pathogens overwinter in soil and crop debris. They respond to plant root exudates and invade plant roots. Cool, wet weather in the spring may favour root rot development. Water stress later in the season may also favour the disease. More specifically, fusarium overwinters in soil as chlamydospores (asexual resting spores which are resistant to extreme temperature and moisture, and germinate after a period of dormancy). The pathogen can disseminate through dust on seed, wind or water-borne soil. *Pythium* spp. are common in soil, have a wide host range, colonize fresh organic debris, persist for many years as oospores (diploid fungal resting spores), and are favoured by a high soil moisture.

### ***Pest Management***

*Cultural Controls:* Seeding at proper depths into warm, slightly moist, well-drained soil will favour emergence of the crop and reduce problems due to root rot. Crop rotations that exclude crucifers will help reduce pathogen populations in the soil. Minimizing soil compaction and using cover crops may also favour soil structure, organic matter and drainage. Avoiding green manure immediately before planting may also reduce root rots.

*Resistant Cultivars:* None available

*Control Products:* Refer to Table 6. *Fungicides and bio-fungicides registered for disease management in rutabaga production in Canada* for products registered for the control of root rot.

### ***Issues for Root Rot***

None identified.

## Soft Rot / Neck Rot (*Pectobacterium carotovorum* and *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,

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 the application of appropriate cultural practices and strict sanitation measures. Cultural practices such as using a four to five year rotation with non-cruciferous crops and non-host crops will help prevent infections in rutabaga. Damaged or infected roots are culled to avoid spreading infection in storage, and storage containers are cleaned thoroughly and disinfected prior to use.

*Resistant Cultivars:* None available.

*Control Products:* 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 overwinters in living tissues including winter canola crops, some cruciferous weeds, volunteer rutabaga plants and infected rutabaga roots from storage warehouses that are discarded in early spring. The virus is transmitted by aphids, many species of which serve as vectors. The virus is not seedborne.

### ***Pest Management***

*Cultural Controls:* Crops grown near fields of winter canola will be more susceptible to infection. Planting done late in the season can favour infection rates. The removal of volunteer rutabaga and culls from storage, as well as the isolation between late seeded fields and early seeded fields, will help prevent the spread of the virus.

*Resistant Cultivars:* None available.

*Control Products:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of aphids.

### ***Issues for Turnip Mosaic Virus***

None identified.

### ***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 and for resistance management. Products currently registered for this use are under threat of loss due to regulatory re-evaluation.
- There is an urgent need for the development of alternative, cost effective management strategies for cabbage maggot in rutabaga.
- Improved pest control strategies, including biological, cultural and chemical approaches, are needed for the management of wireworm.

**Table 7. Occurrence of insect pests in rutabaga production in Canada<sup>1,2</sup>**

Insect	Ontario	Quebec	Prince Edward Island
Cabbage (root) maggot			
Wireworm			
Aphids			
Cabbage aphid			
Green peach aphid			
Turnip aphid			
Lepidopteran pests			
Cabbage looper			
Diamondback moth			
Imported cabbage worm			
Cutworms			
Black cutworm			
Variegated cutworm			
Flea beetles			
Crucifer flea beetle			
Striped flea beetle			
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 pest 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.			

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces.

<sup>2</sup>Refer to Appendix 1 for further information on colour coding of occurrence data.

**Table 8. Adoption of insect pest management practices in rutabaga production in Canada<sup>1</sup>**

Practice / Pest		Aphids	Cabbage (root) maggot	Flea beetles	Diamondback moth	Imported cabbageworm
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 throughout the growing season					
	Tillage / cultivation					
	Removal of other hosts (weeds/ volunteers/ wild plants)					
Monitoring	Scouting / trapping					
	Records to track pests					
	Soil analysis					
	Weather monitoring for degree day modelling					
	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					

...continued

**Table 8. Adoption of insect pest management practices in rutabaga production in Canada<sup>1</sup> (continued)**

Practice / Pest		Aphids	Cabbage (root) maggot	Flea beetles	Diamondback moth	Imported cabbageworm
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					
	Biopesticides					
	Release of arthropod biological control agents					
	Habitat management to enhance natural controls					
	Ground cover / physical barriers					
	Pheromones (eg. mating disruption)					
	Sterile mating technique					
	Trapping					
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Specific Practices	Use of exclusion fencing					
	Use of row covers (mesh net)					
This practice is used to manage this pest by at least some growers in the province.						
This practice is not used by growers in the province to manage this pest.						
This practice is not applicable for the management of this pest						
Information regarding the practice for this pest is unknown.						

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island).

**Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
acetamiprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	R	Swede midge
<i>Bacillus thuringiensis</i> subsp. <i>aizawai</i> , strain <i>ABTS-1857</i>	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptors of insect midgut membranes	11A	R	cabbage looper, cross-striped cabbageworm, diamondback moth, imported cabbageworm
canola oil	not classified	physical (asphyxiation and suffocation )	N/A	R	aphids, scales, mealybugs, mites, psyllids, whiteflies
carbaryl	carbamate	acetylcholinesterase (AChE) inhibitor	1A	RES	grasshoppers, armyworms, corn earworm, diamondback moth (larvae), flea beetles, imported cabbageworm, leafhoppers, lygus bugs, meadow spittlebug, stinkbugs, six spotted leafhopper
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	diamondback moth, cabbage looper, black cutworm, imported cabbageworm, Swede midge, corn earworm, European corn borer, tobacco hornworm, tomato hornworm, armyworm, variegated cutworm, fall armyworm, beet armyworm, leafminers ( <i>Liriomyza sativae</i> , <i>Liriomyza trifolii</i> )
chlorpyrifos	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RE	cabbage maggot, redbacked cutworm, black cutworm, darksided cutworm
cyantraniliprole	diamide	ryanodine receptor modulator	28	R	cabbage maggot, aphids, armyworm, beet armyworm, cabbage looper, corn earworm, European corn borer, fall armyworm, flea beetles, variegated cutworm

...continued

**Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
cypermethrin (in British Columbia only)	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	crucifer flea beetles, cabbage root maggot flies ( <i>Delia radicum</i> ) (suppression)
diazinon	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	root maggot larvae (at the seedling stage)
dichlorvos (for use as toxicant in commercial insect traps)	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RES*	codling moth, forest tent caterpillar, gypsy moth, lepidopterous pests, Mediterranean fruit fly, spruce budworm
ferric phosphate	not classified	unknown	N/A	R	slugs and snails
ferric sodium ethylenediamine tetra acetic acid (EDTA)	not classified	unknown	N/A	R	slugs and snails
flonicamid	flonicamid	chlorotonal organ modulator - undefined target site	29	R	aphids
flupyradifurone	butenolide	nicotinic acetylcholine receptor (nAChR) competitive modulator	4D	R	aphids, leafhoppers, whiteflies,
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, European chafer larvae, flea beetles, leafhoppers

...continued

**Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	imported cabbageworm, aphids, spider mites, cabbage looper
mineral oil	not classified	unknown	N/A	R	to deter the feeding of aphids which spread Turnip Mosaic Virus
<i>Nosema locustae</i> Canning	biological	unknown	N/A	R	may provide suppression of grasshopper and Mormon cricket populations
potassium N-methyldithiocarbamate (metam potassium) (soil fumigant)	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8F	RE	nematodes
potassium salts of fatty acids	not classified	unknown	N/A	R	aphids, mealybugs, spider mites, whitefly, soft brown scale, psyllids, rose or pear slugs, earwigs, elm leafminer
potassium salts of fatty acids + pyrethrin	not classified + pyrethroid, pyrethrin	unknown + sodium channel modulator	N/A + 3A	R + RE	aphids, earwigs, whitefly, spider mites
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	cabbage looper, diamondback moth, imported cabbageworm,
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	imported cabbageworm, diamondback moth, cabbage looper, flea beetle ( <i>Phyllotreta</i> spp., <i>Psylliodes napi</i> , <i>Systema frontalis</i> ) (suppression)

...continued

**Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
sulfoxaflor	sulfoximine	nicotinic acetylcholine receptor (nAChR) competitive modulator	4C	R	aphids
thiamethoxam	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, aster leafhopper

<sup>1</sup>Source: Pest Management Regulatory Agency label database ([www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php](http://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 December 19, 2017**. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

<sup>2</sup>Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.3; July 2017)* ([www.irac-online.org](http://www.irac-online.org)) (accessed Sept. 14, 2017).

<sup>3</sup>PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES\* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2017-18, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2017-2022*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

<sup>4</sup>Source: Fungicide Resistance Action Committee. *FRAC Code List 2017: Fungicides sorted by mode of action (including FRAC code numbering)* ([www.frac.info/](http://www.frac.info/)) (accessed September 13, 2017).

## **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, leaf curls and damage to 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 parthenogenetic females that can reproduce asexually 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:* Planting early and late rutabaga crops well apart and growing rutabaga crops at a distance from corn fields may reduce pest pressure from aphids. Naturally occurring predators including ladybird beetles and parasitoid wasps may suppress aphid numbers, particularly later in the season. Additional management practices for aphids are listed in *Table 8. Adoption of insect pest management practices in rutabaga production in Canada.*

*Resistant Cultivars:* None available.

*Control Products:* Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of aphids.

### ***Issues for Aphids***

None identified.

## **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, and the larvae feed on host plants.

### ***Pest Management***

*Cultural Controls:* Many cruciferous crops act as a host for cabbage maggot, therefore planting rutabaga crops away from other cruciferous crops may help to keep pest pressure down. Crop rotation with non-host crops can help to break pest cycles. Many naturally occurring beneficial insects and nematodes in the family Steinernematidae can help control populations of cabbage maggot. In Newfoundland and Labrador, it was found that the beetle, *Aleochara bilineata*, can kill large numbers of pupae and can feed on eggs. Additional information about cultural management of this pest is available in the Reduced-Risk Strategy for Cabbage Maggot Management in Brassica Crops (<http://www.agr.gc.ca/eng/?id=1301498388181>) and in Table 8. *Adoption of insect pest management practices in rutabaga production in Canada.*

*Resistant Cultivars:* Work is underway to develop rutabaga lines with resistance to cabbage maggot. Information is available at <http://www.agr.gc.ca/eng/?id=1301498388181>.

*Control Products:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of cabbage maggot.

### ***Issues for Cabbage Maggot***

1. There is a need for the development of a cost effective, integrated 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 as there are currently no effective controls for this insect and the products that are registered are currently under regulatory re-evaluation.

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

### ***Pest Information***

*Damage:* The larval stage of the cabbage looper feeds voraciously on the underside of leaves resulting in ragged-edged holes between plant veins. Severely infested plants are stunted and may die.

*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 just one generation in the Atlantic Provinces. This insect does not overwinter in Canada; every spring it migrates as an adult moth from the southern United States, arriving in Canada in July or August. Eggs are mostly laid on the underside of large leaves located higher on the plant, close to the edge of the foliage. Following larval feeding, pupation occurs in webbed cocoons (chrysalis) attached to the stems or undersides of leaves. It takes approximately one month of warm weather for the cabbage looper to complete its life cycle.

### ***Pest Management***

*Cultural Controls:* Many cruciferous crops act as a host for cabbage looper, therefore planting rutabaga crops away from other cruciferous crops may help to keep pest pressure down. Cabbage looper is susceptible to numerous entomopathogens, including fungi, protozoa, bacteria and viruses. Natural enemies such as parasitic wasps and tachinid flies may also contribute to population suppression. Predators include ground beetles, lady beetles, bugs, spiders, birds and small mammals

*Resistant Cultivars:* None available.

*Control Products:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of cabbage looper.

### ***Issues for Cabbage Looper***

None identified.

## **Diamondback Moth (*Plutella xylostella*)**

### ***Pest Information***

*Damage:* Diamondback moth larvae feed on the leaves of rutabaga. While early instars mine into the leaves, older larvae feed on the undersides of leaves, eating out small irregular holes. Upon 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 moths that are blown northward from the United States in the spring. 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 to 6 generations per year. Hot and dry conditions can cause a population outbreak and moths can appear suddenly at epidemic levels, especially if cabbage fields are nearby. Under cold and wet conditions this pest does not pose a problem.

### ***Pest Management***

*Cultural Controls:* Many cruciferous crops act as a host for diamondback moth, therefore planting rutabaga crops away from other cruciferous crops may help to keep pest pressure down. Crop rotation away from host crops and the elimination of cruciferous weeds which act as alternate hosts will also minimize pest populations. Floating row covers can provide a physical barrier in small crop plantings to help prevent oviposition by the diamondback moths. Inter-row planting with unrelated plants may provide benefits by attracting beneficial predatory insects and parasitic wasps, thereby decreasing the larval population. The diamondback moth is preyed upon by several species of wasps, including *Diadegma insulare* and *Microplitis plutaellae*, other insects, mites, spiders, and birds. Predicting the presence of larvae can be aided by monitoring for presence of the adults with the use of pheromone baited traps. Deep ploughing of field debris late in the season reduces numbers of potentially over-

wintering adults. Additional management practices for diamondback moth are listed in *Table 8. Adoption of insect pest management practices in rutabaga production in Canada.*

*Resistant Cultivars:* None available.

*Control Products:* Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of diamondback moth.

#### ***Issues for Diamondback Moth***

1. Resistance to registered products is a concern as the diamondback moth has the ability to quickly develop resistance to pesticides. There is a need for the registration of new chemistries of insecticides as resistance management tools for diamondback moth.

#### **Imported Cabbageworm (*Pieris rapae*)**

##### ***Pest Information***

*Damage:* Larvae cause injury by chewing large irregular holes in the rutabaga leaves and staining the foliage with pellets of dark-green excrement. If left unchecked, the imported cabbageworm often can completely defoliate the plant.

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

##### ***Pest Management***

*Cultural Controls:* Many cruciferous crops act as a host for imported cabbageworm, therefore planting rutabaga crops away from other cruciferous crops may help to keep pest pressure down. Crop rotation, eliminating cruciferous weeds, and planting the crop as far away from fields planted to cruciferous crops in previous years also helps to reduce pest pressure. There are a number of wasps and flies that prey on the imported cabbageworm and some natural control may be contributed by these species. Floating row covers can provide a physical barrier to help prevent oviposition by the imported cabbageworm in small crop plantings. Additional management practices for imported cabbageworm are listed in *Table 8. Adoption of insect pest management practices in rutabaga production in Canada.*

*Resistant Cultivars:* None available.

*Control Products:* Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for the control of imported cabbageworm.

#### ***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. Although it has been generally thought that both of these species of cutworms were wind-blown northward from the US as moths, there is mounting evidence that the variegated cutworm can overwinter as pupae in warmer parts of Canada.

### ***Pest Management***

*Cultural Controls:* Avoiding fields recently converted from meadowlands and those with large weed populations will reduce the risks of cutworm infestation. A thorough harrowing may provide adequate control when cutworms are feeding actively in established fields and fall tillage can help destroy overwintering pupae. Pheromone baited traps can be used to forecast the presence of larvae. Many natural predators, parasites and birds prey upon cutworms and reduce the population as do some nematode species. Both the granulovirus and the nuclear polyhedrosis virus have been shown to affect the variegated cutworm.

*Resistant Cultivars:* None available.

*Control Products:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for the products registered for control of cutworms.

### ***Issues for Cutworms***

1. There is a critical need for the registration of reduced risk insecticides for the management of cutworms to replace organophosphate insecticides and for resistance management.

## **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. Adult beetles thrive in hot sunny weather 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:* Many cruciferous crops act as a host for crucifer flea beetle, therefore planting rutabaga crops away from other cruciferous crops may help to keep pest pressure down. Later planting to avoid early season emergence and use of high seeding rates can reduce the impact of beetles on rutabaga crops. Floating row covers sealed at the edges can be used to exclude beetles during seedling establishment. As well, trap cropping can be used to surround the field to intercept beetles as they try to enter the field. Irrigation can be used during warm periods to drown adults. Additional management practices for flea beetles are listed in Table 8. *Adoption of insect pest management practices in rutabaga production in Canada.*

*Resistant Cultivars:* The variety *American Purple Top* has some resistance against flea beetles.

*Control Products:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in rutabaga production in Canada* for products registered for control of flea beetles.

### ***Issues for Flea Beetles***

1. Flea beetles are present every year and their populations seem to be increasing. Plants are very susceptible to adult feeding from the cotyledon to the two to three leaf stage, resulting in damage mainly to foliage. Currently registered pesticides have good efficacy against adults, however there is a need for the registration of new classes of insecticides for use at the first stages of crop growth and for resistance management.
2. There is a need for the registration of pesticides for the control of the larval stage of flea beetles that cause damage mainly to the roots in the fall.

## **Wireworm (Elateridae)**

### ***Pest Information***

*Damage:* The larvae feed on roots and seed in the soil. Plants attacked during emergence or soon after transplanting are often killed. Damage occurring close to harvest can reduce the marketability of the crop and may also pre-dispose rutabaga roots to secondary bacterial infections.

*Life Cycle:* Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The eggs hatch in about a week and depending on the species, larvae will live for three to five 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 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:* The use of fields known to have heavy infestations or fields coming out of sod will likely lead to increased crop damage. Avoiding planting into fields known to be infested or which were recently in sod, as well as eliminating grassy weeds within fields during the growing season will help minimize wireworm infestation as grasses are known hosts for egg-laying females. Rotation with non-host crops and intensive plowing, three or more times during the late spring and early summer can also reduce wireworm populations. Bait stations set out in the spring or in the fall provide a method for monitoring wireworm presence. Trap cropping with wheat or applying a trap and kill strategy may provide some protection from damage to the rutabaga crop.

*Resistant Cultivars:* None available.

*Control Products:* None available.

### ***Issues for Wireworm***

1. Improved control strategies, including cultural and biological approaches, are required for wireworm as there are no effective controls.
2. There is a need for the registration of products that will control wireworm in rutabaga.

## **Weeds**

### ***Key Issues***

- There is a need for the registration of pre-plant products to control annual weeds in rutabaga, including related weeds in the crucifer family.
- 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 and that can efficiently penetrate the “mesh” (row cover).

**Table 10. Occurrence of weeds in rutabaga production in Canada<sup>1,2</sup>**

Weed	Ontario	Quebec	Prince Edward Island
<b>Annual broadleaf weeds</b>			
Corn spurry			
Redroot pigweed			
Common ragweed			
Hairy nightshade			
Lady's-thumb			
<b>Perennial broadleaf weeds</b>			
Canada thistle			
Scentless chamomile (mayweed)			
<b>Annual grasses</b>			
Annual bluegrass			
Barnyard grass			
<b>Perennial grasses</b>			
Quackgrass			
<b>Cruciferous weeds</b>			
Shepherd's purse			
Wild mustard			
Wild radish			
Stinkweed (pennycress)			
Wormseed mustard			
March yellow cress			
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 pest 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.			

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces.

<sup>2</sup>Refer to Appendix 1 for further information on colour coding of occurrence data.

**Table 11. Adoption of weed management practices in rutabaga production in Canada<sup>1</sup>**

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	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<sup>1</sup> (continued)**

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Cruciferous weeds
Suppression	Pesticide rotation for resistance management					
	Soil amendments					
	Biopesticides					
	Release of 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.)					
Specific practices	Manual weeding					
New practices (by province)	Stale seedbed technique (Quebec, Prince Edward Island)					
This practice is used to manage this pest by at least some growers in the province.						
This practice is not used by growers in the province to manage this pest.						
This practice is not applicable for the management of this pest						
Information regarding the practice for this pest is unknown.						

<sup>1</sup>Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island).

**Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
clopyralid	pyridine carboxylic acid	synthetic auxin	4	R	vetch, alsike clover, common ragweed, Canada thistle, wild buckwheat, scentless chamomile, common groundsel and volunteer alfalfa; suppression of perennial sow-thistle, sheep sorrel and ox-eye daisy
diquat	bipyridylum	photosystem-I-electron diversion	22	R	weeds
EPTC (not for use in eastern Canada)	thiocarbamate	inhibition of lipid synthesis (not ACCase inhibition)	8	R	annual grasses (annual bluegrass, annual rye grass, barnyard grass, crab grass, green and yellow foxtails, goose grass, volunteer grains (barley, oats, wheat), wild oats, witch grass, fall panicum), annual broadleaf weeds (common chickweed, corn spurry, hempnettle, henbit, lamb's-quarters, pigweed (prostrate, redroot, tumble), purslane, nettleleaf goosefoot), perennial weeds (quack grass (couch grass, twitch grass), yellow nutsedge)
ethametsulfuron-methyl (on <i>Laurentian</i> rutabaga)	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetoxy acid synthase (AHAS)	2	R	wild mustard
fluazifop-p-butyl and s-isomer	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	grass weeds (volunteer corn, Johnsongrass, persian dandel, barnyard grass, volunteer spring wheat and spring barley, wild oats, wild proso millet, crab grass, fall panicum, old witchgrass, foxtail (green, yellow and giant), quackgrass, wire-stemmed muhly

...continued

**Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
glyphosate + glufosinate ammonium	glycine + phosphinic acid	inhibition of glutamine synthetase + inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9 + 10	R + R	most annual and perennial weeds
glyphosate	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	R	annual and perennial grasses, broadleaf weeds, woody brush and trees
glyphosate (present as dimethylamine salt)	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	R	most herbaceous plants; annual and perennial grasses, broadleaf weeds, and woody brush and trees
glyphosate (present as isopropylamine salt and potassium salt)	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	R	non-selective weed control, annual grasses and broadleaf weeds, perennial weeds, brush and trees, site preparation prior to transplanting tree and vine crops
glyphosate (present as isopropylamine salt or ethanolamine salt)	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	R	most herbaceous weeds; annual and perennial grasses, broadleaf weeds and woody brush and trees
glyphosate (present as potassium salt)	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	R	non-selective weed control; many annual and perennial grasses, broadleaf weeds, and woody brush and trees

...continued

**Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
metam-potassium (soil fumigant)	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8F <sup>5</sup>	RE	weeds and germinating weed seeds (annual bluegrass, Bermuda-grass, chickweed, dandelion, ragweed, henbit, lamb's-quarters, <i>Amaranthus</i> sp. (pigweed) Johnsongrass, wild morning glory)
metam-sodium (soil fumigant)	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	8F <sup>5</sup>	RE	weeds and germinating weed seeds (annual bluegrass, annual grasses, Bermuda grass, chickweed, dandelion, ragweed, henbit, lamb's-quarters, pigweed ( <i>Amaranthus</i> sp.), purslane, Johnsongrass, wild morning glory; suppression of perennial weeds (quack grass)
napropamide	acetamide	inhibition of mitosis	15	R	annual grasses (annual bluegrass, barnyard grass, foxtail, large crabgrass, sandbur, wild oats, crabgrass, fall panicum, goosegrass), annual broadleaf weeds (chickweed, small-flowered mallow, annual sow-thistle, groundsel, pineapple weed, redroot pigweed, prickly lettuce, prostrate knotweed, purslane, storks bill, lamb's-quarters, carpetweed, pigweed, suppression of common ragweed)
paraquat	bipyridylum	photosystem-I-electron diversion	22	R	grasses and broadleaf weeds (inter-row only)
quizalofop-p-ethyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	RE	annual and perennial grasses

...continued

**Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada (continued)**

Active Ingredient <sup>1</sup>	Classification <sup>2</sup>	Mode of Action <sup>2</sup>	Resistance Group <sup>2</sup>	Re-evaluation Status <sup>3</sup>	Targeted Pests <sup>1</sup>
s-metolachlor and R- enantiomer	chloroacetamide	inhibition of mitosis	15	RE	annual grasses and broadleaf weeds (American nightshade, barnyard grass, crabgrass (smooth, hairy), Eastern black nightshade, fall panicum, foxtail (giant, green, yellow), old witchgrass, yellow nutsedge, redroot pigweed (suppression)
trifluralin	dinitroaniline	microtubule assembly inhibition	3	R	annual grasses (foxtail (green, yellow), barnyard grass, crabgrass, brome grass, cheat, stinkgrass, goosegrass, annual bluegrass, Persian dandel, wild oats) annual broadleaves (cowcockle, pigweed, lambsquarters, Russian thistle, chickweed, purslane, knotweed, carpetweed, wild buckwheat)

<sup>1</sup>Source: Pest Management Regulatory Agency label database ([www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php](http://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 December 14, 2017**. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

<sup>2</sup>Source: Weed Science Society of America (WSSA). Herbicide Site of Action Classification list (last modified August 16, 2017) <http://wssa.net> (accessed Sept. 13, 2017)

<sup>3</sup>PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES\* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2017-18, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2017-2022*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

<sup>4</sup>Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.3; July 2017)* ([www.irac-online.org](http://www.irac-online.org)) (accessed Sept. 13, 2017).

## Annual and Biennial Weeds

### *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 rutabaga production, 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 one 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:* Managing weeds along road sides, ditches, and fence lines by mowing or planting perennial grasses can reduce these sources of infestation in fields. Planting in a site that is as weed free as possible will allow rutabaga plants to thrive. Fields can be scouted the season before planting to determine which weeds might be expected and if these can be controlled in the rutabaga crop. The purchase of certified seed will ensure that it contains the lowest possible quantities of weed seed. The transport of weeds and weed seeds by equipment, soil and debris can be minimized by carefully cleaning equipment 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 can be done during the first two to three weeks after weed emergence if post emergence controls are to be applied. Row spacing that favours row closure will help prevent weeds from emerging. 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. Information about the use of cover crops is available at <http://www.agr.gc.ca/eng/?id=1347460012676>. Additional management

practices for weeds are listed in *Table 11. Adoption of weed management practices in rutabaga production in Canada.*

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

*Control Products:* Refer to *Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada* for products registered for the control of weeds.

### ***Issues for Weeds***

1. There is a need for the registration of new pre-plant products to control annual weeds in rutabaga, including related weeds in the crucifer family.

## **Perennial Weeds**

### ***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 many years. They generally establish themselves from various types of root systems, although many will also spread by seed. Most perennial weed seeds germinate in the spring and the plants grow throughout the summer. During this period, the plants 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 and compete better against developing weeds.

*Control Products:* 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. Refer to *Table 12. Herbicides and bio-herbicides registered for weed management in rutabaga production in Canada* for products registered for the control of weeds.

<i>Issues for Weeds</i>
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1. There is a need for the registration of a longer acting, pre-plant or pre-emergence herbicide to keep the weed population under control when row covers are used and that can efficiently penetrate the “mesh” (row cover).

## Resources

### Integrated Pest Management/ Integrated Crop Management Resources for Production of Rutabaga in Canada

#### Websites

Agri-Réseau <https://www.agrireseau.net/>.

Agri-Réseau - Légumes de Champ <https://www.agrireseau.net/legumeschamp>.

Agri-Réseau - Phytoprotection <https://www.agrireseau.net/phytoprotection>.

Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ) <https://www.craaq.qc.ca/>.

Health Canada, Pest Management Regulatory Agency (PMRA) - Pesticides and Pest Management <https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html>.

Information for Commercial Vegetable Production in Ontario <https://onvegetables.com/category/vegetables/brassica-vegetables/>.

IRIIS Phytoprotection <http://www.iriisphytoprotection.qc.ca/>.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) - Ontario CropIPM <http://www.omafra.gov.on.ca/IPM/english/index.html>.

Ontario Ministry of Agriculture, Food and Rural Affairs. Vegetable Production Information - Commercial Vegetable Production <http://www.omafra.gov.on.ca/english/crops/hort/vegetable.html>.

Perennia - Rutabaga/Turnip <http://www.perennia.ca/fieldservices/vegetable-crops/rutabaga/>.

SAGe Pesticides <http://www.sagepesticides.qc.ca/>.

#### Publications

Howard JR, Garland JA, Seaman WJ. (1994). *Disease and Pests of Vegetable Crops in Canada*. The Canadian Phytopathological Society and Entomological Society of Canada. <http://phytopath.ca/wp-content/uploads/2015/03/Diseases-and-Pests-of-Vegetable-Crops-in-Canada.pdf>.

Ministère de l'Agriculture, Pêcheries et Alimentation du Québec - *Bien identifier les problèmes sur des transplants de crucifères.*

<http://www.agrireseau.qc.ca/lab/documents/Maladies%20transplants%20crucif%c3%a8res.pdf>.

Ontario Ministry of Agriculture, Food and Rural Affairs - *Guide to Weed Control* (2016-2017) Publication 75. <http://www.omafra.gov.on.ca/english/crops/pub75/pub75toc.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. (2008). *Integrated Pest Management for Crucifers*. Publication 701, Agdex 252.

<http://www.omafra.gov.on.ca/english/crops/pub701/p701order.htm>. Available at <https://www.publications.serviceontario.ca/pubont/servlet/ecom/SearchServlet?reqCode=prodView&iN=0701E&JavaScript=y>.

Ontario Ministry of Agriculture, Food and Rural Affairs. *Vegetables - Brassicas: broccoli, cabbage, cauliflower, horseradish, kale, kohlrabi, radish, rutabaga, specialty crucifers*

[http://www.omafra.gov.on.ca/english/crops/hort/cole\\_crops.html](http://www.omafra.gov.on.ca/english/crops/hort/cole_crops.html).

Ontario Ministry of Agriculture, Food and Rural Affairs - *Vegetable Crop Protection Guide* (2014-15). Publication 838; (2016) Supplement 838S.

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

Perennia - Turnip and Rutabaga Management Schedule: *A guide to weed, insect and disease management in turnip & rutabagas in Nova Scotia* 2017 [TUR1-17], updated Feb 22 2017.

<http://www.perennia.ca/wp-content/uploads/2016/04/Rutabaga-2017.pdf>.

## ***Provincial Crop Specialists and Provincial Minor Use Coordinators***

Province	Ministry	Crop Specialist	Minor Use Coordinator
<b>Ontario</b>	Ontario Ministry of Agriculture, Food and Rural Affairs <a href="http://www.omafra.gov.on.ca/">http://www.omafra.gov.on.ca/</a>	Dennis Van Dyk <a href="mailto:dennis.vandyk@ontario.ca">dennis.vandyk@ontario.ca</a>	Jim Chaput <a href="mailto:jim.chaput@ontario.ca">jim.chaput@ontario.ca</a>
<b>Quebec</b>	Ministère de l'Agriculture, Pêcheries et Alimentation du Québec <a href="http://www.mapaq.gouv.qc.ca">http://www.mapaq.gouv.qc.ca</a>	Denis Giroux <a href="mailto:d-giroux@videotron.ca">d-giroux@videotron.ca</a>	Luc Urbain <a href="mailto:luc.urbain@mapaq.gouv.qc.ca">luc.urbain@mapaq.gouv.qc.ca</a>
<b>Prince Edward Island</b>	Prince Edward Island Department of Agriculture and Fisheries <a href="https://www.princeedwardisland.ca/en/topic/agriculture-and-fisheries">https://www.princeedwardisland.ca/en/topic/agriculture-and-fisheries</a>	Susan MacKinnon <a href="mailto:sdmackinnon@gov.pe.ca">sdmackinnon@gov.pe.ca</a>	Sebastian Ibarra <a href="mailto:sibarra@gov.pe.ca">sibarra@gov.pe.ca</a>

## ***Provincial and National Grower Organizations***

Conseil québécois de l'horticulture (CQH) (<http://www.cqh.ca>)

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

Prince Edward Island Horticultural Association (<https://www.peifarmcentre.com/our-tenants>)

### **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 10 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.

Presence	Occurrence information				Colour Code
Present	Data available	Frequency	Distribution	Pest Pressure	
		Yearly - Pest is present 2 or more years out of 3 in a given region of the province.	Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.	High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.	Red
				Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.	Orange
				Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.	Yellow
			Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.	High - see above	Orange
				Moderate - see above	White
				Low - see above	White
		Sporadic - Pest is present 1 year out of 3 in a given region of the province.	Widespread - as above	High - see above	Orange
				Moderate - see above	Yellow
			Localized - as above	Low - see above	White
	High - see above			Yellow	
		Moderate - see above	White		
		Low - see above	White		
		Data not available	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.		
		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.			Blue
Not present	The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.				Black
Data not reported	Information on the pest in this province is unknown. No data is being reported for this pest.				Grey

## References

Burkar SG, Yumlembam RA, eds. (2017). Chapter 8. Bacterial diseases of vegetable crops. In *Bacterial diseases of crop plants*. Boca Raton, FL. CRC Press. 570pp. (accessed Aug 16 2017).

Canadian Forest Service. (2014). *Cabbage looper (Tricoplusia ni)*.  
[http://publications.gc.ca/collections/collection\\_2014/rncan-nrcan/Fo124-9-2014-eng.pdf](http://publications.gc.ca/collections/collection_2014/rncan-nrcan/Fo124-9-2014-eng.pdf).

Capinera J, ed. (2008). Variegated cutworm, *Peridroma saucia* (Hübner) (Lepidoptera: Noctuidae). In *Encyclopedia of Entomology*, 2<sup>nd</sup> edition. Netherlands, Springer. p. 4038-4041.  
[https://link.springer.com/referenceworkentry/10.1007%2F978-1-4020-6359-6\\_3936#page-1](https://link.springer.com/referenceworkentry/10.1007%2F978-1-4020-6359-6_3936#page-1)  
(accessed Sept 15 2017).

Couture L, Brisson JD, Émond G, eds. (2003). *Names of plant diseases in Canada*, 4<sup>th</sup> edition. Quebec Society for the Protection of Plants. Quebec. 340 pp.  
<https://www.craaq.qc.ca/Publications-du-CRAAQ/noms-des-maladies-des-plantes-au-canadanames-of-plant-diseases-in-canada/p/PEDI0104>.

Dara SK. (2017). Chapter 14. Microbial control of arthropod pests in small fruits and vegetables in temperate climate. In *Microbial control of insect and mite pests: From theory to practice*. Lacey LA, ed. New York, NY. Elsevier. 461 pp. (accessed Sept 14 2017).

Department of Agriculture and Fisheries, Prince Edward Island. (Updated 2014). *Controlling Brown-Heart in Rutabagas*. [http://www.gov.pe.ca/photos/original/af\\_fact\\_brheart.pdf](http://www.gov.pe.ca/photos/original/af_fact_brheart.pdf).

Department of Agriculture, Manitoba. Production Information on Vegetable Crops. *Rutabagas*.  
<https://www.gov.mb.ca/agriculture/crops/production/pubs/bmz00s18p.pdf> (accessed Sept 18 2017).

Department of Fisheries, Forestry and Agrifoods, Newfoundland and Labrador. *Managing Clubroot*. [www.faa.gov.nl.ca/publications/pdf/clubroot.pdf](http://www.faa.gov.nl.ca/publications/pdf/clubroot.pdf) (accessed Sept 13 2017).

Department of Fisheries, Forestry and Agrifoods, Newfoundland and Labrador. *Rutabaga and Turnip: Vegetable Crops Production Guide for the Atlantic Provinces*.  
[www.faa.gov.nl.ca/agrifoods/plants/pdf/turnip.pdf](http://www.faa.gov.nl.ca/agrifoods/plants/pdf/turnip.pdf) (accessed July 26 2017).

Farms.com. *Wireworms*. <http://www.farms.com/field-guide/pests/wireworms.aspx> (accessed Sept 18 2017).

Gerber HS. (1994). *Major Insect and Allied Pests of Vegetables in British Columbia*. Department of Agriculture, British Columbia, Victoria, BC. 78 pp. Available at  
[https://www.crownpub.bc.ca/Product/Details/7610008701\\_S](https://www.crownpub.bc.ca/Product/Details/7610008701_S).

Health Canada - Pest Management Regulatory Agency. Revisions to the Residue Chemistry Crop Field Trial Requirements DIR2010-05.

<https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/policies-guidelines/regulatory-directive/2010/revisions-residue-chemistry-crop-field-trial-requirements-dir2010-05.html>.

Helyer N, Cattlin ND, Brown KC, eds. (2014). Chapter 4. Arthropod biological control agents. In *Biological control in plant protection: A color handbook*. Second ed. Boca Raton, FL. CRC Press. 262 pp. (accessed Aug 14 2017).

Les jardins de l'écoumène. <http://www.ecoumene.com/boutique/semences/potageres/rutabaga> (accessed Sept 13 2017).

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

North Carolina State University. Cucurbit Breeding Project. <http://cucurbitbreeding.com/todd-wehner/publications/vegetable-cultivar-descriptions-for-north-america/rutabaga/> (accessed Sept 6 2017).

Ontario Ministry of Agriculture, Food and Rural Affairs. (1990, reviewed 1999). *Caterpillar pests of cruciferous crops*. Agdex 252/625. <http://www.omafra.gov.on.ca/english/crops/facts/99-035.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. (2000, reviewed 2009). *Managing cutworms in vegetable crops*. Agdex 250/625. <http://www.omafra.gov.on.ca/english/crops/facts/00-055.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. (2000, reviewed 2009). *Managing wireworms in vegetable crops*. Agdex 250/625. <http://www.omafra.gov.on.ca/english/crops/facts/00-047.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. *Ontario Crop Integrated Pest Management*. <http://www.omafra.gov.on.ca/IPM/english/index.html>.

Ontario Ministry of Agriculture, Food and Rural Affairs (1980, reviewed 1983). *Storing Rutabagas*. Agdex 258/64. <http://www.omafra.gov.on.ca/english/crops/facts/80-001.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. (1988, reviewed 2009). *Turnip Mosaic Virus (TuMV) of Rutabaga*. Agdex 258/635. <http://www.omafra.gov.on.ca/english/crops/facts/88-091.htm>.

Ontario Ministry of Agriculture, Food and Rural Affairs. (2010-11). *Vegetable Production Recommendations* - Publication 363 and 363S. <http://www.omafra.gov.on.ca/english/crops/pub363/p363toc.htm>.

Pacific Northwest Extension Publishing. (2008, reviewed 2013). *Wireworm: biology and nonchemical management in potatoes in the Pacific Northwest*. <http://hdl.handle.net/1957/20798> (accessed Sept 18 2017).

Pacific Northwest Pest Management Handbooks. (2016). *A Clinic Close-up: Black Leg, Light Leaf Spot, and White Leaf Spot in Western Oregon*. <https://pnwhandbooks.org/sites/pnwhandbooks/files/plant/document/turnip-rutabaga-brassica-sp-light-leaf-spot/black-leg-light-leaf-spot-white-leaf-spot-crucifers16.pdf> (accessed Sept 7 2017).

Pacific Northwest Pest Management Handbooks. (2016). *A Clinical Close-up: Management of Black Leg in Brassica Vegetable Crops*. <https://pnwhandbooks.org/sites/pnwhandbooks/files/plant/document/turnip-rutabaga-brassica-sp-black-leg-phoma-dry-rot/cliniccloseupblacklegmanagementinvegetables2016finaldraft.pdf> (accessed Sept 7 2017).

Pacific Northwest Pest Management Handbooks. *Broccoli, Brussels sprout, cabbage, cauliflower - Cutworm*. <https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/broccoli-brussels-sprout-cabbage-cauliflower-cutworm> (accessed Sept 18 2017).

Pacific Northwest Pest Management Handbooks. *Turnip and Rutabaga (Brassica sp.) - Black Leg (Phoma Dry Rot)*. <https://pnwhandbooks.org/plantdisease/host-disease/turnip-rutabaga-brassica-sp-black-leg-phoma-dry-rot> (accessed Sept 7 2017).

Pacific Northwest Pest Management Handbooks. *Turnip and Rutabaga (Brassica sp.) - Clubroot*. <https://pnwhandbooks.org/plantdisease/host-disease/turnip-rutabaga-brassica-sp-clubroot> (accessed Sept 13 2017).

Pacific Northwest Pest Management Handbooks. *Turnip (roots and tops) and rutabaga - Flea beetle*. <https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/turnip-roots-tops-rutabaga-flea-beetle> (accessed Sept 18 2017).

Semences du patrimoine. <https://www.semences.ca/diversite/indice-catalogues-semences?psp=Turnip%2C+Winter+%28Rutabaga%29> (accessed Sept 6 2017).

Shapiro-Ilan D, Hazir S, Glazer I. (2017). Chapter 6. Basic and applied research: entomopathogenic nematodes. In *Microbial control of insect and mite pests: From theory to practice*. Lacey LA, ed. New York, NY. Elsevier. 461 pp. (accessed Sept 14 2017).

Statistics Canada. CANSIM. <http://www5.statcan.gc.ca/cansim/a33?lang=eng&spMode=master&themeID=920&RT=TABLE>

University of Minnesota Extension. (reviewed 2002). *Caterpillar pests of cole crops in home gardens*. <https://www.extension.umn.edu/garden/insects/find/caterpillar-pests-of-cole-crops-in-home-gardens/> (accessed Sept 14 2017).

University of Vermont Extension. *Flea beetles management*.  
<https://www.uvm.edu/vtvegandberry/factsheets/fleabeetle.html> (accessed Sept 18 2017).

Utah State University Extension. (2016). *Caterpillar pests of Brassica vegetables*. ENT-181-16.  
[http://digitalcommons.usu.edu/extension\\_curall/1595/](http://digitalcommons.usu.edu/extension_curall/1595/) (accessed Sept 14 2017).

Vegetable Cultivar Descriptions for North America – *Rutabaga*.  
<http://cucurbitbreeding.com/todd-wehner/publications/vegetable-cultivar-descriptions-for-north-america/rutabaga/>.

Virginia Cooperative Extension. *Wireworm pest management in potatoes*.  
<https://ext.vt.edu/search-results.html?q=wireworm> (accessed Sept 18 2017).