Crop Profile for Rutabaga in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

March, 2005

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada | Canada

Crop Profile for Rutabaga in Canada

Pest Management Centre
Pesticide Risk Reduction Program
Agriculture and Agri-Food Canada
960 Carling Avenue, Building 57
Ottawa, Ontario
K1A 0C6
CANADA

This profile is based on a report prepared on contract (01B68-3-0043) by:

Steve Howatt
Atlantic Agritech, Inc.
265 New Glasgow, Hunter River RR#3
Prince Edward Island, Canada C0A 1N0

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

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

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

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

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.

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

Table of Contents

List of Tables

Crop Profile for Rutabaga in Canada

The rutabaga (*Brassica napus,* Napobrassica group*)* is a member of the Cruciferae family. Rutabagas are grown in all provinces in Canada, however, for the most part, significant commercial production is limited to British Columbia, Ontario, Quebec and the Atlantic Provinces. Rutabaga is closely related to cole crops, being an interspecies hybrid bred in Switzerland (summer turnip x winter white cabbage). The rutabaga was introduced into England around the end of the 18th century and was called the turnip-rooted cabbage. Both white and yellow fleshed varieties exist. The rutabaga root consists of both true root and true stem. The upper portion of the stem forms a neck, which distinguishes rutabagas from turnips. Rutabaga is a Norwegian term for a "Swede" turnip. The rutabaga is normally 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.

General Production Information

Canadian Production (2002)	52,093 metric tonnes 1,924 hectares
Farm gate value (2002)	$13.6 million
Domestic consumption (2001)	38,266 metric tonnes
Export (2001)	Not available
Imports (2001)	Not available
Source(s): Statistics Canada	

Production Regions

Rutabaga is grown commercially in most provinces in Canada. The majority of production takes place in Ontario (39%) and Quebec (37%), with minor production in Prince Edward Island (9%), Newfoundland (6%), Nova Scotia (3%), New Brunswick (3%), British Columbia (3%) and Saskatchewan (<1%).

Cultural Practices

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

A minimum of four to five years of crop rotation away from cole crops is necessary for acceptable insect and disease control. At least a seven-year rotation may be required in fields infested with the clubroot pathogen. During this period, cruciferous weeds should also be controlled, as they can serve as hosts for clubroot. Rutabaga should follow stubble (cereal crop plowdown) instead of sod from perennial legumes such as alfalfa or clover, to reduce the susceptibility of the crop to diseases and damage from pests that thrive in sod conditions (wireworms and slugs). Limited nitrogen is beneficial for rutabaga growth, and this is easier to

control following stubble than following legumes that fix nitrogen. Using legumes in the rotation for two or more years will improve the soil structure and are beneficial, as long as the rutabaga crop does not immediately follow the legume crop.

When choosing fields for rutabaga production it is also important to consider the possibility of herbicide carryover. Avoid fields where residual herbicides from previous years persist in the soil, as crop injury may occur. For example, if herbicides with the active ingredient metribuzin (e.g., used on potato and soybean) were applied the year before, there is a strong possibility of crop injury to rutabaga.

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

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

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

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

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

Production Issues

Rutabagas suffer from the same problems as other members of the cabbage group. Insect pests are the most important issues for rutabaga production, with the cabbage root maggot being the most damaging pest. The root maggot feeds and tunnels in the roots causing young plants to wilt and die. Even a small amount of feeding on mature rutabaga can lower the grade and reduce marketability of the crop. Controlling the cabbage root maggot is the most important factor in producing a quality crop. Other important insect problems include caterpillars that feed on the foliage and aphids that suck the plant sap, causing plant stress, especially in hot and dry seasons, cutworms that sever the seedlings, and wireworms that feed on the roots. Several diseases such as damping-off, downy mildew, white spot and black rot will damage rutabagas. Rutabagas are affected by weed competition, for which there are few effective herbicides registered. Several physiological disorders also affect rutabagas, including brown heart caused by boron deficiency.

Table 1. Canadian rutabaga production and pest management schedule

Time of Year	Activity	Action
May	Plant care	Planting (earlier in some areas)
	Soil care	Fertilization and liming
	Disease management	Seed treated fungicides
	Insect & mite management	Seed treated insecticides
	Weed management	Cultivation and pre emergence sprays
June	Plant care	Monitoring and Irrigation (if used)
	Soil care	Topdressing
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Post emergent spraying
July	Plant care	Monitoring and Irrigation (if used)
	Soil care	Limited
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Limited
August	Plant care	Monitoring and Irrigation (if used), early harvest
	Soil care	Limited
	Disease management	Monitoring and spraying if necessary
	Insect & mite management	Monitoring and spraying if necessary
	Weed management	Limited
September	Plant care	Harvest and storage
	Soil care	Cultivation

Format adapted from BCMAFF Crop Profile

Source(s): OMFRA. Vegetable production recommendations, 2000-2001. Atlantic Provinces Agriculture Services Co-ordinating Committee. Vegetable Crops Production Guide. Publication 1400, Agdex No. 250

Abiotic Factors Limiting Production

Key Issues

- Brown heart may occur even with adequate soil boron and correctly timed applications of foliar boron. More research is needed to understand this disorder and possible interactions between boron and calcium, and to develop better methods of preventing it.
- Observation suggests that seed vigour is declining. There are fewer and fewer seed-producing areas and the market for rutabaga seed is small. Breeding lines need to be managed so some seed is produced every year.

Herbicide Sensitivity

Rutabaga is extremely sensitive to the drifting of phenoxy herbicides from nearby uses, such as field-crop weed control. Seedling crops of rutabaga can 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. When growing rutabagas, it is always important to consider the possibility of herbicide carryover from previous crops. Fields where residual herbicides from previous years persist in the soil must be avoided, as crop injury may occur. In particular, if herbicides with the active ingredient metribuzin (used on potato and soybean, among other crops) were applied the year before, there is a very strong possibility of crop injury occurring if rutabaga is grown in the same field the following year.

Brown Heart

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

Soil Moisture

Plants take up boron more easily when there is adequate soil moisture. During dry periods, boron may not be very available to the plant. Soils with higher levels of organic matter tend to hold moisture better than soils with lower levels. In fact, organic matter may be a source of boron in acidic soils. However, a pH of greater than 7.0 can also interfere with boron uptake.

Temperature Extremes and Low Light

Bolting or flowering can be a problem with very early-seeded or transplanted crops. Normally rutabaga is a biennial plant; it forms a swollen root during the first year of growth and flowering stems in the second year of growth after a cold period. If transplants are subjected to low temperatures (below 5^{o}C) when they are less than 10 weeks old, this will trigger the development of flowering stems. The duration of the low temperature period required to cause flowering varies with the variety being grown. However, as little as 3 to 5 nights with temperatures around 3^{o}C are believed to result in development of flowering stems. Field plantings or seedlings can be

affected by low temperatures, but transplants more than 10 weeks old require several nights of freezing temperatures to induce flowering.

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

Diseases

Key Issues

- There is a need to register new fungicides with new modes of action in order to decrease the potential for resistance development.
- There is concern over the fact that many diseases do not have any fungicides registered for, and are not controlled adequately using other practices.
- Additional research is needed to develop integrated pest management strategies.
- More trained personnel are required to help in establishing integrated pest management strategies.
- Development of new disease control strategies that are compatible with organic farming practices is required.

Table 2. Degree of occurrence of disease pests in Canadian rutabaga production

	Degree of occurrence							
Major Diseases	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Clubroot	NDR	NDR	E		NDR	D	NDR	
Powdery mildew	NDR	NDR	E		NDR		NDR	
Common scab	NDR	NDR		D	NDR	D	NDR	
Rhizoctonia rot	NDR	NDR	E		NDR	D	NDR	
Black leg	NDR	NDR	E		NDR		NDR	
Black rot	NDR	NDR	E		NDR		NDR	
Minor Diseases	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Downy mildew	NDR	NDR	E	E	NDR	D	NDR	
Turnip mosaic virus	NDR	NDR	E		NDR		NDR	

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

Source(s): Provincial crop and pest management specialists

Major Diseases

Clubroot (*Plasmodiophora brassicae*)

Pest Information

Damage: Diseased plants are chlorotic, turning yellowish, are slow to grow and develop, and partially wilt during warm days. Enlarged clublike growths develop below the root which become infected with secondary bacteria, causing rotting.

Life Cycle: The fungus causing clubroot in rutabagas and cole crops is usually present in areas where these crops have been grown for many years. Land will remain infested for 7 years or longer after a diseased crop. Certain weeds of the mustard family, such as wild radish and wild mustard will maintain or increase the level of infestation year after year. Soils that are cool, wet and acidic (pH less than 7.2) favour the disease. The fungus is soil-borne and is spread by infected seedlings, contaminated manure, drainage water, farm equipment, animals feet, human footwear, and soil blown by the wind. This disease is not a major problem in BC.

Pest Management

Chemical Controls: The seedbed can be fumigated with metham sodium (not registered in Quebec) if pathogen-free soil is not used. Some field control is possible with quintozene, but the fungicide is not used in British Columbia, Prince Edward Island and Quebec (not registered).

Cultural Controls: The best method to avoid a disease problem is to manage the disease correctly when the initial breakout occurs. Plants are scouted regularly. A rotation of at least 7 years with no cole crops should be used once infestation has been encountered, and a 3-year rotation between cruciferous crops can be used on clean land. Manure from animals fed infected crops should not be used on land intended for any cole crop. Soil tests should be conducted to ensure that high soil calcium and magnesium levels are maintained along with a pH over 7.2 without using hydrated lime on seedbeds. Planting in fields with a known history of clubroot should be avoided. Field equipment should be disinfected when moved from field to field. Infested land should be seeded to a sod crop, such as hay or pasture, for at least seven years, to prevent the movement of soil. The land should then be isolated until the sod is well established. Susceptible weeds should also be controlled.

Alternative Controls: None identified.

Resistant cultivars: Resistant cultivars are available; York is resistant to most races, while Kingston is resistant to all races. Neither of these cultivars are used any longer in Quebec.

Issues for Clubroot

1. There is concern over the inconsistency in the effectiveness of chemical controls.
2. There is concern over the many different strains of the pathogen, making varietal control challenging.

Powdery Mildew (*Erysiphe polygoni*)

Pest Information

Damage: The disease appears as a white, fuzzy fungal growth in patches on underside of leaves; the upper side of the leaf displays angular, tan, papery lesions. In advanced stages, leaves are distorted, twisted and stunted in growth and eventually turn yellow and die. The pathogen may also cause internal discolouration of roots.

Life Cycle: E. polygoni is a fungal pathogen that occurs in several physiologic races and attacks a wide range of plants. The fungus over-winters on cruciferous plant debris, weeds and seeds. Powdery mildew disease of rutabaga is of minor importance in Quebec.

Pest Management

Chemical Controls: Fungicides registered for the control of powdery mildew include propiconazole, pyraclostrobin and sulphur.

Cultural Controls: Dense seeding should be avoided and crop residue should be ploughed under following harvest. If infections are severe, rotations out of the Cruciferae family should be used.

Alternative Controls: Monitoring of plants for signs of infection should be done during the growing season.

Resistant cultivars: None available.

Issues for Powdery Mildew

None identified

Common Scab *(Streptomyces scabies)*

Pest Information

Damage: Scab is a well-known disease of potato and may also cause severe damage to rutabaga. Infection results in circular to oval lesions scattered over the surface of the root. Affected tissues may consist of a tan, raised layer, or tissues may become pitted and dark following secondary decay. While scab generally does not cause decreases in yield, it can make the affected roots unmarketable.

Life Cycle: S. scabies is a soil-borne bacterium. Host crops for this bacterial pathogen include potatoes, beet, radish carrot and parsnip.

Pest Management

Chemical Controls: None available.

Cultural Controls: The pathogen can survive in the digestive tract of animals; therefore, using manure from animals fed to contaminated plant material should be avoided in fields intended for growing rutabaga. High lime applications, resulting in high soil pH, may increase the severity of scab. Crop rotations to a non-host crop, such as grass or cereals can be beneficial. The infection is favoured in dry soils, therefore, irrigation can suppress the disease, especially during the period of rapid expansion of the roots.

Alternative Controls: Some naturally occurring bacteria can control the disease but are not commercially available.

Resistant cultivars: None available.

Issues for Common Scab

None identified

Rhizoctonia rot (*Rhizoctonia solani*)

Pest Information

Damage: R. solani is a fungal pathogen causing damping-off, wirestem and root rots of rutabagas and other cruciferous crops. Damping-off occurs when seeds decay and do not germinate, or when germination occurs but plants do not emerge from the soil. Wirestem, also referred to as crater rot, occurs at a later stage, but often when plants are still small (10-15 cm). This disease results from an extension of the damping-off or through new infections by the pathogen. On mature roots, root rot lesions 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. Soil contamination of storage bins can increase the spread and severity of disease in storage.

Life Cycle: The pathogen can survive for many years by producing sclerotia. Sclerotia can be produced in the soil or on plant tissues. Field infections may be more severe when the control of root maggot is not adequate. The amount of decay increases rapidly as the temperature raises above 4 ^{o}C.

Pest Management

Chemical Controls: There are no fungicides available for application on growing rutabaga crops to control Rhizoctonia rot. However, several seed treatments are available and include carbathiin, thiram, fludioxinil (registered in Quebec), and lindane (active ingredient not registered in Quebec). Seed treatments are usually carried out by the seed companies and can keep rhizoctonia problems to a minimum.

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

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Rhizoctonia rot

None identified

Blackleg (*Phoma lingam*)

Pest Information

Damage: This disease does not generally reduce seed crop yields, however, low levels of seed infection coupled with weather favourable for disease spread in seedbeds can lead to severe losses after transplanting. Early symptoms of blackleg appear as small spots on leaves of young plants. 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. Eventually, plants may wilt abruptly and die. This disease occurs in Manitoba, but is of minor importance in B.C. and Quebec.

Life Cycle: Blackleg is a destructive fungal pathogen that is often spread on seed. It over-winters on plant debris and on alternate host plants. Disease spreads by splashing water, workers, and

contaminated equipment. The pathogen has the potential to spread very rapidly through a field; however it is not as mobile as black rot. Blackleg can be found in many cruciferous crops and it is especially evident in canola.

Pest Management

Chemical Controls: None available.

Cultural Controls: Weeds in ditches and hedgerows around the field should be controlled. Work should not be done in the field when plants are wet. Rutabaga should not be planted adjacent to or downwind from fields that were cropped to crucifers or canola in the previous year because water and wind can spread the disease. Manure from animals that have consumed infected plants should not be used. A four year rotation should be practised and cruciferous weeds should be continuously destroyed because they may harbour the black leg pathogen. Use of certified disease-free seeds and hot-water seed treatment should limit spread of the disease.

Alternative Controls: None identified.

Resistant cultivars: Resistant cultivars are available.

Issues for Blackleg

None identified

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

Pest Information

Damage: Infected leaf tissue becomes yellow at the leaf margins and chlorosis progresses toward the leaf center, creating a V-shaped area with the base of the "V" at the leaf midrib. Veins in these areas become dark brown or black. As the infection becomes systemic, symptoms may appear anywhere on the plant and stunting occurs. In infected seeds, the first symptoms appear on cotyledons which rapidly wilt and drop off. Black rot is one of the most common and damaging diseases on crucifers, and the economic losses can be great.

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

Pest Management

Chemical Controls: None available.

Cultural Controls: Work should not be done in the field when plants are wet. Cruciferous weeds should be controlled, as they can be a host for the pathogen that causes black rot. A four year rotation should be used. Equipment used in an infested field should be cleaned and disinfected before moving to other fields. A hot-water seed treatment (50 °C for 15 minutes) will limit spread of the disease. Only certified, disease free seed should be used. Diseased plants should be removed from the field and destroyed.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Black Rot

None identified

Minor Diseases

Downy Mildew (*Peronospora parisitica*)

Pest Information

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

Life Cycle: The disease has the potential to affect a large portion of the rutabaga crop each year. It affects most cruciferous crop and weed plants. Infection can occur at almost any stage of growth, although cool, moist conditions favour disease development. Temperatures in the range of 10 – 15 ^{o}C, and free moisture on the leaves are optimal for disease spread. There is concern about this disease in Quebec and the Atlantic Provinces, where it is a major problem. In some years, 100% of the crop can be affected. The disease can be found on many cruciferous plants as well as common weeds such as shepherd's purse.

Pest Management

Chemical Controls: None available.

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

Alternative Controls: None identified..

Resistant cultivars: None available.

Issues for Downy Mildew

There is concern over the lack of registered fungicides for this disease, especially in Quebec where the disease is of major importance.

Turnip Mosaic Virus

Pest Information

Damage: Turnip Mosaic virus causes premature yellowing and loss of older leaves on affected rutabaga plants.

Life Cycle: The virus over-winters in living tissues, and infects new plants when infected roots from storage warehouses are disposed, or by spreading from volunteers remaining from the previous year. Many species of aphids serve as vectors that spread the virus and aphids that do not live on rutabaga are as important in the spread of the disease as aphids that colonize

rutabaga plants. This disease is primarily a problem in Ontario and Manitoba, and is generally not a concern in Eastern and Western Canada, and Quebec.

Pest Management

Chemical Controls: Insecticides can be used to control aphid populations.

Cultural Controls: Crops should not be grown in or near fields grown with rapeseed or canola. Planting should not be done late in the season. Volunteer rutabaga should be controlled and culls should be removed from storage early. Late seeded fields should be isolated from early seeded fields. Oil sprays are used in the west to control aphid populations.

Alternative Controls: Aphid control through natural predators will help in suppressing the spread of the virus and minimizing crop losses. No thresholds have been established for aphid control.

Resistant cultivars: None available. Sources of resistant germplasm are being researched and developed.

Issues for Turnip Mosaic Virus

None identified

Table 3. Disease control products, classification and performance for Canadian rutabaga production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Disease, pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Carbathiin/ thiram/lindane	Anilide, oxathiin fungicides)/ dithiocarbamate fungicides)/ organochlorine insecticides	7,M	Lindane discontinued after 2004	Rhizoctonia rot		
Mineral oil	Inorganic	M	R	Turnip mosaic virus	A^P	
Propiconazole	Conazole fungicides	3	R	Powdery mildew	A	
Pyraclostrobin	Strobilurin fungicides	11	R	Powdery mildew	A	
Sulfur	Inorganic fungicides	M	R	Powdery mildew	A	
Metham sodium	Dithiocarbamate herbicides	M	R	Clubroot	I	
Quintozene	Aromatic fungicides	14	R	Clubroot	I	

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

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

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

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

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

Table 4. Availability and use of disease management approaches for Canadian rutabaga production

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

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

Insects and Mites

Key Issues

- There is a need for the registration of new and safer insecticide products to control insect pests.
- The organophosphates terbufos and chlorpyrifos are the main insecticides registered for cabbage root maggot, and both are prone to resistance development and under re-evaluation. In addition, no promising new insecticides have been identified that will provide effective control of the cabbage root maggot.
- There is a need to promote ongoing research into alternative management strategies for the cabbage maggot.
- More trained personnel is required for integrated pest management delivery.

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

	Degree of occurrence							
Major Insects	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Cabbage root maggot		DNR	E	E	DNR	E	DNR	
Flea beetle		DNR	E	E	DNR	E	DNR	
Diamondback moth larva		DNR	E		DNR	E	DNR	
Imported cabbage worm		DNR	E		DNR	E	DNR	
Cabbage looper		DNR	E		DNR	D	DNR	
Wire worm		DNR	E		DNR	D	DNR	
Aphid		DNR		E	DNR	E	DNR	
Minor Insects	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Cutworm		DNR	E		DNR	D	DNR	
Red turnip beetle		DNR			DNR		DNR	

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

Source(s): Provincial Crop and Pest Management Specialists

Major Insects and Mites

Cabbage Root Maggot (*Delia radicum*)

Pest Information

Damage: 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 renders the crop unmarketable.

Life Cycle: There are two to three generations in a year. Pupae over-winter in the soil near the roots of the host plant. Adult flies emerge in the spring and crawl to the surface. The adults fly close to the ground near host plants and lay oval shaped white eggs at the base of the stem or in nearby crevices in the soil. Eggs hatch in three to seven days.

Pest Management

Chemical Controls: Registered products include terbufos (registration cancelled by 31 December 2004), chlorpyrifos, diazinon, and azinphos-methyl (registration to be cancelled by 31 December 2005).

Cultural Controls: The rutabaga crop should not be grown near other curciferous crops. Early and late rutabaga should not be grown in close proximity to each other. Crop rotation should be used.

Alternative Controls: Many naturally occurring beneficial insects can help to control populations of cabbage root maggot. In Newfoundland and Labrador the beetle, *Aleochara bilineata,* kills a large number of pupae and feed on eggs.

Resistant cultivars: There are some less susceptible varieties on the market, but very few resistant varieties have been developed.

Issues for Cabbage Root Maggot

1. This insect is the most serious pest of rutabaga in most areas.
2. There is a need to replace the currently used organophosphates, terbufos and chlorpyrifos, with safer and more efficient products. These organophosphates have a high potential for the development of pest resistance and are under re-evaluation.

Flea Beetle (*Phyllotreta cruciferaze*)

Pest Information

Damage: Adult beetles feed on emerging seedlings and can severely damage them. On larger leaves damage appears as small holes. 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 can attack most crucifers. The flea beetle is an important pest in Ontario and Quebec.

Life Cycle: The pest over-winters as adult beetles. Depending on the species, there are one to two generations per year. Hot sunny weather favours the adult beetles and damage is most severe during such periods..

Pest Management

Chemical Controls: Registered products include terbufos (registration cancelled by 31 December 2004), carbaryl, cypermethrin (not registered in Quebec), diazinon, and endosulfan.

Cultural Controls: Early planting should be avoided. High seeding rates can be used to deter the insects. Irrigation can be used during warm periods to drown adults.

Alternative Controls: There are few natural predators of the flea beetle. Some wasps will feed on the beetle but not enough for complete control.

Resistant cultivars: The variety "American purple top" has some resistance to the flea beetle.

Issues for Flea Beetle

None identified.

Diamondback Moth Larva (*Plutella xylostella*)

Pest Information

Damage: When feeding, the larvae produce many small holes in leaves of the host plant. If larvae populations are high, leaves and the crown can be severely damaged.

Life Cycle: The small larva can have 3-6 generations per year. Hot, dry conditions can cause populations of this insect to explode. Under cold, wet conditions this pest is not much of a problem.

Pest Management

Chemical Controls: Registered insecticides include carbaryl, endosulfan, and spinosad.

Cultural Controls: Rutabaga should not be grown near other cruciferous crops. Early and late rutabaga should not be grown close together. Crop rotation and planting the crop as far away from plantings in previous years helps in control. Deep ploughing of field debris late in the season reduces numbers of over-wintered adults.

Alternative Controls: The diamondback moth is preyed upon by several species of wasps, including *Diadegma insulare* and *Microplitis plutaellae*. The bacterial insecticide, *Bacillus thuringiensis* is effective, but moth resistance has been recorded in other countries. The use of pheromone bait traps can help predict the presence of larvae.

Resistant cultivars: None available.

Issues for Diamondback Moth Larva

1. This pest can appear suddenly in epidemic levels.
2. Resistance to registered products is a concern.
3. There is a need to develop thresholds for bait trap catches.

Imported Cabbage Worm *(Pieris rapae)*

Pest Information

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

Life Cycle: Eggs are laid singly on the underside of leaves and give rise to velvety-green larvae with one yellow stripe down the back and a paler broken stripe along each side. Cabbageworm larvae do not loop when they walk. The pupa is silvery green, with sharp points at the broad head end. It is glued to the plant or plant debris at the narrow end and

suspended in an upright position by a loose silk band around the middle. Various stages may be seen on the foliage at the same time. There are three to five generations a year. Pupae over-winter attached to old plants or debris. Larvae mature in two to three weeks and pupate; butterflies emerge in one to two weeks.

Pest Management

Chemical Controls: Insecticides may be used if larvae are causing severe leaf damage. Registered insecticides include endosulfan, spinosad, malathion, carbaryl. .

Cultural Controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga should not be grown close together.

Alternative Controls: There are a number of wasps and flies that prey on the imported cabbageworm. *Bacillus thuringiensis* is a preferred bacterial insecticide. A granulosis virus will cause high mortality rates in the larval stage, but it is not commercially available in Canada.

Resistant cultivars: None available.

Issues for Imported Cabbageworm

None identified

Cabbage Looper (*Trichoplusia ni*)

Pest Information

Damage: Injury occurs as the insect feeds, leaving leaves riddled with ragged-edged holes. The growth of severely infested plants is stunted.

Life Cycle: Since the cabbage looper prefers warmer climates, it is only a major pest in southern Ontario. In Ontario, the pest can have as many as three generations per season, as compared to only one in the Atlantic Provinces late in the season.

Pest Management

Chemical Controls: Chemical sprays can be effectively used. Registered insecticides include carbaryl, endosulfan, spinosad, and malathion.

Cultural Controls: Rutabaga should not be grown near crops of early broccoli, cabbage, cauliflower or other cruciferous crops. Early and late rutabaga should not be grown close together.

Alternative Controls: There are several parasitic wasps, ants, beetles and flies which feed on the larvae and eggs of the cabbage looper. Viruses can be important for control, as the pest is susceptible to many different types. Larvae may be infected by a nuclear polyhedrosis virus, however this virus is not commercially available. *Bacillus thuringiensis* is commercially available and effective.

Resistant cultivars: None available.

Issues for Cabbage Looper

Cabbage looper is a major pest only in southern Ontario where it can have as many as three generations per season. In the Atlantic Provinces it has usually one generation.

Wireworm (*Melanotus communis*)

Pest Information

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

Life Cycle: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about a week and, depending on the species, will live for 1 to 5 years in the ground feeding on roots and seeds. Wireworms require three or more years to complete their life cycle. Wireworms of all sizes and ages are present in the soil throughout the year as there is always an overlapping of generations. Mature larvae pupate in the fall and then become adult beetles that emerge in the spring. Wireworms are often numerous in soil that has been in sod for several years. They are also more abundant in heavy, poorly drained soil. In BC, two introduced European species of wireworm occur in addition to the native species.

Pest Management

Chemical Controls: Insecticides are rarely recommended because of infrequent wireworm outbreaks. Registered products include terbufos and chlorpyrifos. No insecticides are registered for this pest in Quebec.

Cultural Controls: Fields known to have bad infestations or fields coming out of sod should be avoided. Rotation with non-host crops should be done to help reduce populations. Scheduled scouting is not recommended, but ungerminated seed or damaged plants should be removed. Bait stations in spring or fall provide a method for checking to see if wireworms are present.

Alternative Controls: None identified.

Resistant cultivars: None available.

Issues for Wireworm

1. There is a need to establish thresholds for wireworm.

Aphids (*Aphis* spp.)

Pest Information

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

Life Cycle: Aphids may be black, yellow, or pink but mostly are various shades of green.

Pest Management

Chemical Controls: Chemical sprays are used only if aphids are in high enough numbers to cause wilting of leaves during dry weather or if there is concern about the transmission of viruses. Control sprays for root maggot using chlorpyrifos should provide effective control of aphids. Other registered products include diazinon, malathion, dimethoate, and endosulfan.

Cultural Controls: Early and late rutabaga should not be grown close together. Also, rutabaga should be grown as far as possible from corn field, because corn is an important host of aphids.

Alternative Controls: Naturally occurring predators may suppress aphid numbers, particularly later in the season.

Resistant Cultivars: None available.

Issues for Aphid

1. Low population levels of some species can quickly increase in numbers during warm dry weather and completely colonize the upper parts of the plant.

Minor Insects and Mites

Cutworm (*Agrotis ipsilon, Peridroma saucia*)

Pest Information

Damage: Black and dark sided cutworms may cause considerable damage to rutabagas. They attack very young plants that have recently germinated. 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. Cutworm populations rarely get so high that they have any economic importance on rutabaga.

Life Cycle: Cutworms pass through egg, larva, pupa, 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 seedling germination. Depending on the species and the provinces, cutworms can overwinter in most life stages.

Pest Management

Chemical Controls: Cutworms are normally kept under control by chemicals used for cabbage maggot control. If cutworm damage is likely, drenches of chlorpyrifos can be applied.

Cultural Controls: Fields known to have high numbers of cutworm should be avoided.

Alternative Controls: Pheromone bait traps can be used to forecast the presence of larvae.

Resistant Cultivars: None available.

Issues for Cutworm

None identified.

Red Turnip Beetle (*Entomoscelis americana*)

Pest Information

Damage: Adults and the larvae feed voraciously on flowers, seed pods, and foliage. Large, ragged holes are chewed in the leaves; frequently only midribs and stems are left. Yield is reduced or the plants may be killed. The red turnip beetle is often considered as beneficial because it feeds upon and controls cruciferous weeds. It is rare that red turnip beetles cause significant economic damage to crops but when they do, chemical control should be applied immediately.

Life Cycle: The beetle is a sporadic pest in central B.C., the Peace River, and at higher elevations in Southern British Columbia. They can feed and survive on many weeds. There is one generation a year. Eggs over-winter in the soil and hatch in early May. Larvae mature by late June and pupate in the soil. Adults emerge and feed for a short time until hot weather causes them to cease feeding and return to the soil. When temperatures are cool in August and

September, they re-emerge, feed and lay eggs. Adults remain on the plants until the first killing frost.

Pest Management

Chemical Controls: This pest will usually be controlled if a regular root maggot control program is followed. Registered products include terbufos, chlorpyrifos, diazinon.

Cultural Controls: Weeds in and around fields should be controlled. Volunteer canola and other hosts should not be left in the field. Cultivation in the fall or spring will kill many of the eggs.

Alternative Controls: None identified.

Resistant Cultivars: None available.

Issues for Red Turnip Beetle

None identified

Table 6. Insect control products, classification and performance for Canadian rutabaga production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Terbufos	aliphatic organothiophosphate insecticides)	1B	RE (phased out by end of 2004)	Cabbage root maggot	A^P	
				Flea beetle	A^P	Inadequate in PEI
				Wireworm	A^P	Inadequate in PEI; Not registered in Quebec
				Red turnip beetle		
Chlorpyrifos	pyridine organothiophosphate insecticides	1B	RE (restricted number and sites of applcation)	Cabbage root maggot	A	
				Wireworm	I	Not registered in Quebec
				Red turnip beetle		
				Aphids	A	
				Cutworm	A^P	Inadequate in PEI
Diazinon	pyrimidine organothiophosphate insecticides	1B	RE (under active review)	Cabbage root maggot	A^P	Being phased out, inadequate in Quebec and Ontario
				Flea beetle	A^P	
				Red turnip beetle		
				Aphids	I	
Azinphos-methyl	benzotriazine organothiophosphate insecticides	1B	RE (use phase out by end of 2005)	Cabbage root maggot	A^P	Permit required in PEI
Carbaryl	carbamate insecticides	1A	R	Flea beetle	A	
				Diamondback moth larva	A	
				Imported cabbage worm	A	
				Cabbage looper	A	
Cypermethrin	Pyrethroid ester insecticides	3	R	Flea beetle	A^P	Inadequate in PEI; Not registered in Quebec

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Malathion	aliphatic organothiophosphate insecticides	1B	RE (under active review)	Imported cabbage worm	I	
				Cabbage looper	I	
				Aphids	I	
Dimethoate	aliphatic amide organothiophosphate insecticides	1B	RE (some uses phased out by end of 2005)	Aphids	A	
Metasystox – r	aliphatic organothiophosphate insecticides	1B	DI	Aphids	I	
Endosulfan	cyclodiene insecticides	2A	RE (under active review)	Flea beetle	A^P	Inadequate in PEI
				Diamondback moth larva	A	
				Imported cabbage worm	A	
				Cabbage looper	A	
				Aphids	I	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Permethrin	pyrethroid ester insecticides	3	FR	Flea beetle	A^P	Inadequate in PEI
Spinosad				Diamondback moth larva		
				Imported cabbage worm		
				Cabbage looper		
Bacillus thuringiensis	microbial	11	BI	Diamondback moth larva		
				Imported cabbage worm		
				Cabbage looper		

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

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

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

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

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

Source(s): Provincial Crop and Pest Management Specialists

Table 7. Availability and use of insect pest management approaches for Canadian rutabaga production

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

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

Weeds

Key Issues

- There is concern over the fact that in some areas of Canada, weeds have developed resistance to triazine. Triazine-resistant lambs quarters now infests many acres in areas across the country.
- There is a need for a herbicide that will control weeds of the crucifer family (shepherd's purse, wild radish, etc.)
- More trained personnel is needed to implement integrated pest management programs.

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

	Degree of occurrence							
Annual grasses	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Barnyard grass	DNR	DNR	E	E	DNR	E	DNR	
Green foxtail	DNR	DNR	E	E	DNR	D	DNR	
Volunteer wheat	DNR	DNR		E	DNR		DNR	
Wild buckwheat	DNR	DNR		E	DNR	D	DNR	
Wild oats	DNR	DNR	E		DNR	D	DNR	
Annual broadleaf	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Common ragweed	DNR	DNR	E	E	DNR		DNR	
Corn spurry	DNR	DNR		E	DNR	E	DNR	
Hairy nightshade	DNR	DNR	E	E	DNR		DNR	
Hempnettle	DNR	DNR		E	DNR	E	DNR	
Kochia	DNR	DNR			DNR		DNR	
Lady's thumb	DNR	DNR	E	E	DNR	E	DNR	
Lambs quarters	DNR	DNR	E	E	DNR	E	DNR	
Low cudweed	DNR	DNR			DNR	D	DNR	
Redroot pigweed	DNR	DNR	E	E	DNR	D	DNR	
Wild radish	DNR	DNR	E	E	DNR	E	DNR	
Volunteer potatoes	DNR	DNR			DNR		DNR	
Perennial grasses	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Quackgrass	DNR	DNR	E	E	DNR	E	DNR	
Perennial broadleaf	**BC**	**SK**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Canada thistle	DNR	DNR	E	D	DNR	E	DNR	
Field mint	DNR	DNR		D	DNR	E	DNR	
Narrow-leaved goldenrod	DNR	DNR		D	DNR	E	DNR	

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

Source(s): Provincial Crop and Pest Management Specialists

Major Weeds

Annuals and Biennials

Pest Information

Damage: Crop losses can be very high if annual weeds are not controlled. Broadleaf weeds can reach heights similar to rutabaga and compete with the crop for light, water and nutrients. If not controlled effectively, they will reduce rutabaga growth and yield. Annual grasses have fast growth and the ability to compete for necessary resources, making them a serious problem. Grass weeds are very tolerant to extremes in moisture and temperature once established. They can be very difficult to eliminate from infested fields and they require management/control prior to seed-set due to their prolific seeding. In rutabagas, the critical stage for control of annual weeds is early in the growing season.

Life Cycle: Annual grass and broadleaf weeds complete their life cycle in one year, going from seed germination through growth to new seed production. Spring annuals germinate in the early spring and grow to produce 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 in the following year. Annual weeds are very adept at disseminating through the production of huge 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 right. 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 they bolt and send up a flower stock where seeds are produced. The original plants then die at the end of the second growing season. Biennial weeds only disseminate through the seeds produced every other year and so their dissemination potential is slightly less than that of annuals. However, seeds can be banked in the soil for years waiting for the right conditions to germinate.

Pest Management for Annuals and Biennials

Chemical Controls: In some areas of Canada, annual weeds have developed resistance to herbicides. Triazine-resistant lambsquarters now infest many fields across the country. Herbicides currently labelled for control in rutabagas work well on annual grasses and a few small seeded broadleaf weeds. Most annual broadleaf and grass weeds can be controlled in rutabagas with a soil applied pre-emergent residual herbicide. This can provide season long protection against germinating weeds and seedlings. Once the rutabagas emerge, there are limited herbicide options for controlling broadleaf weeds in the crop. Selective systemic herbicides can be used to control grass that emerges after the crop plants.

Cultural Controls: Weeds along road sides, ditches, and fence lines should be controlled by mowing or planting perennial grasses. A site that is as weed free as possible should be selected for growing rutabaga. Fields should be scouted in the previous season to determine what weeds might be expected and to determine if they can be controlled in the rutabaga crop. Purchased seed should be certified to ensure that it contains the lowest possible quantities of weed seed. To reduce the transport of weeds by equipment, adhering soil and debris should be cleaned off when leaving each field. Manure applications may also introduce weeds to a field. Repeated tilling prior to planting and cultivation after planting will reduce germinating weeds. Monitoring for annual weeds should be done during the first 2-3 weeks after weed emergence if post emergence controls are to be applied. Row spacing should be chosen that speeds up row closure. Crop rotation can disrupt perennial and biennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Rotating between broadleaf and grassy crops provides a chance to control broadleaf weeds in grassy crops and grassy weeds in broadleaf crops with selective herbicides. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimize erosion and nutrient uptake over the winter.

Alternative Controls: None available.

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

Perennials

Pest Information

Damage:

Life Cycle: Perennial grass and broadleaf weeds can live for several to many years, and generally establish from various types of root systems, although many will also spread by seeds. Perennial weeds can become very large and be very competitive especially if they have been established for several years. Perennials usually flower every year as well as expand their root system, so can spread effectively by both methods. Most perennial weed seeds germinate in the spring and the plants grow throughout the summer. During this period they also expand their root systems, sending up new plants along the roots as well as expanding the size of existing plants. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds. The critical stage for damage is early in the growing season, as for the other groups of weeds.

Pest Management for Perennials

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

Cultural Controls: See cultural controls for annual and biennial weeds. Cultivation is less effective at controlling perennial weeds as compared to annual weeds. Perennial weeds are harder to control because of their large underground root systems and tillage and cultivation may actually break up the underground portions of the plant and increase the weed problem.

Alternative Controls: None identified. \

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

Issues for Weeds

See key issues section

Table 9. Weed control products, classification and performance for Canadian rutabaga production

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Fluazifop-p-butyl	aryloxyphen-oxypropionic herbicides	1	R	Annual grass	A	
				Perennial grass	A^P	Inadequate in PEI
Napropamide	amide	15	R	Annual grass	A^P	Efficacy is limited
				Annual broadleaf	A^P	Efficacy is limited
				Perennial grass		
				Perennial broadleaf		
S-metolachlor	chloroacetanilide herbicides	15	R	Annual grass	A^P	Performance varies according to timing of product application
				Annual broadleaf	I	
				Perennial grass	I	
				Perennial broadleaf		
				Wild mustard,sheppard's purse	I	
Trifluralin	dinitroaniline herbicides	3	R	Annual grass	A^P	Performance varies according to timing of product application
				Annual broadleaf	I	
				Perennial grass		
				Perennial broadleaf		
				Wild mustard, sheppard's purse	I	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Sethoxydim	cyclohexene oxime herbicides	1	R	Annual grass	A^P	Inadequate in PEI
Paraquat	quaternary ammonium herbicides	22	R	Annual grass	A^P	Inadequate in PEI
				Annual broadleaf	A^P	Inadequate in PEI
				Perennial grass	I	
				Perennial broadleaf	A^P	Inadequate in PEI
				Wild mustard,sheppard's purse	I	
Clopyralid	picolinic acid herbicides	4	R	Annual broadleaf	A^P	Inadequate in PEI
				Perennial broadleaf	A^P	Inadequate in PEI
				Wild mustard,sheppard's purse	I	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Glyphosate	organophosphorus herbicides	9	R	Perennial grass	A^P	Performance varies according to timing of product application
				Perennial broadleaf	A^P	Performance varies according to timing of product application

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

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

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

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

Source(s): Provincial Crop and Pest Management Specialists

Table 10. Availability and use of weed pest management approaches for Canadian rutabaga production

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

no indication that the practice is available/used

available/used

available/not used

not available

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

References used in this document

Advisory Committee on Vegetable Crops. May 1997. Vegetable Crops Production Guide for the Atlantic Provinces. Atlantic Provinces Agricultural Services Co-ordinating Committee. Publication #1400, Agdex 250.

Atlantic Vegetable Committee. 1999. Atlantic Provinces Vegetable Crops Guide to Pest Management 1999-2000. Atlantic Provinces Agricultural Services Co-ordinating Committee. Publication #1400A, Agdex 250.

British Columbia Ministry of Agriculture, Food and Fisheries. 2000. *Fresh Field Vegetable Factsheet – Fresh Field Vegetable Opportunities in BC*.

British Columbia Ministry of Agriculture, Food and Fisheries. 2003. *Measuring Integrated Pest Management Adoption in British Columbia, 1998 Practices*. Food Safety and Quality Branch, British Columbia Ministry of Agriculture Food and Fisheries.

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

Centre de référence en agriculture et agroalimentaire du Québec, 2004-2005 « Répertoire 2004-2005 Traitements de protection des cultures ».

Ministry of Agriculture and Food of Ontario. *Guide to Weed Control 2004-2005.* Publication 75.

Ministry of Agriculture, Food and Rural Affairs of Ontario. 2000-2001. *Vegetable Production Recommendations 2000-2001*.

Pest Management Regulatory Agency. 1998. *Residue Chemistry Guidelines*. Pest Management Regulatory Agency, Health Canada.

Cutcliffe, J.A. and U.C. Gupta. November 1987. Effect of foliar sprays of boron applied at different stages of growth on incidence of brown heart in rutabagas. Canadex 258.532.

Gardner, J. and I. Nonnecke. March 1987. Rutabagas. Ontario Ministry of Food, Agriculture and Rural Affairs. Agdex 258/20.

Gerber, H.S. 1994. *Major Insect and Allied Pests of Vegetables in British Columbia.* British Columbia Ministry of Agriculture, Fisheries and Food. Cloverdale, BC.

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

Lovering, N. 2001. Field Manual for Rutabaga Production. PEI Horticultural Association. 76 pp.

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

Sanderson, K. and S. Wyand. 1998. Effects of boron, broadcast and/or foliar applications, on the degree of brown heart, boron deficiency, on two rutabaga cultivars. Final results of MII Project #3028, unpublished.

Schooley, J., ed. 1996. Integrated Pest Management for Crucifers in Ontario. Ontario Ministry of Agriculture, Food and Rural Affairs. Queen's Printer for Ontario.

Shattuck, V. and B.J. Shelp. November 1985. Brown Heart in Rutabaga. Ontario Ministry of Agriculture, Food, and Rural Affairs. Agdex 258/690.

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

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

Internet references

Alberta Agriculture Food and Rural Development. *Alberta Vegetable Varieties*. Available at: http://www.agric.gov.ab.ca/crops/hort/veg_recommendations.html.

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

British Columbia Ministry of Agriculture, Food and Fisheries. 2002. *Annual BC Horticultural Statistics: 2000*. Statistical Services Unit, Policy and Economics Branch, British Columbia Ministry of Agriculture Food and Fisheries. http://www.agf.gov.bc.ca/stats/index.htm

Crop Profile for rutabaga in California, 2002.
Available at: http://pestdata.ncsu.edu/cropprofiles/docs/carutabaga.html

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

Manitoba Agriculture and Food. *Vegetable Crops*. Available at: http://www.gov.mb.ca/agriculture/crops/vegetablecrops/bmz00s00.html.

Pest Management Regulatory Agency. Available at: http://www.pmra-arla.gc.ca/

IPM / ICM resources for production of rutabaga in Canada

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

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

OMFRA. 2000-2001.*Vegetable production recommendations.*

Internet references

Agriculture and Agrifood Canada. The Cabbage Root Maggot in Newfoundland and Labrador. Available at: http://res2.agr.ca/stjohns/mandate/cabbagemaggot-moucheduchou_e.htm.

Crop Profile for Rutabage in California, 2002.
Available at: http://pestdata.ncsu.edu/cropprofiles/docs/carutabaga.html

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

Name	Organization	Pest type	Specific pests	Type of research
L. Kott	University of Guelph, ON	Insect	Root maggot	Crossing rutabaga with resistant canola cultivars
R.H. Hallett	University of Guelph, ON	Insect	Swede midge, Pea leafminer, Cabbage Maggot	IPM methods for control
S. Goodfellow	University of Guelph, ON	Insect	Swede midge	Evaluation of insecticides and resistant varieties
V.I. Shattuck	Dept. of Horticultural Science, University of Guelph, ON	Disease	Powdery mildew	Evaluating control of powdery mildew for ontario rutabagas
Jim Chaput	Vegetable IPM Specialist/OMAF, ON	Insect & disease	Various	IPM strategies for pest control