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Crop Profile for Asparagus in Canada, 2012

Prepared by:

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Canada

Crop Profile for Asparagus in Canada, 2012

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Preface

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

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

For detailed information on growing asparagus, 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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Asparagus (*Asparagus officinalis*) is a member of the lily family (Liliaceae) and is the only cultivated vegetable in this family. It is a perennial, monocotyledonous plant grown for its tender green shoots (spears) that are harvested in the spring. This crop is highly prized for its delicate flavour, tender texture and for some of its 'medicinal' properties. Asparagus is a source of vitamins A, B and C.

Asparagus originated near the Mediterranean Sea and is grown in most temperate regions of the world. The culture of this crop dates back to 200 BC in the 'old world'. However, in the 'new world', production of this crop is only about 150 years old.

Crop Production

Industry Overview

Asparagus is the fastest growing fresh market vegetable commodity with respect to consumption on a per capita basis throughout all of North America. It is best known (and suited) as a fresh vegetable in the marketplace. However, this crop is also canned, frozen and pickled. The pickling of asparagus is mostly a cottage industry with limited markets. There is some white asparagus produced for the specialty markets by using a process of eliminating light so as to create a spear devoid of chlorophyll. There is increasing interest in organically grown asparagus, although weed pressure can be a serious problem in organic production.

Table 1. General production information

Canadian Production (2012)[1]	6,239 metric tonnes 1,737 hectares
Farm gate value (2012)[1]	$23 million
Fresh asparagus available for consumption in Canada 2012[2]	0.7 kg/ person
Export (2012)[2]	$7 million
	1,511 metric tonnes
Imports (2012)[2]	$88 million
	23,591 metric tonnes

[1]Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database). (Accessed: 2014-03-12)

[2]Agriculture and Agri-Food Canada. Statistical Overview of the Canadian Vegetable Industry, 2012. AAFC no. 12162E-PDF

Production Regions

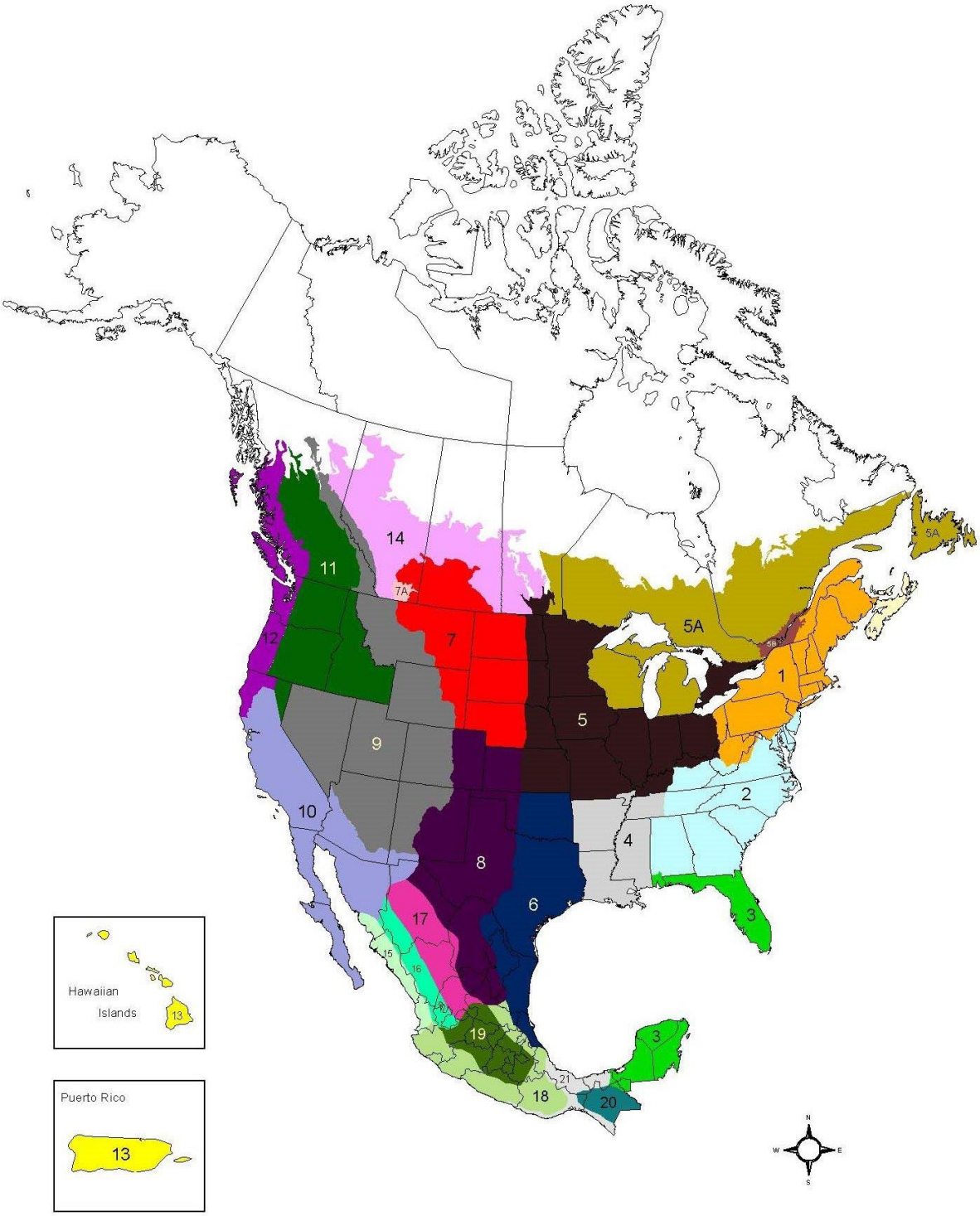
Seventy percent (1,214 ha) of the asparagus grown in Canada is grown in Ontario. Asparagus is also grown in Quebec (295 hectares or 17% of the national acreage), British Columbia (105 hectares or 6%) and Manitoba (89 hectares or 5%).

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

Production Regions[1]	Planted Area 2012 (hectares)	Percent National Production
British Columbia	105	6%
Manitoba	89	5%
Ontario	1,214	70%
Quebec	295	17%
Canada	1,737	100%

[1]Statistics Canada. Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database). (Accessed: 2014-03-12)

North American Major and Minor Crop Field Trial Regions



Scale 1 : 28 000 000

250 0 250 500 Kilometers

Lambert Conformal Conic Projection

Major and Minor Crop Field Trial Regions

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

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

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

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

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

Cultural Practices

Asparagus is best suited to soils that are deep, well-drained, porous and friable, such as a deep sandy-loam or muck soil. Heavy soils should be avoided as they can cause malformed spears, as can stony ground. In addition, heavy soils usually lack sufficient porosity for aeration and water drainage; asparagus plants do not like 'wet feet', which can contribute to disease problems. However, a high water table is desirable for the crop as water is nearer to the plant and its roots. In addition, there should not be a hard-pan or plough-layer that will interfere with root development. Asparagus is very deep-rooted, and roots can reach depths of 3 metres. Ideally, the organic matter content should be 3% or more.

Sites that are routinely subjected to late spring frosts should be avoided because of lost yield due to frost damage. The use of elevated sites that offer better air drainage will reduce the incidence of frost injury. Soils that have low weed pressure are also desirable.

The development of newer varieties and improved cultural practices have increased yields from 2,000 kg/ha to 3,000-4,000 kg/ha. This has resulted in continued, profitable growing of asparagus, despite higher production costs.

There are basically 2 types of asparagus: those that produce seeds and those that do not. The 'newer' and more recent asparagus introductions, mostly from New Jersey and those from the University of Guelph breeding program, are male hybrids. This means that the vast majority of plants within the field will be male and incapable of producing seed. The advantage of male hybrids is that there is no chance for 'volunteer' asparagus seedlings to develop and act as weeds, later competing for space, water and fertilizer. Male hybrids have been shown to be more productive than females, producing a higher percentage of #1 grade spears. One of the newer varieties in the marketplace is called 'Millennium', and is a result of the breeding program at the University of Guelph. This variety compares favourably with the variety 'Jersey Giant', the standard in the industry for the last several years, and to which comparisons are made. 'Millennium' is a male hybrid selected for its superior yield of marketable #1 grade spears cut at the 7"- 9" range. This variety consistently out-yields 'Jersey Giant' by about 40%; however, 'Millennium' is more prone to asparagus rust than 'Jersey Giant'.

Asparagus plantings will be in the ground for a number of years, so considerable care must be taken in site preparation. Troublesome perennial weeds must be eliminated prior to planting. Additions of considerable organic matter are also important in preparing the site. Based on soil testing, fertility adjustments should be done at this time and soil pH should be adjusted through lime applications if necessary. The ideal pH range for asparagus is 6.5 to 6.8.

Windbreaks should be established near new plantings where possible. This will prevent soil erosion from strong winds and therefore increase the efficacy of herbicides used.

Asparagus is a perennial crop, and is established by setting out 1 year-old crowns. These crowns are grown from seed sown into a nursery bed the previous year. Often, crowns are produced by asparagus growers who specialize in crown production.

The importance of planting good crowns cannot be over-emphasised. Crowns should weigh at least 30 g each, preferably up to 50 g. In addition, there should be a few dormant eyes of uniform size having a diameter of 15 mm, plus there should be evidence of several well-developed white roots fully intact. A vigorous asparagus plantation will only be as good as the crowns selected for planting.

Asparagus growers in Quebec are advised to plant crowns 15-20 cm deep with 30 cm between plants in the row and with row spacing of 1.3 - 1.7 metres. In Ontario, the recommendation is to plant the crowns 20 cm deep with spacing in the row between 20 and 30 cm and rows 120 to 150 cm apart. Planting should take place as soon as possible in the spring; however, soil temperatures should be at least 10°C.

Table 3. General asparagus production and pest management schedule in Canada

Time of Year	Activity	Action
April	Plant care	Cut old fern stubble with rotary or flail mower.
	Soil care	Apply broadcast fertilizer or disk in lime.
	Disease management	
	Insect & mite management	
	Weed management	Light disking prior to emergence of new shoots. Application of pre-emergent herbicides.
May	Plant care	Hand or machine-assisted harvest every two to three days.
	Soil care	
	Disease management	
	Insect & mite management	Insecticide applications to control asparagus beetles (if necessary).
	Weed management	Application of burn down herbicide to kill rye cover crops.
June	Plant care	Hand or machine-assisted harvest every two to three days.
	Soil care	Apply broadcast nitrogen fertilizer immediately after harvest.
	Disease management	Fungicide applications to control asparagus rust after last harvest.
	Insect & mite management	Insecticide applications to control asparagus beetle (if necessary).
	Weed management	Apply post–emergent herbicides after last harvest.
July	Plant care	
	Soil care	
	Disease management	Fungicide applications to control asparagus rust.
	Insect & mite management	Insecticide applications to control asparagus beetle or aphids if necessary.
	Weed management	Hand-hoeing (if necessary).
August	Plant care	
	Soil care	
	Disease management	Fungicide applications to control asparagus rust.
	Insect & mite management	Monitor for aphid infestations. Apply insecticides if necessary.
	Weed management	
September	Plant care	
	Soil care	
	Disease management	
	Insect & mite management	
	Weed management	Seed rye cover crops.
October	Plant care	Ferns clipped to 20 cm. for overwintering.
	Soil care	
	Disease management	
	Insect & mite management	
	Weed management	

Abiotic Factors Limiting Production

Frost Injury

Since asparagus is an early season crop, yield losses may result from late-spring frosts. The largest and most vigorous spears are the first to appear and if those are damaged by frost, a disproportionate amount of the yield can be lost. In addition to yield loss, the frost injured spears must be removed from the field resulting in additional expense. An early fall frost can kill or severely injure the asparagus fern before the natural senescence process takes place. This reduces the movement of carbohydrates down to the crown. These carbohydrates are important for the overall survival of the plant and are especially critical for spear production the next season.

Excessive Heat

Extreme or unseasonably warm temperatures can bring on the asparagus growth too fast, preventing the usual harvest practices to keep pace. High temperatures in the spring may also shorten the harvest season.

Hooking

Curvature of newly emerged asparagus stems is often caused by strong winds. Asparagus spears will curve into the prevailing wind because of reduced cell growth on the exposed side. Badly affected spears are usually culled while other, less severely injured spears are sold as ‘seconds’ at a reduced price. Strong winds can also cause sandblasting, which creates wounds on the tender asparagus shoots that serve as points of entry for disease.

Hollow Stem

Hollow stem is thought to be a result of extreme temperature fluctuations during the harvest season, which prevent adequate nutrient uptake. It is only a problem during the harvest season as it impacts the quality of the asparagus spears.

Diseases

Key issues

- Fungicide registrations for diseases such as asparagus rust and phytophthora spear rot need to be harmonized with the US to ensure Canadian growers have access to the same pest management tools.
- Pesticides applied to the fern after harvest or to asparagus seedlings in nurseries are considered non-food uses in the US but not in Canada. This has resulted in inconsistencies in registrations. There is a need to harmonize crop definitions between Canada and the US.
- There is a need for the registration of fungicides for the control of botrytis and phomopsis blights.
- Some fungicides used to control rust may stress plants and increase the likelihood of purple spot.
- Soils infested with fusarium crown rot cannot be replanted to asparagus for many years. Research is required to determine which crops can successfully be grown in such soils and the number of years to rotate out of asparagus.
- Asparagus viruses are often misdiagnosed as other problems or diseases.

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

Disease	Ontario	Quebec
Asparagus rust		
Botrytis blight (gray mould)		
Fusarium crown and root rot		
Phomopsis blight (stem blight)		
Phytophthora spear rot		
Purple spot (stemphylium spot)		
Virus diseases		

Widespread yearly occurrence with high pest pressure.

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

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

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

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

Pest not present.

Data not reported.

[1]Source: Asparagus stakeholders in reporting provinces.

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

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

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

…continued

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

Practice / Pest		Asparagus rust	Fusarium diseases	Phytophthora spear rot	Purple spot	Virus diseases
Monitoring	scouting - trapping					
	records to track diseases					
	soil analysis					
	weather monitoring for disease forecasting					
	use of portable electronic devices in the field to access pest identification/ management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	controlled atmosphere storage					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					

…continued

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

Practice / Pest		Asparagus rust	Fusarium diseases	Phytophthora spear rot	Purple spot	Virus diseases
Crop specific practice (province)	not planted in fields following corn (Quebec)					

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.

[1]**Source: Asparagus stakeholders in reporting provinces (Ontario and Quebec).**

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Soil application						
Bacillus subtilis strain QST 713	*Bacillus subtilis* and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	Phytophthora root rot (*Phythophthora* sp.)
Foliar application						
azoxystrobin	methoxy-acrylate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Purple spot (*Stemphylium vesicarium*)
Bacillus subtilis strain QST 713	*Bacillus subtilis* and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	Botrytis blight (*Botrytis cinerea*)
chlorothalonil	chloronitrile (phthalonitrile)	Multi-site contact activity	Multi-site contact activity	M5	RE	Purple spot (*Stemphylium vesicarium*), rust (*Puccinia asparag*i)
metiram	dithio-carbamate and relatives	Multi-site contact activity	Multi-site contact activity	M3	RE	Asparagus rust
myclobutanil	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Asparagus rust
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Rust (*Puccina asparagi*)

…continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Foliar application						
trifloxystrobin	oximino acetate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Stemphylium purple spot *(Stemphylium vesicarium*), rust (*Puccinia asparagi*), seed decay/ damping-off caused by *Rhizoctonia solani* and *Fusarium* spp.

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 6, 2014. 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.

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

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

Asparagus rust *(Puccinia asparagi)*

Pest information

Damage: Lesions develop on expanding shoots in early summer causing premature defoliation which weakens the plant and reduces yield. Spears are not directly affected as they are usually harvested before symptoms appear.

Life Cycle: Asparagus rust has a complicated life cycle consisting of several stages, all of which occur on asparagus. The fungus overwinters as teliospores on asparagus debris. Teliospores germinate in spring, producing small basidiospores, which are blown onto emerging shoots and cause infection. From April until July, small upraised, light green, oval lesions (patches) called aecia occur on the lower portion of infected fern stalks. Mature aecia release aeciospores that re-infect asparagus fern under suitable moisture conditions. Twelve to fourteen days after re-infection, upraised tan blisters called uredia appear on asparagus stalks and foliage. Uredia break open to expose masses of rusty-coloured spores called urediospores. Urediospores continually re-infect asparagus from June until September. Warm weather with heavy dew, fog, or light rainfall enhances rust development. Late in summer, telia develop, producing the overwintering black teliospores, completing the annual life cycle.

Pest management

Cultural Controls: It is important to monitor for rust after harvest to ensure timely treatments and to prevent the build-up of rust. Since the fungus over-winters on asparagus debris, removal of this debris by light discing or burning of fields early in spring, will help to minimize the disease. Field cultivation may be necessary to aerate the soil and control weeds.

Resistant Cultivars: Although currently available varieties have variable tolerance to rust, none are completely resistant.

Chemical Controls: Refer to table 6. "Fungicides and biofungicides registered for disease management in asparagus in Canada" for fungicides registered for the control of asparagus rust.

Issues for asparagus rust

1. Pesticide registrations for asparagus rust need to be harmonized with the US to ensure Canadian growers have access to the same pest management tools.
2. Some fungicides used to control rust may stress plants and increase the likelihood of purple spot. Research is needed to determine the best approach to controlling both diseases.

Botrytis blight (gray mold) (*Botrytis cinerea*)

Pest information

Damage: The fungus infects dying flowers or injured ferns and can cause extensive blighting, especially in the lower canopy. Lesions are tan with dark brown borders and yellow halos. Newly emerged spears may become completely blighted, turning brown to black. The disease is more severe during periods of moderately warm, humid weather and prolonged periods of leaf wetness, especially in crops with dense canopies with poor air circulation.

Life Cycle: Botrytis is a common, secondary invader of weakened or senescent plant tissues. Conidia are produced within infected tissues and are dispersed via air currents to susceptible tissues where they cause new infections. Botrytis also produces sclerotia that enable the long term survival of the fungus and that give rise to conidia that perpetuate the disease.

Pest management

Cultural Controls: Destroying infected crop residue will help reduce inoculum levels. Minimizing stresses and injuries caused by other diseases and pests will help reduce the development of botrytis blight.

Resistant Cultivars: None identified.

Chemical Controls: Fungicides used for rust control will provide some control of botrytis blight. Refer to table 6. "Fungicides and biofungicides registered for disease management in asparagus in Canada" for fungicides registered for the control of botrytis blight.

Issues for botrytis blight

1. There is a need for the registration of fungicides for the control of botrytis blight.

Purple spot *(Pleospora herbarium) (*anamorph *Stemphylium vesicarium)*

Pest information

Damage: This disease attacks the fern causing sunken lesions with brown centres and purple margins. If severe, the disease will cause the leaves to drop. Lesions on the spears decrease their marketability.

Life Cycle: This disease overwinters as pseudothecia on fern residue. Ascospores are released during cool, moist weather in the early spring and are dispersed by wind, often landing on the windward side of asparagus spears where they cause primary infections. Infections occur through stomata and also through wounds caused by sand blasting. The resulting lesions give rise to spores that cause new infections throughout the summer. No-till systems result in an increase in purple spot inoculum levels, but cultivated fields are more prone to sandblasting which favours infection.

Pest management

Cultural Controls: The removal or burying of crop residue will help to eliminate overwintering inoculum. The use of cover crops such as rye will help to reduce wounds due to sand blasting, which are important infection sites.

Resistant Cultivars: None identified.

Chemical Controls: Refer to table 6. "Fungicides and biofungicides registered for disease management in asparagus in Canada" for fungicides registered for the control of purple spot.

Issues for purple spot

1. Some fungicides used to control rust may stress plants and increase the likelihood of purple spot. Research is needed to determine the best approach to controlling both diseases.

Phomopsis blight (stem blight) (*Phomopsis asparagi*)

Pest information

Damage: Phomopsis blight causes sunken, elliptical lesions with gray centres on asparagus stems.

Life Cycle: Pycnidia develop in stem lesions.

Pest management

Cultural Controls: Destroying infested crop residues helps reduce inoculum levels.

Resistant Cultivars: None identified.

Chemical Controls: Foliar fungicide sprays used to control asparagus rust may also keep this disease in check.

Issues for phomopsis blight

1. There are no fungicides registered to control phomopsis blight.

Fusarium crown and root rot *(Fusarium oxysporum f.sp. asparagi, F. moniliforme)*

Pest information

Damage: Fusarium crown and root rot causes hollow and rotted feeder and storage roots and results in a visible reddish discoloration of infected tissues. Symptoms on the fern include stunting and wilting, yellow to brown discoloration of one or more stalks per crown and generally fewer stalks per crown. Infection usually occurs in patches throughout the field. Most commercial asparagus fields are in some stage of decline due to fusarium infestations

and over the life-time of an asparagus planting perhaps as much as 25% of the total yield will be lost before the field is ploughed out. Fusarium infestations are often mis-diagnosed.

Life Cycle: This is a soil-borne disease that is ubiquitous in Canadian asparagus growing regions. Fusarium can grow saprophytically in the soil. Fusarium colonizes old asparagus roots and crowns and can invade directly through root tips or wounds caused by tillage, harvesting knives or insect feeding.

Pest management

Cultural Controls: Since this disease is present in most soils, it is almost impossible to avoid. Maintaining vigorous plants through careful management, including the appropriate use of fertilizer and irrigation, preventing the over-harvesting of spears and generally avoiding stress on the crop, can minimize infection early in the life of crowns. Other disease management practices include appropriate site selection and reduced tillage and soil compaction. Replanting asparagus on sites that have grown asparagus previously should be avoided.

Resistant Cultivars: None identified.

Chemical Controls: Fungicides are generally ineffective. However, soil fumigation prior to planting, may reduce the amount of fusarium during the plant establishment period.

Issues for fusarium crown and root rot

1. Soils infested with the fusarium crown rot fungus cannot be replanted to asparagus for many years. Research is required to determine which crops can be successfully grown in such soils and the number of years to rotate out of asparagus.

Phytophthora spear rot (*Phytophthora asparagi*)

Pest information

Damage: Lesions develop on the spears near the soil line which lead to deterioration and rot of the spears. Saprophytic bacteria invade rotting tissues resulting in a bad odor.

Life Cycle: This disease is soil-borne and is more likely to develop during periods of prolonged, excessive soil moisture.

Pest management

Cultural Controls: Infected crop residues must be eliminated. Low areas and poorly drained soils must be avoided in asparagus production.

Resistant Cultivars: None identified.

Chemical Controls: None available.

Issues for phytophthora spear rot

1. Phytophthora has been observed infrequently in cool wet springs, but may be reducing yields in more fields than has been recognized.
2. There are no chemical fungicides registered to control phytophthora in Canada, although there are a number registered in the US. There is a need for the harmonization of fungicide registrations with the US.

Virus diseases: asparagus virus I and II (AV-I, AV-II); tobacco streak virus (TSV)

Pest information

Damage: Asparagus viruses reduce the vigour and yield of asparagus. When both AV-I and AV-II are present in the same plant, they can cause serious decline or even death. Tobacco streak virus causes stunting and reduced spear size.

Life Cycle: AV-I is spread by a number of aphids, but not the asparagus aphid. AV-II is seed-borne and likely pollen-borne and may be transmitted mechanically. Infected seed and thrips feeding are two manners by which TSV is transmitted.

Pest management

Cultural Controls: Controlling aphid populations will help reduce the spread of AV-I. The use of disease free planting stock will prevent the introduction of virus diseases to the field.

Resistant Cultivars: None identified.

Chemical Controls: None available.

Issues for asparagus virus I and II and tobacco streak virus

1. Asparagus viruses are often misdiagnosed as other problems or diseases.

Insects and Mites

Key issues

- Pesticides applied to the fern after harvest or to asparagus seedlings in nurseries are considered non-food uses in the US but not in Canada. This has resulted in inconsistencies in registrations. There is a need to harmonize crop definitions between the US and Canada.
- The registration of additional chemicals is required for the management of a number of insect pests on asparagus including asparagus beetles, plant bugs and thrips.
- Pesticide registrations must be harmonized with the United States to ensure Canadian growers have access to the same pest management tools.
- Little is known about economic thresholds or potential yield loss due to thrips feeding on asparagus.
- Research is required on the biology, impact and management of the asparagus leafminer.

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

Insect	Ontario	Quebec
Common asparagus beetle		
Spotted asparagus beetle		
Asparagus aphid		
Variegated cutworm and other cutworms		
Onion thrips		
Tarnished plant bug		
Alfalfa plant bug		
Asparagus miner		

Widespread yearly occurrence with high pest pressure.

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

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

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

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

Pest not present.

Data not reported.

[1]Source: Asparagus stakeholders in reporting provinces.

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

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

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

…continued

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

Practice / Pest		Asparagus beetle	Asparagus aphid	Cutworms	Alfalfa plant bug	Asparagus miner
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model (eg. degree day modelling)					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	beneficial organisms and habitat management					
	ground cover / physical barriers					
	pheromones (eg. mating disruption)					
	sterile mating technique					
	trapping					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Crop specific practice (province)	removal of eggs from spears (Quebec)					

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.

[1]**Source: Asparagus stakeholders in reporting provinces (Ontario and Quebec).**

Table 9. Insecticides and bioinsecticides registered for insect management in asparagus production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
acetamiprid	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	Asparagus aphid, asparagus beetle
carbaryl	Carbamate	Acetylcholinesterase inhibitors	1A	RES*	Asparagus beetle, cutworms (climbing)
cypermethrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	Asparagus beetle
deltamethrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	Asparagus beetle
dimethoate	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	Asparagus aphid
lambda-cyhalothrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	European asparagus aphid
malathion	Organophosphate	Acetylcholinesterase inhibitors	1B	R	Asparagus beetle
permethrin	Pyrethroid, pyrethrin	Sodium channel modulators	3A	RE	Cutworms: army, black, dark-sided, pale western, red-backed and white
potassium salts of fatty acids	Biological	Unknown	N/A	R	Aphids, mites, whiteflies

…continued

Table 9. Insecticides and bioinsecticides registered for insect management in asparagus production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
spinetoram	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Suppression of asparagus beetle
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	Asparagus beetle

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 6, 2014. 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.

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

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

Common asparagus beetle (*Crioceris asparagi*) and spotted asparagus beetle (*Crioceris duodecimpunctata*)

Pest information

Damage: Feeding by the adults of both species of beetles and the larvae of the common asparagus beetle can reduce the vigour of the asparagus. Severe defoliation can occur and potentially cause reduced yields in subsequent crops. Eggs laid on the spears in the early spring are unsightly and can result in the spears being culled. Larvae of the spotted asparagus beetle feed within the berries, reducing seed production.

Life Cycle: Crop residues provide overwintering sites for adults of both species of beetles. In the early spring, the adults begin to feed and lay eggs on newly emerged asparagus spears. The eggs hatch in 1-2 weeks and larvae feed for 3-4 weeks, before dropping to the ground to pupate. New adults emerge in late July and give rise to a second generation, which matures by September and overwinters.

Pest management

Cultural Controls: Allowing a row of asparagus to fern-out early in the season has been shown to be a good 'trap' for asparagus beetles. As beetles become concentrated on the more mature and 'luxuriant' plants, the individual row can be sprayed. This will minimize beetles in the rest of the field during harvest.

Resistant Cultivars: None identified.

Chemical Controls: A number of insecticides are available for the control of asparagus beetles. (Refer table 9: "Insecticides and bioinsecticides registered for insect management in asparagus production in Canada"). The rotation of insecticides is necessary to prevent resistance development.

Issues for common asparagus beetle

1. Since daily harvesting is necessary, insecticides are required with a one day pre-harvest interval. The registration of reduced risk insecticides, harmonized with the US, is required.

Variegated cutworm (*Peridroma saucia*) and other cutworms

Pest information

Damage: Cutworms feed on the growing tips of asparagus spears. Damaged spears are culled. Damage is more severe in early spring as spear growth is slow and there are fewer spears.

Life Cycle: Cutworms overwinter as partially grown larvae. They resume feeding in the spring and feed until early June before they pupate in the soil. The emerging cutworm moths lay

eggs from about late June until mid-August. The eggs hatch and the larvae feed on a variety of weeds, including some asparagus.

Pest management

Cultural Controls: None identified.

Resistant Cultivars: None identified.

Chemical Controls: Registered insecticides are listed in table 9: "Insecticides and bioinsecticides registered for insect management in asparagus production in Canada". Cutworm damage often first occurs at the field borders and can be minimized by spot spraying.

Issues for cutworms

None identified.

Asparagus aphid (*Brachycorynella asparagi*)

Pest information

Damage: Asparagus aphids feed on mature ferns after harvest causing the ferns to take on a dwarf, dense, "bonsai" appearance. Aphids inject a toxin as they are feeding that causes the dwarf appearance of the fern. The toxin also causes a proliferation of spears and weakening of the crown. Heavy infestations result in reductions in vigour and yield and eventual death of the plant. Plants weakened by aphid feeding are more susceptible to fusarium root and crown rot. Aphids may also be vectors of viruses.

Life Cycle: The asparagus aphid overwinters as eggs on asparagus debris. Stem mothers hatch from the eggs and produce female nymphs which mature and give rise to subsequent generations of female aphids. Aphid populations build up quickly as aphids give birth to live young. The build-up of aphid populations is also favoured by hot and dry weather. It is not until late summer and early fall that a generation of winged males are produced. Following mating, females lay overwintering eggs, completing the cycle.

Pest management

Cultural Controls: Lady bird beetles feed on aphids but do not provide complete control. As aphid numbers can increase rapidly in September, it is important to scout fields regularly throughout the growing season.

Resistant cultivars: None identified.

Chemical Controls: Registered insecticides are listed in table 9: "Insecticides and bioinsecticides registered for insect management in asparagus production in Canada".

Issues for asparagus aphid

1. It is difficult to scout for aphids and this pest is under-reported.

Plant bugs: tarnished plant bug (*Lygus lineolaris*) and alfalfa plant bug (*Adelphocoris lineolatus*)

Pest information

Damage: Tarnished plant bugs cause 'tip die-back' injury to the asparagus fern and to newly emerged spears during the post-harvest season. Yield losses as high as 10% have been reported. The injury is caused by adult and nymph feeding. During feeding, salivary enzymes are injected into the plant. The enzymes are toxic to asparagus and cause a collapse of the vascular tissue and death of the plant above the point of injury. The alfalfa plant bug can be present in nearby alfalfa fields and may migrate into asparagus if the alfalfa fields are cut and cause similar injury to that of the tarnished plant bug.

Life Cycle: Tarnished plant bugs overwinter as adults in sheltered sites. Adults become active in mid to late April with the onset of warm weather and begin to feed and lay eggs on a variety of hosts. There are at least 2 generations per year, with the 1st generation appearing about 2 months after the over-wintering adults become active. The life cycles differ between species.

Pest management

Cultural Controls: Good weed control in and around the asparagus planting will make the asparagus planting less attractive to plant bugs. Eliminating crop debris will reduce overwintering sites.

Resistant Cultivars: None identified.

Chemical Controls: Insecticide treatments for the control of asparagus beetle will also provide some control of plant bugs.

Issues for plant bugs

1. There are no insecticides registered for plant bugs on asparagus. There is a need for the registration of insecticides for the management of plant bugs and harmonization of registrations with the United States.

Onion thrips (*Thrips tabaci*)

Pest information

Damage: The onion thrips feeds on a variety of forage and vegetable crops and sporadically feeds on asparagus. Thrips have rasping mouthparts and suck the sap from plants. Their feeding can disfigure plants.

Life Cycle: Onion thrips overwinter as adults in plant debris and in living crops and weeds. They move into asparagus as soon as the spears emerge.

Pest management

Cultural Controls: None identified.
Resistant Cultivars: None identified.
Chemical Controls: Many of the products that control asparagus beetle also control thrips.

Issues for onion thrips

1. There are no pest control products registered for thrips on asparagus.
2. Little is known about economic thresholds or potential yield loss due to thrips feeding on asparagus.

Weeds

Key Issues

- There is a need for the harmonization of herbicide registrations with the United States to ensure Canadian growers have access to the same pest management tools.
- There is a need for the registration of herbicides with a 1 day pre-harvest interval for the control of annual grasses at harvest.
- There is concern about the spread of herbicide resistant weeds. There is an need for the registration of new herbicides with different modes of action to combat these weeds.
- Some perennial weeds are only suppressed and not controlled by herbicides registered for asparagus.

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

Weed	Ontario	Quebec
Annual grasses		
Annual broadleaf weeds		
Redroot pigweed		
Perennial grasses		
Quackgrass		
Perennial broadleaf weeds		
Broad-leaved plantain		
Colt's-foot		
Dandelion		
Field bindweed		
Other weeds		
Field horsetail		
Yellow nut sedge		

Widespread yearly occurrence with high pest pressure.

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

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

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

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

Pest not present.

Data not reported.

[1]Source: Asparagus stakeholders in reporting provinces.

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

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

Practice / Pest		Annual grasses	Annual broadleaf weeds	Perennial grasses	Perennial broadleaf 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 asparagus production in Canada[1] (continued)

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

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.

[1]**Source: Asparagus stakeholders in reporting provinces (Ontario and Quebec).**

Table 12. Herbicides and bioherbicides registered for weed management in asparagus production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
2,4-D	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	RES	Plantains, dandelion, curled dock, mustards, redroot pigweed, prostrate pigweed, Russian pigweed, common ragweed, shepherd's purse, lamb's-quarters, stinkweed, cocklebur, prickly lettuce, narrow-leaved hawk's beard (fall rosette or spring at 1-2 leaf stage), Russian thistle, sow thistle and seedling Canada thistle
diuron	Urea	Inhibition of photosynthesis at photosystem II	7	R	Seedlings of pigweed, ragweed, lamb's-quarters, crabgrass and foxtail
fenoxaprop-P-ethyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	Foxtail (green and yellow), barnyard grass, crabgrass, wild proso millet, fall panicum, old witch grass, volunteer corn
fluazifop-P-butyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	RES	Annual grasses; volunteer corn, Johnson grass, Persian darnel, barnyard grass, volunteer spring wheat and spring barley, wild oats, wild proso-millet, crabgrass, fall panicum, old witchgrass, green, yellow (wild millet) and giant foxtail, quackgrass, wirestem muhly
flumioxazin	N-phenylphthalimide	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	Redroot pigweed, green pigweed, common ragweed, lamb's-quarters, green foxtail, hairy nightshade, dandelion, eastern black nightshade, kochia, Canada fleabane
glufosinate ammonium	Phosphinic acid	Inhibition of glutamine synthetase	10	R	Common chickweed, green foxtail, lamb's-quarters, stinkweed, wild mustard, redroot pigweed, dandelion, oak-leaved goosefoot, wild buckwheat

…continued

Table 12. Herbicides and bioherbicides registered for weed management in asparagus production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
glyphosate	Glycine	Inhibition of EPSP synthase	9	RE	Non-selective; many weeds
linuron	Urea	Inhibition of photosynthesis at photosystem II	7	RE	Most annual grasses and common chickweed, corn spurry, goosefoot, groundsel, knotweed, kochia, lamb's-quarters, postrate pigweed, purslane ragweed, redroot pigweed, shepherd's purse, smartweed, wild buckwheat, wildradish, wormseed mustard; also seedlings of dandelion, plantain and sowthistle
MCPA	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	Most broadleaved weeds
mesotrione	Triketone	Bleaching:Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	Lamb's-quarters, redroot pigweed, velvetleaf, wild mustard, common ragweed (suppression only)
metribuzin	Triazinone	Inhibition of photosynthesis at photosystem II	5	R	Crabgrass, foxtail (yellow, green and giant), cheatgrass, fall panicum, witch grass, Johnson grass (seedling), barnyard grass (partial control), common chickweed, dandelion (seedling), lamb's-quarters, wild mustard, redroot pigweed, common ragweed, shepherd's purse, prickly mallow, lady's-thumb, yellow wood-sorrel, velvetleaf, green smartweed, Jimsonweed, Russian thistle, prostrate pigweed

…continued

Table 12. Herbicides and bioherbicides registered for weed management in asparagus production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
mineral spirits	Biological	Unknown	N/A	R	Seedling bluegrasses, chickweed, barnyard grass and other weeds
napropamide	Acetamide	Inhibition of cell division (Inhibition of VLCFAs)	15	R	Annual bluegrass, barnyard grass, foxtail, large crabgrass, sandbur, wild oats, chickweed, small-flowered mallow, annual sow-thistle, groundsel, pineapple weed, redroot pigweed, prickly lettuce, prostrate knotweed, purslane, storks bill, lamb's-quarters
paraquat	Bipyridylium	Photosystem-I-electron diversion	22		Many grasses and broadleaf weeds
sethoxydim	Cyclohexanedione 'DIM'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	Annual grasses, wild oats, volunteer cereals and quackgrass
simazine and related triazines	Triazine	Inhibition of photosynthesis at photosystem II	5	RES	Lady's-thumb, lamb's-quarters, purslane, ragweed, volunteer clovers, wild buckwheat, smartweed, barnyard grass, crabgrass, wild oats, yellow foxtail and most perennial species starting freshly from seed.
s-metolachlor	Chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs)	15	R	American nightshade, eastern black nightshade, crabgrass (smooth, hairy), barnyard grass, redroot pigweed (suppression only), fall panicum, foxtail (green, yellow, giant), old witchgrass, yellow nutsedge

…continued

Table 12. Herbicides and bioherbicides registered for weed management in asparagus production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
terbacil	Uracil	Inhibition of photosynthesis at photosystem II	5	R	Barnyard grass, bluegrass, crabgrass, foxtail, chickweed, downy brome (cheatgrass), perennial rye grass, wild barley, mustard, prickly lettuce, stinkweed, annual sow thistle, henbit, lamb's-quarters, pigweed, purslane, and ragweed; partial control of quackgrass, horsenettle and yellow nutsedge
trifluralin	Dinitroaniline	Microtubule assembly inhibition	3	RES	Wild oats (suppression), green and yellow foxtail (wild millet), barnyard grass, crabgrass, bromegrass, cheat, stinkgrass, goosegrass, annual bluegrass, Persian darnel, wild buckwheat (suppression), cowcockle, pigweed, lamb's-quarters, Russian thistle, chickweed, purslane, knotweed and carpetweed

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 11, 2014. 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.

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

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

Annual grasses

Pest information

Damage: Annual grasses compete for water and nutrients with the asparagus crop.

Life Cycle: Annual grasses germinate from seeds once soil temperatures have warmed in the spring. They grow vegetatively, flower and produce seeds in one season.

Pest management

Cultural Controls: Dead, rye cover crop mulch prevents a certain amount of sunlight from reaching the soil surface and therefore prevents the germination of some annual grass seeds. Tillage is used in many cases early in the year to remove last year's plant stubble and to eliminate overwintering weeds and those weeds that are newly germinating. Tillage is not generally used where a rye cover crop is grown. Some hand hoeing may be used to control annual grasses.

Chemical Controls: Pre-plant or pre-emergent herbicides will control most grass seedlings. Any grass seedlings which germinate are controlled with post emergent grass herbicides. Glyphosate, used to kill rye cover crops will also control newly germinated seedling grasses. Refer table 12. Herbicides and bioherbicides registered for weed management in asparagus production in Canada".

Issues for annual grasses

1. Annual grasses are often a problem during harvest in June when tillage cannot be used to control weeds. A number of grass herbicides with short pre-harvest intervals are available in the US. There is a need to register these herbicides for use in Canada and harmonize registrations with the US.

Annual broadleaf weeds

Pest information

Damage: Broadleaf weeds compete with the asparagus crop for nutrients and moisture.

Life Cycle: Broadleaf weeds are often divided into winter annuals and summer annuals. Winter annuals are those weeds that germinate in the fall and over winter in a vegetative state, flower in the spring, form seeds and then die. Summer annuals germinate in the spring, flower and fruit in the summer or fall and die before the onset of winter.

Pest management

Cultural Controls: Rye is seeded into the asparagus crop in the fall of the year (September) and is "burned off" in the spring with an application of glyphosate. This practice may also kill winter annuals present, but more importantly the dead rye mulch reduces the amount of sunlight reaching the soil surface and reduces the germination of some spring annual seeds.

Tillage can be used early in the year to remove crop stubble from the previous season and eliminate weeds. However tillage that is too deep will cut into the asparagus crowns and provide an entry point for disease organisms. Tillage is not generally used where a rye cover crop is planted. Some hoeing and hand pulling are used to control annual broadleaf weeds.

Resistant Cultivars: None available.

Chemical Controls: Pre-plant incorporated (PPI) applications of herbicides are best suited for the control of summer annuals. Contact herbicides are best suited to control winter annuals. Registered herbicides are listed in table 12: ". Herbicides and bioherbicides registered for weed management in asparagus production in Canada".

Issues for annual broadleaf weeds

1. Problems due to herbicide resistant weeds are increasing. There is a need for the registration of new herbicides with different modes of action to combat these weeds.

Perennial grasses

Pest information

Damage: Perennial grasses compete with asparagus for moisture and nutrients.

Life cycle: Perennial grasses reproduce by underground tillers or rhizomes and seed. Their numbers can build up over time in asparagus plantings due to the perennial life (up to 20 years) of the crop. Tillage equipment can spread perennial grasses.

Pest management

Cultural Controls: None available.

Resistant Varieties: None available.

Chemical Controls: Contact, non-selective or herbicides are primarily used to control perennial grasses. Repeated applications may be necessary to provide control.

Issues for perennial grasses

1. Registered herbicides may not provide the required control.

Perennial broadleaf weeds

Pest information

Damage: Perennial broadleaf weeds compete with asparagus for moisture and nutrients.

Life Cycle: Perennial weeds live for many years. Perennials can regenerate from roots, shoots and other structures and can reproduce both vegetatively and through seed.

Pest management

Cultural Controls: Tillage is often used to eliminate stubble from the previous season. However, tillage can spread creeping perennials.

Resistant cultivars: None available.

Chemical Controls: Registered herbicides are listed in table 12: "Herbicides and bioherbicides registered for weed management in asparagus production in Canada".

Issues for perennial broadleaf weeds

1. Some perennial broadleaf weeds are only suppressed and not controlled by herbicides registered for asparagus. High populations of persistent perennial weeds, particularly field bindweed (*Convolvulus arvensis*) may require the removal of the asparagus planting.

Resources

IPM/ICM resources for production of asparagus in Canada

Websites

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

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

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

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

Publications

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

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

Guide to Weed Control 2012-13 OMAF Publication 75
http://www.omafra.gov.on.ca/english/crops/pub75/pub75toc.htm

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

Ontario Vegetable Crop Protection Guide (2012-13) OMAF Publication 838^{E}; 2013 Supplement (838S)
http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Elaine Roddy elaine.roddy@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	Pierrot Ferland pierrot.ferland@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca

National and Provincial Vegetable Grower Organizations

Provincial

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

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

Ontario Asparagus http://www.asparagus.ca

National

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

Appendix 1

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th><td></td></tr>
<tr><td rowspan="5">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented</td><td>Yellow</td></tr>
<tr><td rowspan="2">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="5">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>Black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>Grey</td></tr>
</table>

References

British Columbia Ministry of Agriculture. *B.C. Farm Products A-Z Asparagus.* http://www.agf.gov.bc.ca/aboutind/products/plant/aspargus.htm

Foster, Rick and Brian Flood. 1995. *Vegetable Insect Management -With Emphasis on the Midwes*t. Meister Publishing Company, Willoughby, Ohio.

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

Ohio State University. Ohio State University. *Bulletin #826 Asparagus Production, Management & Marketing*. http://ohioline.osu.edu/b826/

Washington State University Bulletin # EB0997. 1982. *Washington Asparagus Production Guide*. https://openlibrary.org/works/OL12215944W/Washington_asparagus_production_guide

Robb, A. R. 1984. *Physiology of asparagus (Asparagus officinalis) as related to the production of the crop.* New Zealand Journal of Experimental Agriculture Vol. 12(3): 251-260