Crop Profile for Raspberry in Canada, 2016

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Agriculture and Agri-Food Canada   Agriculture et Agroalimentaire Canada

Canada

Third Edition – 2019
Crop Profile for Raspberry in Canada, 2016
Catalogue No.: A118-10/18-2016E-PDF
ISBN: 978-0-660-29359-2
AAFC No: 12889E

Second Edition – 2016
Crop Profile for Raspberry in Canada, 2013
Catalogue No.: A118-10/18-2013E-PDF
ISBN: 978-0-660-04528-3
AAFC No.: 12483E

First Edition –2007
Crop Profile for Raspberry in Canada
Catalogue No.: A118-10/18-2007E-PDF

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

Paru également en français sous le titre: « Profil de la culture de la framboise au Canada, 2016 »

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

Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

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

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

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

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

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Contents

Crop Production....1
Industry Overview....1
Production Regions....2
North American Major and Minor Field Trial Regions....3
Cultural Practices....5
Abiotic Factors Limiting Production....8
Moisture....8
Frost....8
Nutrient Imbalance....8
Diseases....9
Key issues....9
Botrytis Diseases: Grey mould, Fruit Rot, Cane Blight and Wilt *(Botrytis cinerea)*....14
Spur Blight (*Didymella applanata*)....15
Cane Blight (*Leptosphaeria coniothyrium*)....15
Anthracnose or Cane Spot (*Elsinoe veneta* and *Colletotrichum* spp.*)*....16
Yellow Rust (*Phragmidium rubi-idaei*)....17
Late Yellow Rust (*Pucciniastrum americanum*)....18
Fire Blight (*Erwinia amylovora*)....18
Bacterial Blight (*Pseudomonas syringae pv. syringae*)....19
Verticillium Wilt (*Verticillium dahliae* and *V. albo-atrum*)....20
Phytophthora Root Rot *(Phytophthora fragariae var. rubi* and *P. cinnamomi)*....20
Crown Gall (*Agrobacterium tumefaciens*)....21
Virus Diseases: Raspberry Bushy Dwarf Virus (RBDV), Raspberry or Tomato Ringspot Virus (ToRSV)....22
Nematodes: Root Lesion (*Pratylenchus* spp.), Dagger (*Xiphinema* spp.), Sting *(Belonolaimus* spp.*)*....23
Fungicides, bactericides and biofungicides registered for disease management in raspberry production in Canada....24
Insects and Mites....31
Key issues....31
Aphids: Small Raspberry Aphid (*Aphis rubicola*) and Large Raspberry Aphid (*Amphorophora agathonica*)38
Leafhoppers....38
Potato Leafhopper (*Empoasca fabae*)....39
Tarnished Plant Bug (*Lygus lineolaris*) and other *Lygus* spp.....39
Thrips (*Thysanoptera*)....40
Spider Mites: Two-Spotted Spider Mite (*Tetranychus urticae*) and McDaniel Spider Mite (*T. mcdanieli*)....40
Caterpillars: Obliquebanded Leafroller (OBLR) (*Choristoneura rosaceana*), Cabbage Looper (*Trichoplusia ni*) and Bruce Spanworm (*Operophtera bruceata*)....41
Climbing Cutworms: Bertha Armyworm (*Mamestra configurata*) and Variegated Cutworm (*Peridroma saucia*)....42
Fruitworms: Raspberry Fruitworm (*Byturus unicolor*) and Western Raspberry Fruitworm (*Byturus bakeri*).43
Raspberry Sawfly (*Monophadnoides geniculatus*)....43
Raspberry Crown Borer (*Pennisetia marginata*)....44
Rednecked Cane Borer (*Agrilus ruficollis*)....44
Raspberry Cane Borer (*Oberea bimaculata*)....45
Raspberry Cane Maggot (*Pegomya rubivora*)....45
Raspberry Bud Moth (*Lampronia corticella*)....46
Sap Beetles (*Coleoptera: Nitidulidae*)....46
Spotted Wing Drosophila (*Drosophila suzukii*)....47
Weevils: Black Vine Weevil (*Otiorhynchus sulcatus*), Clay Coloured Weevil (*Otiorhynchus singularis*), Strawberry Root Weevil (*Otiorhynchus ovatus*), and Obscure Weevil (*Sciopithes obscurus*)....48
Strawberry Bud (Clipper) Weevil (*Anthonomus signatus*)....49
White Grubs: Japanese Beetle (*Popillia japonica*) and European Chafer (*Rhizotrogus majalis*)....49

Redheaded Flea Beetle (*Systena frontalis*) 50
Harvest Contaminants 50
Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in raspberry production in Canada 51
Weeds 57
Key Issues 57
Weeds 60
Herbicides and bioherbicides registered for weed management in raspberry production in Canada 61
Vertebrate Pests 66
Resources 67
Integrated Pest Management / Integrated Crop Management Resources for Production of Raspberry in Canada 67
Provincial Crop Specialists and Provincial Minor Use Coordinators 68
National and Provincial Small Fruit Grower Organizations 69
Appendix 1 70
References 71

List of Tables and Figure

Table 1. General production information, 2016 2
Table 2. Distribution of raspberry production in Canada, 2016 3
Table 3. Summer and fall bearing raspberries production and pest management schedule in Canada 6
Table 4. Occurrence of diseases in raspberry production in Canada 10
Table 5. Adoption of disease management practices in raspberry production in Canada 11
Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada 25
Table 7. Occurrence of insect and mite pests in raspberry production in Canada 32
Table 8. Adoption of insect pest management practices in raspberry production in Canada 34
Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada 52
Table 10. Occurrence of weeds in raspberry production in Canada 57
Table 11. Adoption of weed management practices in raspberry production in Canada 58
Table 12. Herbicides and bioherbicides registered for weed management in raspberry production in Canada 62
Table 12. Herbicides and bioherbicides registered for weed management in raspberry production in Canada 64

Figure 1. Common zone map: North American major and minor field trial regions 4

Crop Profile for Raspberry in Canada

Raspberries (*Rubus* spp.) are members of the Rosaceae (rose) family. Raspberries have been cultivated for many centuries, and by the 19^{th} Century, there were more than 20 cultivars of red raspberries in cultivation in England and North America. Although raspberry species produce fruit of various shades of red, black, yellow and purple, red raspberries (*Rubus idaeus* L.) make up the major portion of the commercial crop. Raspberries are consumed fresh, frozen, or processed in jam, juice, yogurt and wine. Individually quick-frozen (IQF) raspberries are the premium quality and priced product and consumer demand for this product type continues to grow. Red raspberries contain ellagic acid, a potent anti-carcinogenic and anti-mutagenic compound and are used in the formulation of a variety of natural health promoting products. Raspberries are also rich in Vitamin C, iron and calcium.

Crop Production

Industry Overview

Globally, Canada is a minor raspberry producer, responsible for just 2% of world production. Canada produced 11,670 metric tonnes of raspberries in 2016, a decrease over the two previous years. Production area was 2,314 hectares for a total farm value of $38 million (Table 1). British Columbia produces approximately 80% of the raspberries grown in Canada. Most raspberries are exported frozen mainly to the American market. Both summer and fall bearing raspberries are grown in Canada. The latter are grown in a high-tunnel production with adapted cultivars. This is gaining in popularity as it enables an extended production season, and shows some promise for reduced use of pest management products. Organic production is on the rise representing about 10% of the total Canadian raspberry acreage.

Table 1. General production information, 2016

	Raspberries
Canadian production[1]	11,670 metric tonnes 2,314 hectares
Farm gate value[1]	$38.0 Million
Fruit consumption[2]	0.40 kg/ person (fresh equivalent)
Exports	Fresh and Frozen[3]: $12.9 Million
Imports	Fresh and Frozen[3]: $372.9 Million

[1] Source: Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009) - Area, production and farm gate value of fresh and processed fruits, by province (database accessed: 2018-11-23).

[2] Source: Statistics Canada. Table 32-10-0054-01 (formerly CANSIM 002-0011) - Food available in Canada (database accessed: 2018-11-23).

[3] Source: Statistics Canada. Canada. CATSnet, February 2017.

Production Regions

Raspberries are produced commercially in all provinces of Canada. The greatest planted area is in British Columbia with 1,289 ha (56% of national area of production), with Quebec (516 ha or22%) and Ontario (200 ha, 13%) responsible for most of the remaining hectares (see Table 2). Most commercial production of raspberries in British Columbia occurs in the Fraser Valley. It is worth noting that British Columbia produces a disproportionately high share of the crop (80% of national production). British Columbia production is based on about ten varieties of raspberries, with Meeker the dominant one.

Table 2. Distribution of raspberry production in Canada, 2016

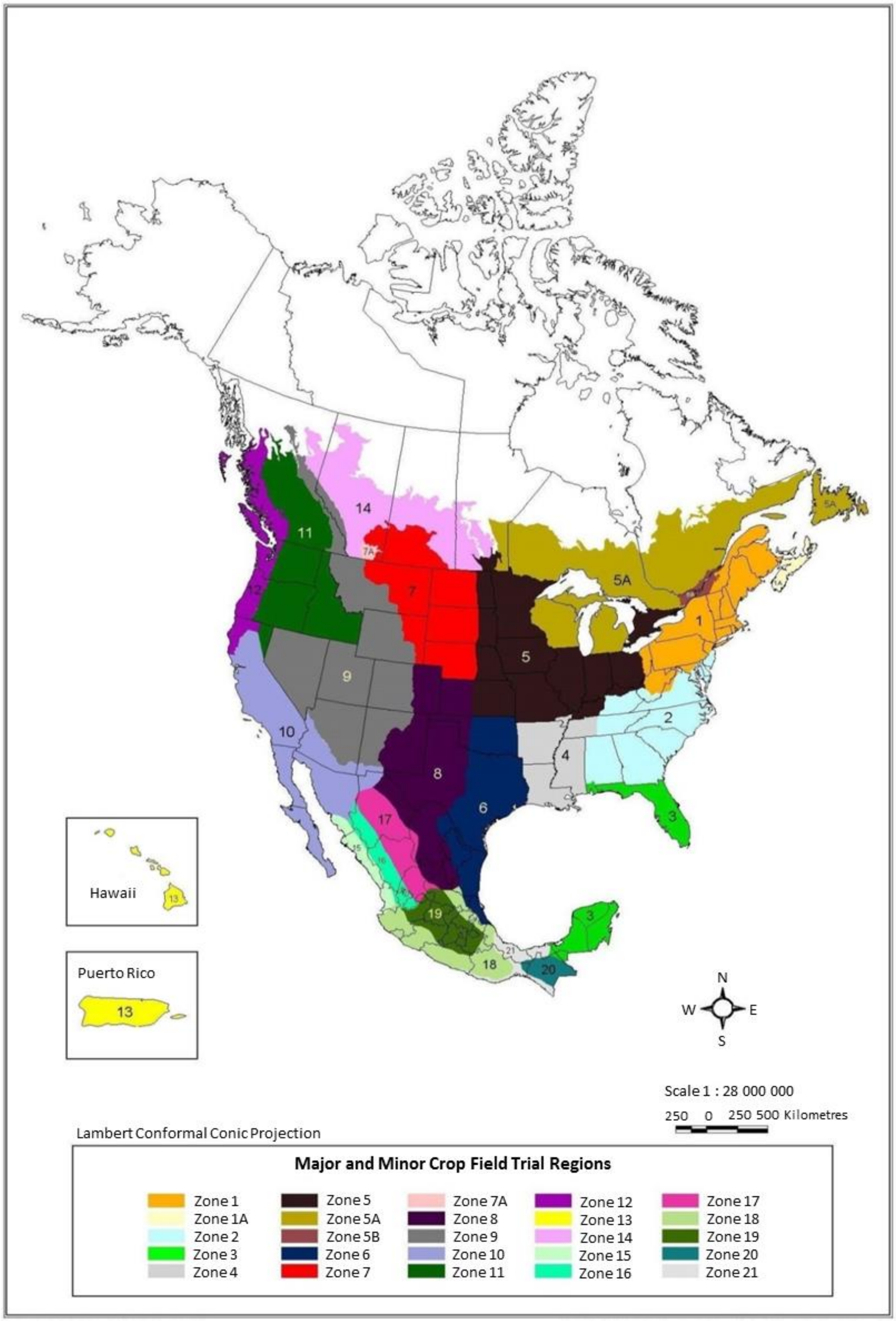
Production Regions	Cultivated area[1] (hectares) and percentage ( )	Marketed production[1] (metric tonnes) and percentage ( )	Farm gate value[1] ($)
	Raspberries		
British Columbia	1,289 ha (56%)	9,040 m. t. (78%)	$20.74 Million
Ontario	299 ha (13%)	962 m. t. (8%)	$6.85 Million
Quebec	516 ha (22%)	1,362 m. t. (12%)	$8.21 Million
Canada	2,314 ha	11,670 m. t.	$37.95 Million

[1] Source: Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009)-Area, production and farm gate value of fresh and processed fruits, by province (database accessed: 2018-11-23).

North American Major and Minor Field Trial Regions

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 (EPA) to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate but they do not correspond to plant hardiness zones. For additional information, please consult the PMRA Regulatory Directive 2010-05: *Revisions to the Residue Chemistry Crop Field Trial Requirements*.

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



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

Cultural Practices

Raspberries have a perennial crown and root system, with a biennial cane system. In the spring, buds on the roots give rise to new canes called primocanes. Primocanes remain vegetative throughout the first season. In the second year, the primocanes become floricanes, as they produce flower buds and fruits. In fall fruiting or everbearing raspberries, primocanes produce fruit late in the first season. The average lifespan of a raspberry planting is seven to ten years.

Raspberries do best on loam or sandy-loam soils that are slightly acidic (pH 5.8 to 6.5). Raspberries can also be grown on sandy or gravelly soils, but careful management of water and nutrients is required as these soils do not hold water or nutrients well. Roots are highly susceptible to drought stress during dry periods and to overwatering and flooding which can predispose them to rot, resulting in poor yields and a shortened lifespan of the planting. Thus, drainage is important for optimum production of the planting, and a sub-surface drainage system may be necessary on fields with poor natural drainage, such as clay-loam soils. Planting new raspberries into these soils can be done on 25-30 cm raised beds which improve drainage and reduce the risk of root rots.

Soil testing for nutrients, pH and pest species of nematodes, conducted the year prior to planting, will ensure sufficient time to implement necessary corrective measures such as amendments or cover crops. If used, some cover crops may be disked into the soil in time to allow for decomposition before planting in the spring. Permanent cover crops, which may be used for soil health and weed management, are more typically mowed in the spring. Limestone may be broadcast in the fall prior to cover crop planting, or in the spring before planting, if the soil pH is lower than 5.5.

Certified planting stock is used in new plantings to reduce the risk of introducing nematodes, viruses, root rot and other pests and diseases into the field. Varieties are selected based on fruit quality, disease resistance, harvest maturity time, suitability for hand or mechanical harvest and suitability for the fresh or processing market.

There is growing interest in the use of high tunnels for increased raspberry production. High tunnels are large hoop houses covered with plastic, the ends and sides of which can be raised or lowered to regulate temperature. Raspberry plants may be planted directly in the ground or in large pots or bags under these tunnels. High tunnels provide the benefit of extending the growing season for raspberries resulting in improved fruit yields and quality. As the high tunnels create a microclimate for the raspberry canes, the spectrum of diseases and pests under the tunnels will vary from that observed in the field.

Table 3. Summer and fall bearing raspberries production and pest management schedule in Canada

Time of Year / Plant Stage	Activity	Action
January - Plants dormant	Plant care	Prune canes (BC).
February Plant tops dormant; roots becoming active (BC); plants dormant (QC, ON)	Plant care	Top canes if necessary. Chop prunings. Set-out new plantings (BC).
	Soil care	Spring soil test; apply manure, if used. Incorporate manure and lime in sites of new plantings (BC).
	Weed management	Apply herbicide for weeds within rows (BC).
March Buds starting to swell and open, , new canes and fruiting laterals (BC); plants dormant (QC, ON)	Plant care	Complete all pruning and topping of canes and chopping of prunings. Continue planting (BC). Remove first flush of primocanes by "shoot burning" (BC). Hand prune or mow (ON).
	Disease management	If field has history of spur blight, apply pre-bloom fungicide. Apply delayed dormant spray for cane diseases and yellow rust. Apply spray for bacterial blight control. Monitor for phytophthora root rot, spur blight, cane blight and botrytis cane wilt (BC).
	Insect & mite management	Drench crowns for crown borers, as needed. Monitor for climbing cutworms and clay coloured weevils. Apply controls as needed (BC).
April – early May New canes and fruiting laterals (BC); buds start to swell and open, roots become active (QC, ON);	Plant care	Remove first flush of primocanes by "shoot burning" (BC). Apply granular fertilizer. Continue hand pruning or mowing (ON).
	Soil care	Apply commercial fertilizer; fertilize new plantings, as necessary (BC, QC). Prepare land for planting and plant as soon as possible (ON, QC).
	Disease management	Monitor for root rot, spur blight, cane blight, cane wilt and yellow rust. Apply copper for bacterial blight, as needed. Apply fungicide for yellow rust and root rot, as needed (BC, QC). Apply delayed dormant spray of lime sulfur for cane diseases (ON, QC).
	Insect and mite management	Continue monitoring for climbing cutworms and clay coloured weevils. Monitor for leafrollers and western raspberry fruitworm. If insecticides are needed, apply before bloom to protect bees. Treat for cutworms, as needed (BC). Drench or soak crowns for crown borers, as needed. Monitor for climbing cutworms and clay coloured weevils and. apply controls if needed (QC).
	Weed management	Cultivate between rows. Apply treatments for quackgrass control, as needed (BC). Apply pre-emergent herbicide (ON).
May Start of flowering (BC); new canes & fruiting laterals; start flowering at end of May (QC); bud swell and leafing out (ON)	Plant care	Apply foliar feed sprays for micronutrients as needed. Irrigate as needed. Place honeybees in field at the start of flowering. Apply boron or magnesium as needed (QC). Install post and wire trellises in new plantings.
	Disease management	Continue monitoring for yellow rust. Apply fungicide for yellow rust and spur blight, as needed. Apply fungicides for botrytis fruit rot control (BC). Prune-out canes affected by anthracnose and spur blight (QC). Apply delayed dormant spray for cane diseases (ON).
	Insect and mite management	Continue monitoring for clay coloured weevils, leafrollers, and western raspberry fruitworm. Begin monitoring for black vine weevil, mites, spotted wing drosophila and predators. (ON, QC). Remove canes affected by mites and borers (QC). Apply insecticides as necessary (ON, QC).

…continued

Table 3. Summer and fall bearing raspberries production and pest management schedule in Canada (continued)

Time of Year / Plant Stage	Activity	Action
June Bloom to Harvest	Plant care	Foliar feed as required; Irrigate as needed. Begin harvest (BC). Suppress primocanes in biennial systems (ON).
	Disease management	Monitor for cane wilt. Apply fungicide for cane wilt, fruit rot, as needed (BC).
	Insect and mite management	Continue monitoring for leafrollers, western raspberry fruitworm, black vine weevil, mites, spotted wing drosophila and predators. Apply sprays if needed, observing required PHI; monitor for sawfly, leafrollers and mites (ON).
Late June to early August (and beyond, for fall bearing raspberries) Harvest	Plant care	Harvest fruit. Irrigate if necessary.
	Disease management	Continue fruit rot sprays, as needed. Monitor primocanes for spur blight. Monitor for cane wilt and spot mould (fruit) during rainy seasons.
	Insect and mite management	Continue monitoring for mites, spotted wing drosophila and arthropod predators. Apply controls for spotted wing drosophila, weevils, leafrollers and cutworms if harvest contamination is a problem, observing required PHI
August Harvest (QC); after harvest (BC)	Plant care	Irrigate to maintain growth in new canes. Apply foliar sprays, as needed. Apply foliar boron, if needed. Test for nitrates post-harvest.
	Soil care	Alleviate soil compaction that occurred during harvest. Prepare soil for cover crop, if using.
	Disease management	Remove floricanes to improve air circulation. Implement cultural controls if root rot was problematic. Apply fungicides for spur blight, as needed.
	Insect and mite management	Continue monitoring for mites and predators and application of controls if needed.
September After harvest	Plant care	Irrigate as needed. Start pruning floricanes (QC).
	Soil care	Plant fall (cereals) cover crops. Loosen compacted soil to improve winter drainage. Install drainage in new fields, as required. Collect soil samples for fall nutrient analysis.
	Disease management	Continue cultural controls for root rot, as needed. Fumigate new plantings.
	Insect and mite management	Continue monitoring for mites and predators and apply controls as needed. Apply insecticide for crown borer, as needed.
	Weed management	Mow or cultivate as needed.
October Pre-dormancy	Plant care	Begin pruning of floricanes.
	Soil care	Collect soil samples for fall nutrient analysis.
	Disease management	Apply fungicide for root rot control, as needed. Apply controls for bacterial blight, as needed.
	Insect and mite management	Apply spray for crown borer, as needed.
	Weed management	Apply fall and early winter herbicides, as needed. Eliminate tall weeds and grass to discourage mice.
November & December Plants becoming dormant	Plant care	Continue pruning of floricanes. Remove weak or unwanted primocanes. Mow fruiting canes in a biennial system once plants are dorman.t
	Weed management	Apply early winter or pre-emergent herbicides, as needed.

Abiotic Factors Limiting Production

Moisture

Water management is a critical factor in raspberry production. Poor drainage and periodic flooding are major contributing factors to phytophthora root rot disease. However, coarse, sandy soils suitable for raspberry production can also dry out quickly in the summer. Drought can lead to stressed plants, resulting in small berries and reduced yields, while overwatering may result in leaching of nutrients and root rot.

Frost

Frost injury increases the susceptibility of raspberries to cane and shoot dieback caused by pseudomonas and vice versa. Excess nitrogen in the fall increases the likelihood of frost injury and damage from pseudomonas bacterial blight in the spring. Severe frosts can also kill new primocanes in spring.

Nutrient Imbalance

Magnesium, boron, and calcium levels are often low in coarse, sandy soils. Magnesium deficiencies cause interveinal areas of leaves to become yellow and red, eventually resulting in leaf death, starting with older leaves. Symptoms of boron deficiency include uneven bud break in the spring, downward cupping of leaves, death of the terminal bud on new canes and crumbly fruit and narrowing of new leaves in late summer. Calcium deficiencies result in slow growth, dieback of the terminal growth and spotting of leaves. Phosphorus deficiencies can cause purpling and reddening of new leaves in early spring. This is more severe in cold, wet years, but the plants generally overcome these symptoms as the weather warms up.

Diseases

Key issues

- Phytophthora root rot is a serious disease affecting raspberry production in Canada. There is a need for the development of an integrated approach for the management of this disease. In addition, there is a need for the registration of alternative fungicides for resistance management strategies, and for user-friendly fumigation products pre- and post- planting for the management of phytophthora root rot.
- The development of new cultivars with resistance to Raspberry Ringspot Virus and Raspberry Bushy Dwarf Virus is required. There is a need for a fungicide with multi-site activity for the management of Botrytis. There is concern over the possible loss through re-evaluation of captan, a fungicide with multi-site activity. Resistance to several commonly used fungicide groups is developing world wide. Surveys are needed to determine the extent of this problem in Canada and to track efficacy of fungicides over time. In addition, growers need access to diagnostic tools to determine which fungicides are no longer useful due to resistance on their farm.
- Cane pathogens causing various blights are very challenging to control in raspberry. The fungicides available do not provide adequate control. There is a need for research on the biology of spur blight and cane blight to facilitate the development of effective approaches to the management of these diseases.
- Anthracnose causes very serious losses from the cane blight and the fruit rot phases of the disease in Quebec. There are no effective controls available. There is a need for the registration of reduced risk fungicides and the development of an effective approach to the management of this disease.
- There is a need for research or evaluation of cost-effective nematicides and application techniques.

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

Disease	British Columbia	Ontario	Quebec
Grey mould			
Spur blight			
Cane blight			
Anthracnose or cane spot			
Raspberry leaf spot			
Rusts			
Yellow rust			
Late yellow rust			
Fire blight			
Bacterial blight			
Verticillium wilt			
Phytophthora root rot			
Crown gall			
Virus diseases			
Nematodes			
Root lesion nematode			

Widespread yearly occurrence with high pest pressure.
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.
Pest is present and of concern, however little is known of its distribution, frequency and pressure.
Pest not present.
Data not reported.

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

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

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

Practice / Pest		Botrytis diseases	Phytoph-thora root rot	Spur blight	Anthracnose (cane spot)	Rusts	Fire blight
Avoidance	Varietal selection / use of resistant or tolerant varieties						
	Planting / harvest date adjustment						
	Rotation with non-host crops						
	Choice of planting site						
	Optimizing fertilization for balanced growth and to minimize stress						
	Minimizing wounding and insect damage to limit infection sites						
	Use of disease-free propagative materials (seed, cuttings or transplants)						
Prevention	Equipment sanitation						
	Canopy management (thinning, pruning, row or plant spacing, etc.)						
	Manipulating seeding / planting depth						
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth						
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)						
	End of season or pre-planting crop residue removal / management						
	Pruning out / removal of infected material throughout the growing season						
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity						

…continued

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

Practice / Pest		Botrytis diseases	Phytoph-thora root rot	Spur blight	Anthracnose (cane spot)	Rusts	Fire blight
Monitoring	Scouting / spore trapping						
	Maintaining records to track diseases						
	Soil analysis for the presence of pathogens						
	Weather monitoring for disease forecasting						
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases						
Decision making tools	Economic threshold						
	Use of predictive model for management decisions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed disease symptoms						
	Use of portable electronic devices in the field to access pathogen / disease identification / management information						

...continued

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

Practice / Pest		Botrytis diseases	Phytoph-thora root rot	Spur blight	Anthracnose (cane spot)	Rusts	Fire blight
Suppression	Use of diverse product modes of action for resistance management						
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen populations						
	Biopesticides (microbial and non-conventional pesticides)						
	Controlled atmosphere storage						
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)						
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms						
New practices (by province)	Modified atmosphere storage (Ontario)						

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

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

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

Information regarding the practice for this pest is unknown.

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Botrytis Diseases: Grey mould, Fruit Rot, Cane Blight and Wilt *(Botrytis cinerea)*

Pest Information

Damage: This fungus infects blossoms and fruit resulting in mouldy and dried berries and also causes primocane lesions known as botrytis cane blight and wilt. In wetter years, the disease can drastically reduce both fruit quality (grade) and marketable yield and even with fungicide use, losses can be up to 30%. The disease is less severe in raspberries grown under tunnels.

Life Cycle: Botrytis cinerea overwinters as resting bodies (sclerotia) on primocanes and as vegetative fungal strands (mycelia) on dead leaves and mummified fruit. These overwintering structures produce spores in the spring which infect blossoms. The early blossom infections remain inactive (latent) until the fruit is nearly ripe. When conditions are favourable for fungal growth within the berry, the fungus sporulates on the berry surface, appearing as a distinctive grey mould. These spores contribute to secondary infection of fruit, primocanes and other green tissues. The infection and spread of the disease are favoured by high moisture and poor drying conditions.

Pest Management

Cultural Controls: Cultural practices that improve air circulation within the crop, such as pruning, elimination of weeds and increased plant spacing help to minimize the disease. Biennial crop production and primocane suppression help improve air movement and thus can help reduce the incidence of Botrytis, as will avoiding excessive nitrogen fertilization and timing overhead irrigation such that plants to not remain wet for prolonged periods.

Resistant Cultivars: Cv. Meeker displays some field resistance and in British Columbia, cvs. Malahat, Squamish, Chemanius, Saanish, and Wakefield have also shown some resistance to Botrytis rots.

Issues for Botrytis Diseases

1. Resistance to several commonly used fungicide groups is developing world wide. Surveys are needed to determine the extent of this problem in Canada and to track efficacy of fungicides over time.
2. Growers need access to diagnostic tools to determine which fungicides are no longer useful due to the development of resistance in pathogen populations on their farm.
3. A focused effort on the development of best management practices to prevent or delay development of resistance to fungicides is needed, as are resource materials for growers about these best management practices.
4. There are concerns regarding the potential loss of captan as a result of re-evaluation, as this is an important resistance management tool.
5. There is a need to verify existing forecasting models for use by growers in the field.

Spur Blight (*Didymella applanata*)

Pest Information

Damage: Yield loss from this disease tends to be cumulative over the years. Infection causes dieback of leaves, shoots and fruiting spurs. The disease first appears in mid- to late summer as wedge-shaped lesions on leaves. As the disease progresses, infections travel down the leaf petiole, infecting the cane at the nodes. Primocane lesions can damage buds at the base of the infected leaf. Damaged buds are predisposed to winter injury and weak growth the following season, potentially reducing yield.

Life Cycle: The fungus overwinters on infected primocanes and in the spring produces ascospores (sexual spores) and conidia (asexual spores) which can be spread by wind-blowing or rain-splashing and infect new primocanes. Release of conidia continues throughout the growing season during wet weather.

Pest Management

Cultural Controls: Scouting for characteristic symptoms may be done throughout the season to determine the need for fungicide treatments. Practices that improve air circulation and facilitate drying of foliage will make conditions less suitable for infection. The removal of old floricanes and infected primocanes after harvest will reduce overwintering inoculum.

Resistant Cultivars: None available. Vigorous cultivars are more susceptible.

Issues for Spur Blight

1. Cane diseases are very challenging to control in raspberry. The available products do not provide adequate control.
2. There is a need for studies on epidemiology, (environmental conditions and timing of infection, etc.), effective management practices and also fungicides to manage cane diseases.

Cane Blight (*Leptosphaeria coniothyrium*)

Pest Information

Damage: Cane blight causes purple-black cankers at sites of pruning, insect and other mechanical damage to raspberry canes, resulting in girdling of the canes and wilting of shoots. The fungus remains in the vicinity of the wound, but toxins produced by the fungus move up the cane, killing vascular tissue and buds.

Life Cycle: The fungus overwinters on old cane stubs. Old, dead canes may produce spores for several years. Pycnidia (spore producing bodies) develop in the spring and release spores which are rain splashed and wind-blown to nearby canes where they cause new infections. Physical damage to the surface of the primocanes enables the fungus to enter the vascular tissue. Moist conditions are required for infection.

Pest Management

Cultural Controls: The disease can be controlled by removal of infected canes. Other important cultural techniques include reducing damage from mowing equipment, trellising, and harvesting machinery (by adjusting the tension of catcher plates). Examination of suspect primocanes in the fall and early spring is recommended to confirm the presence of this disease. Fast cane growth promoted by high nitrogen levels is more susceptible to cane blight infection injury.

Resistant Cultivars: None available.

Issues for Cane Blight

1. Cane diseases are very challenging to control in raspberry. The products available do not provide adequate control. There is a need for research on the biology of the disease to facilitate the development of effective controls.
2. There is a need for a better understanding of which fungicides provide control and investigation of possible label expansions to increase availability of registered control products.

Anthracnose or Cane Spot (*Elsinoe veneta* and *Colletotrichum* spp.)

Pest Information

Damage: The first symptoms of anthracnose are small, purplish circular patches on the cane or petioles. The patches enlarge and canes may eventually be girdled, resulting in dieback and the potential for uneven fruit ripening. Considerable cane injury may result from anthracnose in years when weather remains wet into late May or early June, but early infections are more damaging. Uneven berry ripening may result from infected canes, and the disease also causes a fruit rot which can result in down-grading of the fruit.

Life Cycle: In the fall, the disease spreads via spores produced in small black fruiting bodies. In the spring, splashing rain carries the spores to new shoots, leaves or fruit, where infection takes place. Both *E. veneta* and *Colletotrichum* species resembling *C. gloeosporioides* have been associated with this disease in British Columbia. *E. veneta* is the most common species in eastern Canada.

Pest Management

Cultural Controls: Effective management practices include pruning out infected canes after harvest and avoiding the application of excessive nitrogen.

Resistant Cultivars: Resistant red raspberry varieties include Willamette, Nootka, Meeker and Heritage.

Issues for Anthracnose

1. Serious losses can result from both the cane blight and fruit rot phases of anthracnose, and there are no effective control methods. There is a need for the registration of reduced risk fungicides with short pre-harvest intervals and the development of an effective integrated approach to the management of this disease.
2. There is a need for a better understanding of which fungicides may provide control so as to pursue possible label expansions of registered control products.
3. There is a need for the development of weather-based prediction models for use in integrated approaches to pest management.

Yellow Rust (*Phragmidium rubi-idaei*)

Pest Information

Damage: Yellow rust infects floricane and primocane foliage. In some years, it causes significant premature leaf death, reducing plant vigour and increasing the likelihood of winter injury.

Life Cycle: The fungus overwinters in old primocane leaf debris trapped in bundles of canes where they are tied to the trellis wire. Spores released by the fungus in the spring cause the initial infection of floricane leaves. The first visible symptom of disease is the appearance of yellow-orange pustules on older leaves. Spores from these lesions lead to secondary spread of the disease and to the overwintering stage.

Pest Management

Cultural Controls: In infected fields, removal of leaves from primocanes before they are tied up in the fall, or delaying tie up until after leaves have dropped can reduce sources of infection for the following year. Tilling leaves into the soil will help to remove infected leaves as an inoculum source. Scouting in late April and early May as well as after harvest can assist in decision-making on the application of dormant or pre-bloom fungicide sprays and post-harvest cultural practices to reduce winter carryover.

Resistant Cultivars: None available.

Issues for Yellow Rust

1. There is a need for better understanding of the impact of pruning and other cultural practices on the development and management of yellow rust.
2. There is a need for the registration of additional fungicides from different chemical groups for disease management and as resistance management tools.

Late Yellow Rust (*Pucciniastrum americanum*)

Pest Information

Damage: This rust attacks leaves causing premature leaf drop and greater susceptibility to winter injury. Fruit can also be infected, resulting in unsightly and unmarketable berries. Severe outbreaks usually occur at harvest (late July to mid-August) and are often linked to conditions favourable for the development of the disease on nearby white spruce earlier in the season.

Life Cycle: The pathogen requires two different host species to complete its life cycle. Spores are produced on an alternate host, mainly white spruce, in mid-June to early July and are windblown to raspberry where they infect the leaves, calyces and flowers. Rust pustules develop on the infected tissues and give rise to spores of a different type which cause new infections on raspberry throughout the growing season. In the fall an overwintering spore type is produced on raspberry which gives rise to yet another spore type in the spring which re-infects white spruce.

Pest Management

Cultural Controls: The removal of white spruce in the vicinity of the raspberry planting may help to break the disease cycle and reduce the likelihood of disease development on raspberry. Practices that promote drying of the foliage including proper row and plant spacing and weed management will result in conditions less favourable for disease development.

Resistant Cultivars: Cultivars Nova and K81-6 are resistant to late yellow rust.

Issues for Late Yellow Rust

1. There is a need for the registration of fungicides having short pre-harvest intervals for the control of late yellow rust.

Fire Blight (*Erwinia amylovora*)

Pest Information

Damage: Fire blight infected tips and lateral branches of primocanes become wilted and blackened, frequently developing a characteristic shepherd's crook. Symptoms of water soaking and blackening can also develop on infected fruit or flower clusters which eventually become hard and dry, remaining attached to the plant. Droplets of white or amber bacterial "ooze" may be produced in infected tissue.

Life Cycle: Bacteria overwinter in cankers on first-year canes and survive on living tissue. In the spring, they spread to healthy tissues by rain splash or wind. Adverse weather conditions such as high winds, driving rains or hail can result in tiny wounds which provide entry sites for the bacteria. Insects such as tarnished plant bugs, earwigs and ants can spread the fire blight bacterium and facilitate infection. Strains of *E. amylovora* causing fire blight on raspberries differ from those causing the disease in apples and pears, with the raspberry strain unable to infect apple/ pear and vice versa.

Pest Management

Cultural Controls: The removal and destruction of infected canes will eliminate a source of the bacterial infection. Minimizing the creation of potential infection sites, such as those caused by overhead irrigation on susceptible varieties, will help to reduce disease development. The control of insects, if necessary, will reduce a potential means of spread.

Resistant Cultivars: Cvs. Heritage, Nova, and Royalty are resistant cultivars, while cv. Ruby, Avon, Polana and Caroline are partially resistant.

Issues for Fire Blight

1. There is a need for the registration of protectant products which prevent fire blight development.
2. There is a need for improved understanding of the epidemiology of fire blight on raspberries and to identify conditions which lead to infection, as an aid to better time applications of registered and new products.
3. The development of an integrated approach to the management of fire blight, that includes varietal resistance and a predictive model, is required.

Bacterial Blight (*Pseudomonas syringae pv. syringae*)

Pest Information

Damage: Bacterial blight is seldom a problem but when present can cause severe losses in British Columbia.

Life Cycle: The bacterium survives on leaf surfaces, in healthy buds and on weeds. It may be spread by splashing rain, wind, insects and infected planting stock.

Pest Management

Cultural Controls: Practices which will avoid late growth due to excessive soil nitrogen, summer drought followed by resumption of growth with fall rains, and refraining from topping of canes too early in the fall will minimize the potential for development for this disease.

Resistant Cultivars: None available.

Issues for Bacterial Blight

None identified.

Verticillium Wilt (*Verticillium dahliae* and *V. albo-atrum*)

Pest Information

Damage: Verticillium wilt also known as bluestem, affects the water conducting tissues of the plant, causing leaves to develop a dull green colour and eventually become brown and dry. Growth may be stunted and display symptoms of nutrient deficiency or wilt. Fruit production may be poor in the second or third year and later years. A characteristic blue streak may develop on stems of red raspberry cultivars.

Life Cycle: These pathogens are soil-borne and enter through the roots, moving upwards in the vascular system and blocking water and nutrient movement. *V. albo-atrum* does not persist in the soil for more than one season, but *V. dahliae* produces microsclerotia (resting bodies) which can survive and remain infective for many years. Both pathogens have a very wide host range.

Pest Management

Cultural Controls: As verticillium wilt can affect many plants, it is important that raspberries are not planted where strawberries, potatoes, or other susceptible crops have been grown in the past if *V. dahliae* has been present.

Resistant Cultivars: There is no varietal resistance.

Issues for Verticillium Wilt

None identified.

Phytophthora Root Rot *(Phytophthora fragariae var. rubi* and *P. cinnamomi)*

Pest Information

Damage: Under excessively wet and poorly drained soil conditions, the phytophthora species can invade and kill root and crown tissues. Above ground symptoms include poor growth, wilting, leaf scorch and foliar dieback. In summer, fruiting canes wither and dry as a result of root infections which occur during wet seasons. Primocanes are killed and eventually whole bushes die. The disease increases in plantings from year to year.

Life Cycle: The pathogens can persist in the soil for many years by means of resting spores (oospores). Mycelia in infected roots produce sporangia (reproductive structures) in spring and fall which release zoospores that move in water and infect new root tips in wet conditions. *P. fragariae* is a cool weather pathogen, infecting roots in cool soils. In irrigated fields, it is possible that infection from *P. cinnamomi* can occur in warmer soils.

Pest Management

Cultural Controls: Cultural practices to prevent infection include avoidance of fields with a history of the disease, improvement of soil drainage, ridging or planting raspberries into raised beds, cleaning of cultivation equipment to avoid spreading the pathogen from infected to healthy fields, and the use of certified, disease-free root stock. Fields can be scouted before or during harvest for symptoms.

Resistant Cultivars: Some root rot tolerance has been observed with cvs. Meeker, Squamish, CascadeBounty, CascadeDelight and also on the fall-fruiting variety Summit in British Columbia. In Ontario, the cultivar Titan is particularly susceptible.

Issues for Phytophthora Root Rot

1. There is a need for the development of an effective, integrated approach to the management of phytophthora root rot. The impact and potential benefits of soil amendments such as organic matter and calcium sulfate on suppressing phytophthora root rot needs further study.
2. There is a need for alternative fungicides to metalaxyl to manage resistance, and for user-friendly fumigation products pre- and post-planting for the management of phytophthora root rot.

Crown Gall (*Agrobacterium tumefaciens*)

Pest Information

Damage: This bacterial disease can cause significant reductions in yield. The pathogen causes woody swellings on raspberry roots, crowns or canes at ground level. Infected raspberry plants develop short, weak fruiting canes with leaves that yellow and dry out in warm weather. Root and crown galls reduce nutrient uptake, resulting in yield loss and early decline of plantings. The long-term impact can be even more significant, since fields remain infested for many years and the disease will affect a new crop when fields are replanted. This disease causes more damage under dry conditions. A related disease, caused by *Agrobacterium rubi,* attacks fruiting stems in Quebec.

Life Cycle: The bacterium is soil-borne and can be introduced in infected planting stock or be present in the soil if infected plants were grown there previously. The bacterium invades through wounds created by insects and mechanical damage, and causes the development of galls. As the galls age, they become woody and brown, eventually releasing bacteria into the surrounding soil, where the bacteria can persist for many years.

Pest Management

Cultural Controls: The introduction of the bacterium can be prevented by carefully checking planting stock for galls and using only certified planting stock. Other cultural controls include disinfecting pruning shears and minimizing mechanical plant injury by avoiding close cultivation and making sure that catch plates on mechanical harvesters are working properly. Effective control of root weevils and nematodes will help to prevent root damage and subsequent crown gall infection.

Resistant Cultivars: Resistant or tolerant varieties include Willamette and Meeker.

Issues for Crown Gall

1. There is a need for better management strategies, including use of clean propagation stock, biopesticides, and sanitation practices during production. There is a need for more information on the susceptibility of different cultivars to crown gall.

Virus Diseases: Raspberry Bushy Dwarf Virus (RBDV), Raspberry or Tomato Ringspot Virus (ToRSV)

Pest Information

Damage: Raspberry bushy dwarf virus (RBDV) causes a loss of yield and fruit quality and a shortened lifespan of plantings. This virus, despite its name, does not cause bushy or dwarfed plants, but rather crumbly fruit. Once a plant is infected, it will continue to produce a poor quality and reduced yields of fruit. Yield and fruit quality losses are estimated at 20- 30% in infected plantings. Raspberry ringspot virus (ToRSV) causes reduced yield and vigor. This virus stunts raspberry plants and causes crumbly fruit, thus impacting both yield and fruit quality. Some varieties also develop leaf symptoms such as mottling, yellowing, ringspots, mosaic patterns or curling. The disease is only present in sandy soils.

Life Cycle: The disease is spread by infected pollen. Once infected with RBDV, plants remain infected for life.

Pest Management

Cultural Controls: RBDV is controlled by planting certified, disease-free stock and through the use of resistant varieties. Infected plants must be removed and replaced with healthy nursery stock. If growing susceptible varieties, removal of fruiting laterals from first year plantings before bloom can delay infection.

The ToRSV virus is spread by the dagger nematode (*Xiphinema americanum*) and possibly other species, therefore practices which control nematodes may be helpful in reducing incidence of this virus in raspberry plantings.

Resistant Cultivars: Willamette, Cowichan Nootka, and Chilcotin are resistant to RBDV. Meeker and Willamette are susceptible to ToRSV.

Issues for Virus Diseases

1. RBDV is a major factor in poor fruit quality and the only effective control is the use of resistant varieties. There is a need for a more intensive breeding program for resistance to RBDV in varieties with good processing fruit and mechanical harvest qualities.
2. A survey for raspberry viruses is necessary to determine the distribution of emerging viruses and their vectors.
3. As preventative measures for all virus diseases, improved, affordable and DNA-based diagnostic tools, virus-indexing, and the establishment of phytosanitary requirements (or guidelines) for planting stock is required.
4. Plant growers need access to disease-free nursery stock for the propagation of virus-free transplants and research is needed to support sampling methods and diagnostics in plant production fields.
5. Economic thresholds for virus vectors and tests to determine the percent vectors carrying the virus are also required.

Nematodes: Root Lesion (*Pratylenchus* spp.), Dagger (*Xiphinema* spp.), Sting *(Belonolaimus* spp.*)*

Pest Information

Damage: Nematodes feed on plant roots causing early decline of plantings and a gradual loss of vigour. The sandy soils where raspberries are grown are highly favourable for pathogenic nematodes. If left uncontrolled, root lesion nematodes will shorten the productive life span of an established field by two to three years. Root lesion nematodes weaken plants and reduce their ability to overcome other pest damage or stress. Dagger nematodes (*Xiphinema* spp.) transmit raspberry (tomato) ringspot virus. The impact of nematodes on a vigorous field is less pronounced than on a weak field. Damage may occur at lower nematode densities if plants are also stressed by root rotting diseases, insects or other factors.

Life Cycle: Plant-feeding nematodes can progress from the egg stage, through a number of juvenile stages, to egg-laying adults in as little as 21 to 28 days during warm summer months. Nematodes are believed to survive from season to season primarily as eggs in the soil. Adult females lay eggs in the soil or within roots depending on their species.

Pest Management

Cultural Controls: Cultural methods to reduce nematodes include good weed control and long rotations out of raspberries. Beneficial practices include the growing of non-nematode host crops or the growing of nematode-suppressing cover crops and the addition of soil amendments, including manure. Keeping fields fallow and weed-free for one year prior to planting raspberries will reduce but not eliminate nematode populations. Soil samples, to monitor for root lesion and dagger nematodes can be collected before field planting and to determine pre-plant fumigation needs.

Resistant Cultivars: None available.

Issues for Nematodes

1. There is a need for the registration of cost-effective nematicides.
2. There is a need for the development of new application methods for nematicides.
3. Further research is required on soil preparation and amendments, including the use of green manures that can reduce nematode populations before planting.

Fungicides, bactericides and biofungicides registered for disease management in raspberry production in Canada

Active ingredients registered for the management of **diseases** in raspberry are listed below in Table 6 *Fungicides, bactericides and biofungicides registered for disease management in raspberry production in Canada*. This table also provides registration numbers for **products registered on raspberry as of November 30, 2018** for each active ingredient, in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **diseases**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Agrobacterium radiobacter, strain K84	21106	biological	N/A	unknown	unknown	R
Aureobasidium pullulans DSM 14940 and DSM 14941	31248	biological	N/A	unknown	unknown	R
Bacillus subtilis strain QST 713	28549, 31666, 33035	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
BLAD polypeptide	22399	polypeptide (lectin)	BM01	BM: biologicals with multiple modes of action	BM: multiple effects on cell wall, ion membrane transporters; chelating effects	R
boscalid	30141	pyridine-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
boscalid + pyraclostrobin	27985	pyridine-carboxamide + methoxy-carbamate	7 + 11	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R + R
canola oil	32408, 32819	diverse	N/C	not classified	unknown	R

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
captan	4559, 9582, 23691, 24613, 26408, 31949	phthalimide (electrophile)	M04	multi-site contact activity	multi-site contact activity	R (RVD2018-12)
copper (present as copper oxychloride)	13245, 19146	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
copper octanoate	31825	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
copper sulfate	9934	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
cyazofamid	27984, 30392	cyano-imidazole	21	C4: respiration	complex III: cytochrome bc1 (ubiquinone reductase) at Qi site	R
cymoxanil + famoxadone	27435	cyanoacetamide-oxime + oxazolidine-dione	27 + 11	unknown + C3: respiration	unknown + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	RE + R
cyprodinil + fludioxonil	28189, 30185	anilino-pyrimidine + phenylpyrrole	9 + 12	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	RE + R (RVD2018-04)

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
fenhexamid	25900	hydroxyanilide	17	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	RE
ferbam	20136, 20536	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	RE
fluopyram	30509	pyridinyl-ethyl-benzamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
fluopyram + pyrimethanil	30510	pyridinyl-ethyl-benzamide + anilino-pyrimidine	7 + 9	C2: respiration + D1: amino acid and protein synthesis	complex II: succinate-dehydrogenase + methionine biosynthesis (proposed) (cgs gene)	R + R
fluxapyroxad	30565, 31697	pyrazole-4- carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
fosetyl-Al	24458, 24564, 27688	ethyl phosphonate	P07	P7: host plant defence induction	phosphonate	RE
iprodione	15213, 24709	dicarboximide	2	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	R (RVD2018-16)
isofetamid	31758	phenyl-oxo-ethyl thiophene amide	7	C2: respiration	complex II: succinate-dehydrogenase	R

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
kasugamycin	30591	hexopyranosil antibiotic	24	D3: amino acids and protein synthesis	protein synthesis (ribosome initiation step)	R
lime sulphur (calcium polysulphide)	16465	inorganic	M02	multi-site contact activity	multi-site contact activity	R
metalaxyl-M and S-isomer	25384, 28474	acylalanine	4	A1: nucleic acids synthesis	RNA polymerase I	R
myclobutanil	22399	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
oxamyl	17995	carbamate[4]	1A[4]	acetylcholinesterase (AChE) inhibitor[4]	acetylcholinesterase (AChE) inhibitor[4]	R
oxathiapiprolin	32101, 32102, 32103, 32104	piperidinyl-thiazole isoxazoline	49	F9: lipid synthesis or transport / membrane integrity or function	lipid homeostasis and transfer / storage	R
Pantoea agglomerans (strain C9-1)	28392	biological	N/A	unknown	unknown	R
penthiopyrad	30331	pyrazole-4- carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
phosphites (mono and dibasic sodium, potassium and ammonium phosphite)	30449	not classified	N/A	unknown	unknown	R
polyoxin D zinc salt	32688, 32918	polyoxin	19	H4: cell wall biosynthesis	H4: chitin synthase	R
propiconazole	numerous products	triazole	3	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	R
pyriofenone	32376	benzoylpyridine	50	B6: cytoskeleton and motor protein	actin/ myosin/ fimbrin function	R
pyrimethanil	28011	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	R
tea tree oil (*Melaleuca alternifolia*)	30910	terpene hydrocarbons and terpene alcohols	46	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	R
thiophanate-methyl	12279, 25343, 27297, 31784, 32096	thiophanate	1	B1: cytoskeleton and motor proteins	ß-tubuline assembly in mitosis	RE
Soil fumigant						
chloropicrin (pre-plant soil fumigant)	25863, 28715	chloropicrin[4]	8B[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	R (REV2017-04, RVD2018-30)

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in raspberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Soil fumigant (continued)						
metam-sodium	19421, 25103, 28247, 29128, 29142	methyl isothiocyanate generator	8F[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	RE
methyl bromide	19498	alky halide[4]	8A[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	PO[5]
oriental mustard seed meal (oil) (*Brassica juncea*)	30263	diverse	N/C	not classified	unknown	R

[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 November 30, 2018.** While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on raspberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2018: Fungicides sorted by mode of action (including FRAC code numbering).* February 2018. (www.frac.info/) (accessed August 20, 2018).

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 and other re-evaluation documents: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.4; May 2018)* (www.irac-online.org) (accessed August 23, 2018).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Insects and Mites

Key issues

- The spotted wing drosophila (SWD) has significantly changed the landscape of pest management in raspberry. Some of the current control options are particularly harsh on beneficial mite species, and thus negatively impact integrated pest management (IPM) for other pests. The registration of products with one or two-day pre-harvest intervals is needed, along with improved understanding of SWD biology and the development of integrated approaches to manage this serious pest. In addition, there is an urgent need for management options for SWD in organic raspberry production.
- The development of improved approaches for the management of mites is required, particularly given the prevalence of this pest in high tunnel growing systems. Available miticides have limited utility due to high cost, pest resistance development in some cases, or use patterns which do not allow for in-crop sprays, when most mite damage occurs. An early season ovicide would be of benefit to help prevent mite buildup. As well, the efficacy of beneficial species such as predator mites is under threat due to sprays used for SWD, some of which negatively impact these species, with the result that pressure from spider mites is increasing.
- Cane and crown borers can be serious problems in raspberry production, and there are concerns that damage from these pests may increase with the phasing out of broad-spectrum insecticides. There is a need for the registration of alternative products to replace those being phased out, and for use patterns to be established at the time of registration.
- Sap beetles, weevils, earwigs, cutworms, caterpillars lygus bugs, and various aphids can be a problem at harvest, particularly in mechanical harvest situations. Reduced- risk products with short pre-harvest intervals and alternative controls are needed.
- Raspberry fruitworms are a problem in all types of production. There is a need to develop solutions to control fruitworms as replacements for diazinon. In addition, further studies are required on the efficacy and usefulness of monitoring and decision-making tools, and their potential for use in mass-trapping of fruitworms.
- Japanese beetle and rose chafers are becoming an increasing concern. There is a need to develop an effective management strategy for these pests.

Table 7. Occurrence of insect and mite pests in raspberry production in Canada

Insect	British Columbia	Ontario	Quebec
Aphids			
Large raspberry aphid			
Leafhoppers			
Potato leafhopper			
Tarnished plant bug			
Spider mites			
Two spotted spider mite			
McDaniel spider mite			
Caterpillars (various species)			
Obliquebanded leafroller			
Bertha armyworm			
Variegated cutworm			
Raspberry sawfly			
Fruitworms			
Raspberry fruitworm			
Western raspberry fruitworm			
Redheaded flea beetle			
Raspberry crown borer			
Red-necked cane borer			
Raspberry cane borer			
Raspberry cane maggot			
Raspberry bud moth			
Sap beetles			
Spotted wing drosophila			
Thrips			
Weevils			
Black vine weevil			
Strawberry root weevil			
Clay coloured weevil			
Obscure weevil			
Strawberry bud (clipper) weevil			

…continued

Table 7. Occurrence of insect and mite pests in raspberry production in Canada (continued)

Insect	British Columbia	Ontario	Quebec
Japanese beetle			
Harvest contaminants			

Widespread yearly occurrence with high pest pressure.
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.
Pest is present and of concern, however little is known of its distribution, frequency and pressure.
Data not reported.

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

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

Table 8. Adoption of insect pest management practices in raspberry production in Canada

	Practice / Pest	Mites	Caterpillars (various species)	Fruitworms	Raspberry cane borer	Raspberry crown borer	Spotted wing drosophila
Avoidance	Varietal selection / use of resistant or tolerant varieties						
	Planting / harvest date adjustment						
	Rotation with non-host crops						
	Choice of planting site						
	Optimizing fertilization for balanced growth						
	Minimizing wounding to reduce attractiveness to pests						
	Reducing pest populations at field perimeters						
	Use of physical barriers (e.g. mulches, netting, floating row covers)						
	Use of pest-free propagative materials (seeds, cuttings and transplants)						
Prevention	Equipment sanitation						
	Canopy management (thinning, pruning, row or plant spacing, etc.)						
	Manipulating seeding / planting depth						
	Irrigation management (timing, duration, amount) to manage plant growth						
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)						
	End of season or pre-planting crop residue removal / management						
	Pruning out / removal of infested material throughout the growing season						
	Tillage / cultivation to expose soil insect pests						
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity						

…continued

Table 8. Adoption of insect pest management practices in raspberry production in Canada (continued)

Practice / Pest		Mites	Caterpillars (various species)	Fruitworms	Raspberry cane borer	Raspberry crown borer	Spotted wing drosophila
Monitoring	Scouting / trapping						
	Maintaining records to track pests						
	Soil analysis for pests						
	Weather monitoring for degree day modelling						
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests						
Decision making tools	Economic threshold						
	Use of predictive model for management decisions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed presence of pest at susceptible stage of life cycle						
	Use of portable electronic devices in the field to access pest identification / management information						

…continued

Table 8. Adoption of insect pest management practices in raspberry production in Canada (continued)

Practice / Pest		Mites	Caterpillars (various species)	Fruitworms	Raspberry cane borer	Raspberry crown borer	Spotted wing drosophila
Suppression	Use of diverse pesticide modes of action for resistance management						
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations						
	Biopesticides (microbial and non-conventional pesticides)						
	Release of arthropod biological control agents						
	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)						
	Mating disruption through the use of pheromones						
	Mating disruption through the release of sterile insects						
	Trapping						
	Targeted pesticide applications (banding, variable rate sprayers, spot treatments, etc.)						
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms						

…continued

Table 8. Adoption of insect pest management practices in raspberry production in Canada (continued)

Practice / Pest		Mites	Caterpillars (various species)	Fruitworms	Raspberry cane borer	Raspberry crown borer	Spotted wing drosophila
New Practices (by province)	Shortened harvest intervals (British Columbia)						

This practice is used to manage this pest by at least some growers.
This practice is not used by growers to manage this pest.
This practice is not applicable for the management of this pest.
Information regarding the practice for this pest is unknown.

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Aphids: Small Raspberry Aphid (*Aphis rubicola*) and Large Raspberry Aphid (*Amphorophora agathonica*)

Pest Information

Damage: Aphids are rarely responsible for direct feeding damage in raspberries, but they are contaminants in machine harvested fruit and also transmit some viral diseases. They are usually found as colonies on new shoot growth, buds, undersides of leaves and near flower and fruit clusters.

Life Cycle: Aphids overwinter as eggs and hatch in May. Young aphids mature to be winged or wingless females, which give birth to live young during the summer. The winged form can fly and spread over great distances, unlike the wingless form. Males are produced only in the fall and mate with females which then lay overwintering eggs. The development time and the number of generations depend on the host crop and weather conditions.

Pest Management

Cultural Controls: Aphids are controlled by a number of native predators and parasites including ladybird beetles, lacewings and syrphid fly larvae. Aphids may also be controlled by insecticide sprays for other insects.

Resistant Cultivars: Varieties such as Chemainus, Malahat and Rudi have been selected for having aphid resistance. However, in recent years resistance-breaking strains of raspberry aphids have been detected in British Columbia.

Issues for Aphids

1. With neonicotinoid insecticides currently under regulatory review, there is a need for the registration of replacement chemicals for the management of aphids on raspberry.

Leafhoppers

Pest Information

Damage: Both nymph and adult leafhoppers feed on the underside of leaves, sucking sap and causing white flecks or spots on the upper leaf surfaces. Heavy infestations result in mottled leaves which can wither and curl in hot weather. Plants may show a lack vigour and berries can remain small and become sticky with honeydew secreted by the leafhoppers. A black mould can develop on the honeydew. Leafhoppers may also be present as fruit contaminants at harvest.

Life Cycle: There are two generations of leafhoppers each year. Most of the population overwinters as eggs laid under the bark of raspberry canes. In early May, first generation nymphs hatch and feed for a few weeks before becoming winged adults. Second generation nymphs hatch in late July and early August, mature and lay the overwintering eggs.

Pest Management

Cultural Controls: The presence of leafhoppers can be detected by monitoring the underside of leaves for nymphs, beginning in early May. Leafhoppers are often controlled by insecticide sprays for other insects.
Resistant Cultivars: None available.

Issues for Leafhoppers

None identified.

Potato Leafhopper (*Empoasca fabae*)

Pest Information

Damage: Adults and nymphs feed by piercing and sucking plant juices from leaves. Toxins are injected into the plant while they feed, blocking the vascular system. Feeding reduces vigour of the plant and prevents the normal movement of water and nutrients to the affected areas of the plant. Leaves turn yellowish or develop small white spots, curl downward at the margins and eventually turn brittle and brown.
Life cycle: The pest does not overwinter in Canada. It is carried by wind currents from the southern United States, across the Great Lakes and into eastern provinces. The first adults arrive as early as mid-May and continue to arrive well into June. They often migrate to raspberry fields after the first cut of hay. Larvae and adults are found on the undersides of leaves and can have many generations between June and September.

Pest management

Cultural controls: Monitoring includes visual observation for visible damage. No spray thresholds have been established. Avoiding planting raspberry fields in the proximity to alternate hosts like alfalfa and keeping plantings free of weeds can help to reduce the likelihood of damage from potato leafhoppers.
Resistant cultivars: There are no resistant cultivars.

Issues for Potato Leafhopper

None identified.

Tarnished Plant Bug (*Lygus lineolaris*) and other *Lygus* spp.

Pest Information

Damage: Adults and nymphs feed on flower buds and fruits by puncturing the fruit skin and sucking sap, resulting in fruit deformation.
Life Cycle: Adult bugs overwinter under plant debris and in other protected places. They emerge when temperatures reach 8^{o} C. In spring, females lay eggs in the flower stalks and buds when temperatures rise. Nymphs hatch in 7-10 days and develop through three to five stages (instars) to become adults. There can be several overlapping generations per year.

Pest Management

Cultural Controls: Tarnished plant bugs are attracted by fast growing weeds and cover crops, therefore keeping fields free of weeds, and mowing borders will help to keep pest numbers down. Threshold levels for control may vary between summer-bearing and fall-bearing raspberry varieties.

Resistant Cultivars: None available.

Issues for Tarnished Plant Bug

1. Further studies are required to establish the impact and economic threshold of tarnished plant bug on raspberries.

Thrips (*Thysanoptera*)

Pest Information

Damage: Although thrips feed on all cane fruits, they seldom cause extensive damage. However, their presence in the fruit can render berries unmarketable. Thrips can attack in the spring, but are most abundant in July and August when the weather is hot and dry.

Life Cycle: Thrips overwinter in the soil at the base of canes. Eggs hatch in the spring and the nymphs develop through two or more stages before pupating and emerging as adults. The entire lifecycle is several weeks long and there are numerous generations per year.

Pest Management

Cultural Controls: Thrips populations build up on weeds, therefore mowing borders may reduce populations. Larvae and adults of the minute pirate bug (*Orius* spp.) are considered as predators of thrips.

Resistant Cultivars: None available.

Issues for Thrips

1. Further studies are required to establish the impact and economic threshold of thrips on raspberries.

Spider Mites: Two-Spotted Spider Mite (*Tetranychus urticae*) and McDaniel Spider Mite (*T. mcdanieli*)

Pest Information

Damage: Mites feed on the underside of leaves by piercing and sucking plant sap causing a white stippling and bronzing of the foliage or, in the case of McDaniel spider mite, yellowish leaf spots or discoloured blotches. Feeding damage reduces plant vigour and may cause leaves to drop prematurely, contributing to the potential for winter injury and subsequent yield loss. If uncontrolled, excessive defoliation during and after harvest from two-spotted mite feeding damage can reduce yield by 25% in the following season. Foliar symptoms associated with spider mite feeding differ between species.

Life Cycle: Spider mites overwinter as adult females in the soil in raspberry fields and begin to colonize the plants in early summer, moving upward on the canes. Each generation lasts about two weeks and there are four to six generations per year. Populations usually increase through June and July with potential for rapid increase after harvest in mid to late August. In September populations decline as a result of predation by natural enemies and migration of overwintering females from the raspberry plants to overwintering sites.

Pest Management

Cultural Controls: Cultural practices, including irrigation and fertilization, help maintain vigorous plantings and reduce the impact of spider mite feeding. Most growers consider the degree of foliar damage, the vigour of the field and the time of the year to determine the need for spray programs. Predators, such as the naturally-occurring predatory mite, *Amblyseius fallacis* play a major role in suppressing spider mites, and can in some cases provide control equal to that of chemical products. Other spider mite predators include the minute pirate bug *(Orius tristicolor)* and the small black lady beetle (*Stethorus punctillum*) known as the "spider mite destroyer", a significant natural predator in British Columbia. In other growing regions, other naturally-occurring predatory mites and *Stethorus* species aid in managing phytophagous mites.

Resistant Cultivars: None available.

Issues for Spider Mites

1. Spotted-wing drosophila (SWD) treatments have created an increase in pressure from spider mites. An early season ovicide would be of benefit to help prevent mite buildup. Mite pests are more prevalent in tunnel growing systems.

Caterpillars: Obliquebanded Leafroller (OBLR) (*Choristoneura rosaceana*), Cabbage Looper (*Trichoplusia ni*) and Bruce Spanworm (*Operophtera bruceata*)

Pest Information

Damage: Caterpillars feed on foliage, buds and fruit throughout the season and can contaminate harvested fruit. The timing of the development of these insects varies from year to year depending on weather conditions. There are more than 25 species of caterpillars that may attack raspberries. However, the obliquebanded leafroller (OBLR) is the most prevalent pest among leafrollers in raspberries. OBLR larvae feed on raspberry foliage during April and May. The foliar damage is rarely economically important, but the larvae of the second generation can contaminate hand-picked and machine-harvested fruit in July and August if not controlled prior to harvest.

Life Cycle: While most caterpillar pest species overwinter as eggs or pupae, the OBLR overwinters as a larva, usually within protected old foliage or cane bundles in the field. In the spring the larvae move to feed on developing foliage, pupate and emerge as adult moths.

Pest Management

Cultural Controls: Monitoring for caterpillars can be done by inspecting foliage for feeding damage and rolled leaves. Parasitoids are important contributors to the biological control of caterpillars. Pheromone traps can be used to monitor flights of adult moths of some species to help determine the timing for treatments. *Bacillus thuringiensis* var. kurstaki (Bt or Btk) based biopesticides are available for use against some caterpillar species (Table 9). Parasitic control with a commercially available parasitoid wasp (*Trichogramma minutum*) has been reported to reduce pest numbers to below spraying thresholds in British Columbia.

Resistant Cultivars: None available.

Issues for Caterpillars

1. The development of an integrated approach is required for the management of caterpillars in raspberry.
2. There is a need for the registration of control products suitable for use in organic production systems.

Climbing Cutworms: Bertha Armyworm (*Mamestra configurata*) and Variegated Cutworm (*Peridroma saucia*)

Pest Information

Damage: Cutworms feed on buds and new growth early in the season and can be a significant contaminant at harvest. Major fruit contamination occurs in years when the larval stage of cutworms coincides with harvest (from late June to early August).

Life Cycle: Bertha armyworms lay their eggs in masses of 50 to 500 eggs on the undersides of raspberry leaves. Peak larval emergence varies between July and September, depending on environmental conditions. Variegated cutworm larvae are present from April to October.

Pest Management

Cultural Controls: Bertha armyworms have several natural enemies, including a virus and a parasitic wasp (*Trichogramma minutum*). Commercially available *T. minutum* applied to control leafrollers will also control Bertha armyworms, as the wasp parasitizes the eggs of many lepidopteran species. Pheromone traps are sometimes used for monitoring cutworm moths.

Resistant Cultivars: None available.

Issues for Climbing Cutworms

1. The registration of reduced risk products with short pre-harvest intervals is required for the management of climbing cutworms.

Fruitworms: Raspberry Fruitworm (*Byturus unicolor*) and Western Raspberry Fruitworm (*Byturus bakeri*)

Pest Information

Damage: Raspberry fruitworm has the potential to become a very significant fruit contaminant if not controlled. Adult beetles feed on new leaves and flower buds in May, but the main injury is caused by larvae which feed on the receptacle inside the fruit. There is a very low tolerance for this pest because of the effect on fruit quality.

Life Cycle: Overwintering fruitworm beetles emerge from the soil during April and May. These beetles feed in the early spring, mate and then lay eggs on flower buds and inside opening flowers. The emerging larvae move into the centre of the developing fruits where they feed for 30 days or more. Fully grown fruitworm larvae drop to ground and burrow into the soil where they pupate and overwinter, emerging as adults the following spring.

Pest Management

Cultural Controls: Adult populations are monitored by direct examination of the earliest open flowers and/or with a beating tray from mid-April through early bloom.

Resistant Cultivars: None available.

Issues for Raspberry Fruitworm and Western Raspberry Fruitworm

1. There is a need for the registration of reduced risk pesticides and organic solutions to control fruitworms. Replacements for diazinon are needed.
2. Further studies are required on the efficacy of monitoring and decision-making tools, and the potential for the use of monitoring tools in mass-trapping of fruitworms.

Raspberry Sawfly (*Monophadnoides geniculatus*)

Pest Information

Damage: Large infestations of the raspberry sawfly can result in defoliation and loss of the crop. Larvae feed on leaves causing large, interveinal holes or skeletonization. Vigorous raspberry plants are not seriously damaged by sawfly larvae unless they are in outbreak numbers.

Life Cycle: Mature larvae overwinter in a cocoon on the ground. Adult sawflies lay eggs on leaves in May and June. When mature, sawfly larvae drop to the soil where they overwinter. There is one generation per year.

Pest Management

Cultural Controls: A number of predators and parasitoid wasps attack the sawfly larvae. Cocoons left on the ground are easy prey for ground beetles helping to minimize populations for the following year.

Resistant Cultivars: None available.

Issues for Raspberry Sawfly

1. The registration of reduced risk products for raspberry sawfly is required.

Raspberry Crown Borer (*Pennisetia marginata*)

Pest Information

Damage: The raspberry crown borer is considered more problematic in older, established plantings. Feeding damage in canes and crowns can weaken plants and kill infested canes. Infested areas often have uneven bud break in the spring and spindly canes, which break off at ground level. Damage provides entry point to diseases, such a s crown gall. Without controls, estimated yield loss could be as high as 50%. The pest is devastating and is not readily noticed until significant crop losses have occurred.

Life Cycle: The raspberry crown borer has a two-year life cycle. Adult moths are present from late July through early October. Eggs are laid on the underside of leaflets and upon hatching, caterpillars crawl down to the base of the canes and form an overwintering cell beside the cane in a protected area. Larvae begin feeding in early March on cane buds around the plant crown and then burrow into crowns.

Pest Management

Cultural Controls: Weak areas within a field can be checked for evidence of this insect during pruning or cane tying. Infested canes or canes with galls can be pruned out close to the crown, immediately after harvest or when setting canes on wires. Monitoring for the raspberry crown borer is difficult as the current techniques are destructive and involve digging up the plant.

Resistant Cultivars: None available.

Issues for Raspberry Crown Borer

1. There is a need for the registration of alternative products as existing options are being phased out.
2. Studies are required on how to integrate new products into IPM approaches. Grower education is required on how best to use the new product chlorantraniliprole in terms of timing of application.

Rednecked Cane Borer (*Agrilus ruficollis*)

Pest Information

Damage: The adult feeds along leaf margins from May through early August. Young larvae tunnel up and down the cane in a spiral pattern. Older larvae develop in the pith. Infested canes develop galls at the site of the tunnelling. This weakens canes causing them to break near the swellings, while unbroken canes can wither and die. Swollen canes are usually first observed in July and August.

Life Cycle: Females deposit eggs on the bark of new growth near the bottom of the cane in May and June. Following hatch, larvae feed within canes and reach full size in the fall. Larvae overwinter in the canes and pupate then emerge as adult beetles in the spring.

Pest Management

Cultural Controls: The pruning out and removal of galled canes from the raspberry planting before buds break in the spring will reduce the insect population.
Resistant Cultivars: None available.

Issues for Rednecked Cane Borer

None identified.

Raspberry Cane Borer (*Oberea bimaculata*)

Pest Information

Damage: Damage caused by the raspberry cane borer, results from egg laying and larval tunnelling in the cane. Damage includes tip and floricane dieback.
Life Cycle: The female cane borer lays single eggs close to the tip of the cane and then girdles the cane both above and below the egg. This results in wilting and sometimes breakage of the tip of the cane. Following hatch, the larvae tunnel within the cane. The first winter is spent within the cane close to the soil surface. In the second year, the larva burrows into the crown below soil level, where it spends the winter. Following pupation, adults emerge in late spring.

Pest Management

Cultural Controls: The borer infestation can be reduced by pruning-out of infested canes in June, targeting the area below the characteristic double rings as well as any insect tunnelling. Burning the prunings will destroy the larvae.
Resistant Cultivar: None available.

Issues for Raspberry Cane Borer

1. There is concern that cane borers will become more common with the uptake of more targeted, reduced risk products.

Raspberry Cane Maggot (*Pegomya rubivora*)

Pest Information

Damage: The raspberry cane maggot adult closely resembles a small housefly. Newly hatched maggots bore into the pith, and then turn outward and girdle the stem, causing the shoot to wilt and die.

Life Cycle: Pegomya rubivora has one generation per year. It lays eggs in the tips of shoots in early spring. When mature, the maggot bores down to the base of the plant to pupate and overwinter.

Pest Management

Cultural Controls: Removing and destroying the infested shoots will help to keep populations of this pest down.
Resistant Cultivars: None available.

Issues for Cane Maggot

None identified.

Raspberry Bud Moth (*Lampronia corticella*)

Pest Information

Damage: The raspberry bud moth is a sporadic pest of raspberry in the Atlantic Provinces. Larvae tunnel into the buds and lateral shoots of fruiting canes in the spring.
Life Cycle: Larvae overwinter in the soil and move to fruiting canes in the spring.

Pest Management

Cultural Controls: The elimination of crop debris and pruning out of affected shoots will reduce the pest population.
Resistant Cultivars: None available.

Issues for Raspberry Bud Moth

1. Further information is required on the biology and potential for crop damage caused by the raspberry bud moth under Canadian conditions. There is a need for the development of an integrated management approach for raspberry bud moth.
2. The registration of products suitable for use in organic production systems is required for the control of raspberry bud moth.

Sap Beetles (*Coleoptera: Nitidulidae*)

Pest Information

Damage: Sap beetles are a sporadic fruit contaminant in eastern Canada. They are more prevalent in areas where field and sweet corn are grown. The beetles have been implicated in the transmission of rot pathogens.

Life Cycle: Sap beetles overwinter as adults in protected locations. They have generally one generation per year. Egg laying and larval development occurs in decaying organic matter. Adult beetles are attracted to and feed on over-ripe or decaying fruit.

Pest Management

Cultural Controls: The timely harvesting of fruit and elimination of damaged and over-ripe fruit in the field will help reduce problems due to sap beetles.

Resistant Cultivars: Fall-bearing varieties are more susceptible to these attacks.

Issues for Sap Beetles

1. Sap beetles are primarily a problem at harvest and for this reason, safer, alternative controls including baits and reduced risk products with short pre-harvest intervals, are needed.

Spotted Wing Drosophila (*Drosophila suzukii*)

Pest Information

Damage: Spotted wing drosophila (SWD) is a serious pest of soft fruit and berries. This fruit fly is known to infest raspberry, blackberry, blueberry, strawberry, cherry, peach, nectarine, apricot and plum, as well as numerous wild hosts. Unlike other fruit flies, SWD will attack sound fruit. Larvae feed within the fruit causing softening and breakdown of flesh which makes the fruit unmarketable.

Life Cycle: There can be as many as five generations per year in British Columbia. The insect overwinters as adult flies. Flies mate in the spring and lay eggs under the skin of ripening fruit. Wounds caused by egg-laying serve as entry points for disease. Larvae feed and develop within the fruit. The entire life cycle from eggs, through larval and pupal stages to adult, varies between seven to 50 days, dependent upon temperature. Due to the short generation time and extended period of egg laying by adults, there can be several, overlapping generations each year. The insect is spread short distances by wind and can be carried to new areas through the movement of infested fruit.

Pest Management

Cultural Controls: Strict sanitation measures are important in the field and in processing areas. The frequent harvest of all ripe fruit and removal of unmarketable fruit culls from the field will help reduce the chance of the fly infesting the fruit and reduce sources of continued infestations. Keeping equipment and processing areas free of old fruit will also help. Flies can be monitored using apple-cider vinegar traps.

Resistant Cultivars: None identified.

Issues for Spotted Wing Drosophila

1. The spotted wing drosophila has significantly changed the landscape of pest management in raspberry. There is a need for improved understanding of the biology of this insect,

including, behavior, population dynamics and factors affecting the growth and decline of populations in order to develop more effective control strategies in this crop.

2. There is a need to develop an integrated approach to manage SWD. Effective monitoring tools and predictive models need to be developed. The potential for mass trapping, attract and kill approaches and repellents require further investigation.
3. The registration of insecticide products, including biopesticides with short pre-harvest intervals (one to two days) is required for the control of SWD. There is an urgent need to develop controls for use in organic raspberry production. News products must not be injurious to beneficial insects and predatory mites.

Weevils: Black Vine Weevil (*Otiorhynchus sulcatus*), Clay Coloured Weevil (*Otiorhynchus singularis*), Strawberry Root Weevil (*Otiorhynchus ovatus*), and Obscure Weevil (*Sciopithes obscurus*)

Pest Information

Damage: The larvae of several species of weevil feed on the roots of raspberry. The bark of larger roots may be damaged and smaller roots may be completely eaten. Root injury may result in foliar wilt. Adults feed at night and cause notching on the leaf edges. Weevil adults can be serious fruit contaminants when the adult stage coincides with harvest.

Life Cycle: Black vine and strawberry weevils have one generation per year. They overwinter as grubs in the soil and resume feeding on plant roots in the spring. Weevil grubs pupate in April and emerge from the soil as adults during May and early June. These adults feed on above-ground plant parts during June and July. Newly emerged adults begin laying eggs in late June prior to the onset of harvest. The life cycle of the obscure weevil is similar to that of the black vine weevil. Adult clay coloured weevils begin emerging from the soil in mid-March.

Pest Management

Cultural Controls: Monitoring is used to identify the species that are present and provide an estimate of population density before and after treatment. Three-year cycle rotation between strawberry or raspberry and other non-host crops will reduce populations levels. Ground beetles (Carabids) are known to feed on weevil grubs, pupae and adults; however, the contribution these natural enemies make to control weevil populations has not been determined.

Resistant Cultivars: None identified.

Issues for Root Weevils

1. As weevils are a harvest contaminant, particularly associated with mechanical harvesting, there is a need for the registration of insecticide controls with short pre-harvest intervals.

Strawberry Bud (Clipper) Weevil (*Anthonomus signatus*)

Pest Information

Damage: Damage from the strawberry bud weevil results when females sever raspberry buds from their pedicel, preventing fruit formation.

Life Cycle: The strawberry bud weevil has one generation per year, with overwintering adults emerging early in the season from ground litter in wooded areas. They migrate to berry fields in late April. Females puncture unopened buds with their long beaks and deposit a single egg into the bud. Larvae develop in the buds, reaching maturity in three to four weeks. Adults emerge in June, feed on flower pollen and then move to overwintering sites in mid-summer, remaining inactive the rest of the season.

Pest Management

Cultural Controls: Damage caused by the strawberry clipper weevil is readily apparent and can be detected by scouting. Threshold levels are available for timing of control products. Removal of weeds in and around raspberry fields, particularly pollen-producing plants will reduce infestation.

Resistant Cultivars: None identified.

Issues for Strawberry Bud (Clipper) Weevils

None identified.

White Grubs: Japanese Beetle (*Popillia japonica*) and European Chafer (*Rhizotrogus majalis*)

Pest Information

Damage: White grubs are the larvae of beetles of the *Scarabaeidae* family. They feed on plant roots. Injured plants may wilt and lose vigour. Japanese beetle adults are general feeders and will attack over 300 different plants. They feed on fruit and tender leaf tissues of raspberry, leaving a network of veins resulting in browning and dropping of severely affected leaves.

Life Cycle: The Japanese beetle and European chafer have one-year life cycles. Eggs are laid in the soil and after hatching, the white grubs feed on roots in the upper 10 to 12 cm of soil. European chafer and Japanese beetle feed in the fall, overwinter as grubs, resume feeding in early spring, then pupate and emerge as adults.

Pest Management

Cultural Controls: Avoidance of planting raspberries in fields following sod, corn, potato, strawberry or cereal species, all of which are hosts for white grubs, will help to reduce damage from grubs. Controlling grassy weeds will make the field less attractive to white grubs. Summer fallowing and frequent cultivation can also reduce grub populations by physically destroying larvae and pupae, or exposing them to predators such as birds.

Resistant Cultivars: None available.

Issues for White Grubs

1. Japanese beetles are becoming an increasing concern. There is a need to develop an effective management strategy for this insect.

Redheaded Flea Beetle (*Systena frontalis*)

Pest Information

Damage: Adults forage on leaves, leaving them riddled with holes. Infested plants have a delay in fruit maturation.

Life Cycle: This insect has one generation per year. Eggs overwinter in the soil and some adults overwinter in hedgerows and the edges of woodlots. This flea beetle has three larval stages. After hatching in late May to early June, larvae feed on roots until adult stage and climb towards the foliage.

Pest Management

Cultural Controls: Removal of weeds from raspberry fields will help to reduce pest numbers.

Resistant Cultivars: None available.

Issues for Redheaded Flea Beetle

None identified.

Harvest Contaminants

Pest Information

Damage: Insects may be shaken off with the raspberries during machine harvesting and may contaminate the harvested fruit. Any insect present in the crop at harvest, including innocuous and beneficial insects, have the potential to become contaminants. Insects that can contaminate crops include raspberry aphids *(Amphorophora agathonica, Aphis rubicola)*, European earwigs *(Forficula auricularia)*, various stink bugs (Family: *Pentatomidae*), lygus bugs (Family: *Miridae*), weevils, spiders, slugs, snails, and ants. Fruit contamination can result in the crop being downgraded or rejected by processors.

Life Cycle: The biology and life cycle of the harvest contaminants varies with the insect.

Pest Management

Cultural Controls: Some insects can be removed by hand on the machine belt and the sorting belt in the processing plant. Harvesters are equipped with air suction fans, which help remove some plant and insect debris.

Resistant Cultivars: None available.

Issues for Harvest Contaminants

1. Harvest contaminants such as earwigs, caterpillars, stink bugs, weevils are often an issue with machine-harvested raspberries. There is a need for more products with short pre-harvest intervals to support the competitiveness of the Canadian industry.

Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in raspberry production in Canada

Active ingredients registered for the management of **insects and mites** in raspberry are listed below in Table 9 *Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in raspberry production in Canada*. This table also provides registration numbers for **products registered on raspberry as of November 30, 2018** for each active ingredient, in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **insects and mites**, the reader is referred to individual product labels on the PMRA label database, https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
abamectin	24551, 31607	avermectin, milbemycin	6	glutamate-gated chloride channel (GluCl) allosteric modulator	RE
acequinocyl	28641	acequinocyl	20B	mitochondrial complex III electron transport inhibitor	R
acetamiprid	27128	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	11252, 24978, 26508	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	26854, 27750	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
bifenazate (British Columbia only)	27925	bifenazate	20D	mitochondrial complex III electron transport inhibitor	R
bifenthrin	31396	pyrethroid, pyrethrin	3A	sodium channel modulator	R
canola oil	32408, 32819	not classified	N/A	unknown	R

…continued

Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
carbaryl	17534, 22339, 27876	carbamate	1A	acetylcholinesterase (AChE) inhibitor	R
chlorantraniliprole	28981	diamide	28	ryanodine receptor modulator	R
clofentezine	21035	clofentezine	10	mite growth inhibitor	R
cyantraniliprole	30895	diamide	28	ryanodine receptor modulator	R
cypermethrin	30316	pyrethroid, pyrethrin	3A	sodium channel modulator	R (RVD2018-22)
diazinon	11889, 15921, 27538	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R
ferric phosphate	27085, 27096, 30025	not classified	N/A	unknown	R (RVD2018-23)
ferric sodium ethylenediamine tetra acetic acid (EDTA)	28774	not classified	N/A	unknown	R
flupyradifurone	31452	butenolide	4D	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
imidacloprid	24094, 28475	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*

…continued

Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
kaolin	27469	not classified	N/A	unknown	R
lime sulphur or calcium polysulphide	16465	not classified	N/A	unknown	R
malathion	8372	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R
metaldehyde	26650, 32149	not classified	N/A	unknown	R
methoxyfenozide	27786	diacylhydrazine	18	ecdysone receptor agonist	R
mineral oil	27666, 33099	not classified	N/A	unknown	R
oxamyl	17995	carbamate	1A	acetylcholinesterase (AChE) inhibitor	R
potassium salts of fatty acids	14669, 27886, 31433	not classified	N/A	unknown	R
pyridaben	25135	METI acaricide and insecticide	21A	mitochondrial complex I electron transport inhibitor	RE

…continued

Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
pyrethrin	30164	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
spinetoram	28777, 28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	R
spinosad	26835, 27825, 30382	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	RE
spiromesifen	28905	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spirotetramat	28953	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
thiamethoxam	28408	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*

…continued

Table 9. Pesticides and biopesticides registered for insect and mite management in raspberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
Soil fumigant					
methyl bromide	19498	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]

[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 November 30, 2018.** While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on raspberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.4; May 2018)* (excluding pheromones) (www.irac-online.org) (accessed Aug. 23, 2018).

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

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

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Weeds

Key Issues

- Weed management continues to be challenging in raspberry. Alternative, residual herbicides are required for the management of both annual and perennial weeds.
- An IPM approach for the management of annual and perennial grass weeds needs to be developed for use in raspberry production.

Table 10. Occurrence of weeds in raspberry production in Canada

Weed	British Columbia	Ontario	Quebec
Annual broadleaf weeds			
Annual grass weeds			
Perennial broadleaf weeds			
Canada thistle			
Creeping yellow cress			
Curled dock			
Perennial grass weeds			
Quackgrass			
Field horsetail			
Yellow nutsedge			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest not present.			
Data not reported.			

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

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

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

	Practice / Pest	Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Avoidance	Varietal selection / use of competitive varieties				
	Planting / harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization for balanced crop growth				
	Use of weed-free propagative materials (seed, cuttings or transplants)				
	No till or low disturbance seeding to minimize weed seed germination				
	Use of physical barriers (e.g. mulches)				
Prevention	Equipment sanitation				
	Canopy management (thinning, pruning, row or plant spacing, etc.)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to maximize crop growth				
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)				
	Weed management in non-crop lands				
Monitoring	Scouting / field inspection				
	Maintaining records of weed incidence including herbicide resistant weeds				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds				

…continued

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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Decision making tools	Economic threshold				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed presence of weed at susceptible stage of development				
	Decision to treat based on observed crop damage				
	Use of portable electronic devices in the field to access weed identification / management information				
Suppression	Use of diverse herbicide modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations				
	Biopesticides (microbial and non-conventional pesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (hand pulling, hoeing, flaming)				
	Use of stale seedbed technique				
	Targeted pesticide applications (banding, spot treatments, variable rate sprayers, etc.)				
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				

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

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

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

Information regarding the practice for this pest is unknown.

[1]Source: Raspberry stakeholders in reporting provinces (British Columbia, Ontario and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Weeds

Pest Information

Damage: Annual and perennial grass and broadleaf weeds compete with raspberry plants for water and nutrients. In addition, weeds interfere with harvesting efficiency and reduce air circulation, thus increasing the likelihood of cane, fruit and foliar diseases. Many weeds are also hosts to nematode species, a number of which are vectors to virus diseases.

Life Cycle: Winter annuals are weeds that germinate in the fall, overwinter in a vegetative state, flower in the spring, form seeds and then die. Summer annual weeds germinate in the spring, flower and fruit in the summer or fall, dying before the onset of winter.

Simple perennials regenerate each year from a root or crown tissues and reproduce by flowering and setting seed. Creeping perennials can regenerate from roots, shoots and other structures and can also reproduce by flowering. Broken root pieces, tubers and rhizomes can give rise to a new weed.

Pest Management

Cultural Controls: Cultural controls of **annual weeds** include mechanical weeding, hand weeding, cover cropping and mulching. Weeds between the rows are managed primarily by regular, frequent, shallow cultivation during the growing season and/ or use of perennial or annual cover crops. Managing all types of weeds in headlands and other non-productive areas and preventing weeds from setting seed on cropland can gradually decrease the reservoir of weed seeds in raspberry fields. Weeds are controlled in areas immediately around fields primarily by maintaining year-round sod, which is mowed regularly during the growing season.

Avoiding infested fields when establishing a new raspberry planting can reduce problems due to **perennial weeds**. Removing seedlings during hand weeding operations and following strict sanitation procedures to avoid spreading perennial roots, tubers or rhizomes, will help prevent new weed infestations. Prior to planting new fields, perennial weeds may be controlled by cultivation and herbicide treatments. Deep ploughing to thoroughly invert the soil is an effective cultural control of nutsedge infestations.

Issues for Weeds

1. An alternative residual herbicide is needed for control of perennial weeds such as creeping yellow cress, yellow nutsedge, field bindweed, curled dock, buttercup, goldenrod, vetch, thistles, wild burdock, purple dead nettle and Watson's willow herb.
2. The development of an integrated approach to the management of perennial weeds is required.

Herbicides and bioherbicides registered for weed management in raspberry production in Canada

Active ingredients registered for the management of **weeds** in raspberry are listed in *Table 12. Herbicides and bioherbicides registered for weed management in raspberry production in Canada*. This table also provides registration numbers for **products registered on raspberry as of December 5, 2018** for each active ingredient, in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **weeds**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

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

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
2,4-D	5931, 14726, 17511, 26163, 28271, 29248, 31332	phenoxy-carboxylic-acid	4	synthetic auxin	R (REV2017-08)
2,4-D (present as choline salt)	32412	phenoxy-carboxylic-acid	4	synthetic auxin	R (REV2017-08)
ammonium soap of fatty acids	30012, 30515	not classified	N/A	not classified	R
carfentrazone-ethyl	28573, 33127	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
dichlobenil	12533	nitrile	20	inhibition of cell wall synthesis site A	R
fluazifop-p-butyl	21209	aryloxyphenoxy-propionate 'FOP'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
flumioxazin	29231, 29235	N-phenylphthalimide	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R

…continued

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

Active Ingredient[1]	**Product Registration Numbers**	**Chemical Family**[2]	**Resistance Group**[2]	Site **of Action**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
glufosinate ammonium	23180, 24081, 28532	phosphinic acid	10	inhibition of glutamine synthetase	R
glyphosate (present as dimethylamine salt)	29775, 28840, 28977, 29774, 30319, 30516, 31090	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salt)	numerous products	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salt and potassium salt)	29888, 31316, 32228, 32532, 33029, 33030	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as potassium salt)	27487, 27764, 27988, 28198, 28608, 28609, 29841, 29868, 30104, 32504	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
indaziflam	30220, 30221, 30451	unknown	29	inhibition of cell wall synthesis site C	R
napropamide	25231, 31081, 31688	acetamide	15	inhibition of mitosis	R
oxyfluorfen	24913	diphenylether	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R

…continued

Table 13. Herbicides and bioherbicides registered for weed management in raspberry production in Canada

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
paraquat (present as dichloride)	8661, 33125	bipyridylium	22	photosystem-I-electron diversion	R
rimsulfuron	30057	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R
sethoxydim	24835	cyclohexanedione 'DIM'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
simazine and related triazines	15902, 16370, 23181	triazine	5	inhibition of photosynthesis at photosystem II site A	R
sulfentrazone	29012, 32846	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
terbacil	10628, 30082	uracil	5	inhibition of photosynthesis at photosystem II site A	R

…continued

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

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Soil fumigant					
metam-sodium	19421, 25103, 28247, 29128, 29142	methyl isothiocyanate generator	8F[4]	miscellaneous non-specific (multi-site) inhibitor[4]	RE
methyl bromide	19498	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]

[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 December 05, 2018.** While every effort has been made to ensure all herbicides, bioherbicides and plant growth regulators registered in Canada on raspberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Weed Science Society of America (WSSA). Herbicide Site of Action Classification list (last modified August 16, 2017) http://wssa.net (accessed August 23, 2018)

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.4; May 2018)* (www.irac-online.org) (accessed August 23, 2018).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Vertebrate Pests

Field mice occasionally kill plants by chewing on crowns and stripping bark. Deer and porcupines cause considerable damage by direct feeding on both primocanes and floricanes. Fencing raspberry plantings can help keep deer out. Birds feed on ripe fruit, but generally damage is minor.

Resources

Integrated Pest Management / Integrated Crop Management Resources for Production of Raspberry in Canada

Agri-Réseau, Petits fruits. Centre de référence en agriculture et agroalimentaire du Québec. www.agrireseau.qc.ca/petitsfruits/

British Columbia Ministry of Agriculture. *2012 Berry production Guide – Beneficial Management Practices for Berry growers in British Columbia.* http://productionguide.agrifoodbc.ca

Bushway, Lori, Marvin Pritts and David Handley (Technical editors). 2008. *Raspberry and Blackberry Production guide for the Northeast, Midwest and Eastern Canada*, *NRAES-35*. Natural Resource, Agriculture and Engineering Service Cooperative Extension, Ithaca, New York. 157 p.

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

IRDA. Institut de recherche et de développement en agroenvironnement. 2017. *Framboise: Production fruitière intégrée.* Liste de pesticides recommandés. https://www.irda.qc.ca/assets/documents/Publications/documents/production_fruitiere_integree-framboise2017.pdf

Munger, A., G. Legault, GA. Landry. 2018. *Survol des pratiques et des recherches sur la Framboise Biologique d'ici et d'ailleurs*. Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ). Pub. No. PPTF0125-02PDF. 22 pp.

Ontario Ministry of Agriculture, Food and Rural affairs. *Guide to Fruit Production*, 2018-19, Publication 360. 443 pp. Available online at: http://www.omafra.gov.on.ca/english/crops/pub360/p360toc.htm

Ontario Ministry of Agriculture, Food and Rural affairs. *Publication 105, Growing Red Raspberries in Ontario.* 2011. Order *No. 105, Agdex No. 230.* http://www.omafra.gov.on.ca/english/crops/pub105/p105order.htm

Ontario Berry Growers: Ontario Ministry of Agriculture, Food and Rural Affairs. 2016. In collaboration with University of Guelph. *Growing Raspberries in Tunnels and Greenhouses: maximizing yield*. http://www.omafra.gov.on.ca/english/crops/hort/news/allontario/ao0216a4.htm

Perennia. Fruit Production Raspberry Publications. http://perennia.ca/fruit.php

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/agri	Maria Jeffries Plant Health Coordinator Maria.Jeffries@gov.bc.ca	Caroline Bédard caroline.bedard@gov.bc.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Erica Pate Fruit Crop Specialist (Berry) erica.pate@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Québec	Ministère de l’Agriculture, des Pêcheries et de l’Alimentation du Québec www.mapaq.gouv.qc.ca	Christian Lacroix Horticulture Specialist christian.lacroix@mapaq.gouv.qc.ca	Mathieu Coté mathieu.cote@mapaq.gouv.qc.ca

National and Provincial Small Fruit Grower Organizations

Provincial:

Association des producteurs de fraises et de framboises du Québec (APFFQ);
http://fraisesetframboisesduquebec.com/

British Columbia Raspberry Industry Development Council;
http://bcraspberries.com/growers/

Berry Growers of Ontario;
http://ontarioberries.com/

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

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

National:

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

Organic Federation of Canada;
http://organicfederation.ca/

Appendix 1

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

Information on the occurrence of disease, insect and mite, and weed pests in each province is provided in Tables 4, 7 and 10 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and pressure in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th rowspan="2">Colour Code</th></tr>
<tr><td rowspan="15">Present</td><td rowspan="13">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</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>

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