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Crop Profile for Spring Wheat in Canada, 2010

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

Canada

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Preface

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

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticides or pest control techniques 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 spring wheat, 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.

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

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

Table of Contents

List of Tables and Figure

Crop Profile for Spring Wheat in Canada

Spring wheat (*Triticum aestivum* and *T. turgidum* var. *durum*) has a special place as a crop in Canada in that it was first grown by pioneers, opening up the agricultural areas of Canada in the1800's. Currently, it is one of the most important crops in Canada, comprising over eight million hectares. The crop is consumed throughout Canada and in more than 70 countries worldwide. Because of the enormous area involved in wheat production, the crop has received much attention from industry and government scientists with respect to the development of crop varieties. The bulk of breeding for spring wheat in Canada is supported through provincial and federal government research programs, and by a $3M check-off fund paid by growers which is administered by the Western Grains Research Foundation (www.westerngrains.com). Over 175 varieties are categorized into 12 spring wheat types are grown in Canada. These include:

Canada Western Red Spring (CWRS)
Canada Prairie Spring Red (CPSR)
Canada Prairie Spring White (CPSW)
Canada Western Extra Strong (CWES)
Canada Western Amber Durum (CWAD)
Canada Western Soft White Spring (CWSWS)
Canada Western Hard White Spring (CWHWS)
Canada Western General Purpose (CWGP)
Canada Eastern Hard White Spring (CEHWS)
Canada Eastern Amber Durum (CEAD)
Canada Eastern Red Spring (CERS)
Canada Eastern Soft White Spring (CESWS)

Spring wheat is processed into flour, cereal food and feed, bread, pasta and bakery products. Durum wheat is processed into semolina flour that is used to make pasta and couscous. Red spring wheat is recognized as premium quality wheat, ideal for bread making due to its superior milling qualities, baking characteristics and protein content. The prairie spring wheat classes are known for their medium protein, medium kernel hardness and medium dough strength properties, which is desirable for special end uses. Furthermore, due to its higher starch content and lower protein concentration in comparison to red spring wheat, prairie spring wheat has recently become recognized as a viable feedstock for ethanol production.

Crop Production

Industry Overview

General production information is presented in table 1.

Table 1. General Production Information[1,2]

Canadian Production (2010)[1]	24 million tonnes 9,350,000 hectares (cultivated area)
Farm gate value (2010)[1]	million
Domestic consumption (2010)	kg/person
Exports (2010 - 11)	17.3 million tonnes
Imports (2010 - 11)	52,000 tonnes

[1]Source: Market Outlook Report Volume 2 No. 1 April 1, 2010 (ISSN 1920-20082X AAFC No. 10918E)

[2]Figures include both spring and winter wheat.

Production Regions

While wheat is the largest crop in Canada, the area in spring wheat has declined steadily since the early-1990s as farmers have moved towards more diversified cropping systems. Approximately 64,000 grain farmers in Western Canada produce between 22 and 24 million tonnes of wheat every year. Most of the Canadian production of spring wheat occurs in the west. The distribution of national production is presented in table 2.

Table 2. Distribution of spring wheat (including durum) production in Canada[1]

Production Regions	Non-durum wheat (000's of ha's)	Durum wheat (000's of ha's)	Total spring wheat cultivated area 2010 (000's of ha's)	Total spring wheat cultivated area (percent national ha's)
British Columbia	24.2	-	24.2	0.3%
Alberta	2,428.1	145.7	2,573.8	32.4%
Saskatchewan	2,974.3	1,129.1	4,103.4	51.7%
Manitoba	1,133.0	-	1,133.0	14.3%
Ontario	46.5	-	46.5	0.6%
Quebec	48.5	-	48.5	0.6%
Atlantic Provinces	12.4	-	12.4	0.2%
Canada	6,667.0	1,274.8	7,941.80	100.1%

[1]Source: Statistics Canada Field Crop Reporting Series Vol 90 # 2 Catalogue Number 22-002 X1B

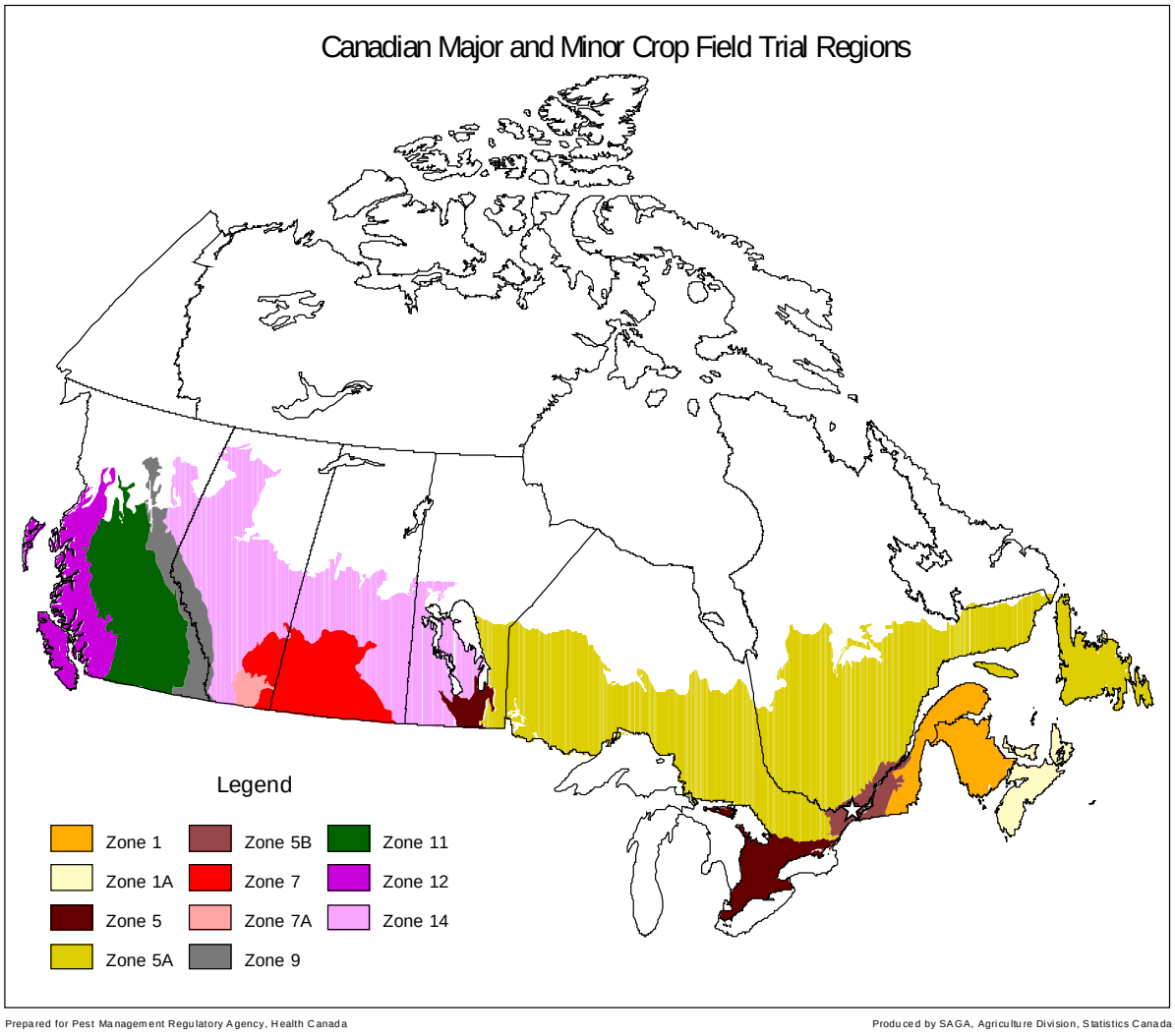

Figure 1. Common Zone Map: Canadian Major and Minor Field Trial Regions

The major and minor crop field trial regions were developed following extensive stakeholder consultation and have been harmonized between the Pest Management Regulatory Agency (PMRA) and the Environmental Protection Agency of the USA. The identified regions are used for experimental studies in support of residue chemistry data requirements for the registration of new pesticide uses. The regions are based on soil type and climate and do not correspond to plant hardiness zones. For additional information, please consult the PMRA Directive 98-02 Residue Chemistry Guidelines (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir98-02/index-eng.php).

Cultural Requirements

In the prairie region, spring wheat is typically grown as part of diverse crop rotations that include canola, pulse crops (eg. pea or lentil) and other cereal crops (eg. barley or oats). Spring wheat on the prairies is typically grown using no-till management.

Outside the prairie region, spring wheat is typically grown under a conventional tillage system. In central and Atlantic Canada, spring wheat is grown as a rotational crop in a variety of cropping systems including small grain-oilseed rotations, forage-based rotations, corn-soybean rotations and potato/vegetable-based rotations.

Spring wheat is a widely adapted crop and can be grown on various soil types. It is best suited to well-drained soils that have not been seeded to a wheat crop in the previous year. It is best to establish spring wheat into a firm, moist, weed-free seedbed. Weeds need to be controlled either with a pre-seed herbicide application or with tillage prior to seeding. Spring wheat should be planted at a uniform depth between 2 and 4 cm. Depending on the growing region, target plant populations for spring wheat range from 200 plants/ m^2 to 450 plants/ m^2, with optimal target populations tending to increase from drier to more humid climates.

Fertilizer should be applied in below-surface bands that give the crop preferential access to the nutrients.

Table 3. General spring wheat production and pest management schedule in Canada

TIME OF YEAR	ACTIVITY	ACTION
Winter (November to late March)	Planning	Crop planning. Source seed supplies.
April	Weed Management	Calibrate application equipment.
	Plant Care	Prepare seed and fertilizer for planting. Calibrate seeding equipment.
	Soil Care	Conduct soil tests.
May	Weed Management	Pre-seeding glyphosate application or cultivation prior to seeding for weed control.
	Plant Care	Seed spring wheat
	Soil Care	Fertilize according to soil test
June	Weed Management	Scout fields for weeds; apply herbicide if warranted.
July	Plant care	Monitor crop development
	Disease Management	Scout fields for all diseases; apply fungicide if warranted
	Insect Management	Scout fields for all insects; apply insecticide if warranted
August	Plant Care	Monitor seed set to estimate yield potential
	Disease Management	Continuation of field scouting for all diseases; fungicide application if warranted
	Weed Management	Scout fields for perennial weeds. Apply pre-harvest glyphosate herbicide treatment if warranted.
September	Plant Care	Harvest when 75% of seeds have reached maturity
	Soil care	Harrow fields after harvest for residue management
October	Soil care	Conduct soil tests
	Weed Management	Scout fields for weeds; apply herbicide if warranted.

Abiotic Factors Limiting Production

Moisture: soil water and in-season precipitation

The amount of water available to the crop either from stored soil water or from in-season precipitation is the most important weather factor affecting spring wheat production. Both the amount of precipitation and how it is distributed throughout the growing season affects production. Dry weather in critical periods in the late-spring and summer negatively affects spring wheat yields.

Soil water conservation practices like no-till farming can increase the amount of stored soil water and reduce evaporation rates. These conservation agriculture systems have improved the drought resilience of spring wheat production, reducing the impact of summer droughts.

Flooding

Spring flooding from snowmelt may delay seeding until late-June, increasing the risk of impact on the crop from fall frost. Spring flooding can also reduce the amount of land seeded to spring wheat. In addition, in-season flooding from high levels of precipitation can drown wheat crops.

Frost

Fall frost negatively affects spring wheat quality. The level of frost damage to spring wheat depends on both the maturity of the crop and the severity of the frost. Fall frost can be expected any time after early-September. Early frost, occurring in mid to late August, can severely damage spring wheat and affect both yield and quality.

Occasionally spring frost can damage spring wheat seedlings and reduce plant populations.

Physiological leaf spot

Wheat varieties differ in their susceptibility to physiological leafspot. Symptoms of physiological leafspot begin as small yellow (chlorotic) spots, 1-3 mm in diameter, on the upper leaves, that eventually develop dark brown centers. Physiological leaf spot is often confused with leaf spot complex diseases like tanspot, stagonospora and septoria leaf spots.

Physiological leaf spots develop from the interaction of genetic factors with the environmental conditions during the growing season. Physiological leaf spots often occur following extended cloudy periods interspersed with a few sunny days. The leaf spots are the result of UVA and UVB damage. In addition, other causes of leaf spotting are nutrient deficiencies and herbicide injury.

Key Issues

- There is a need for alternatives to triazole fungicides to facilitate resistance management in relation to *Fusarium* head blight pathogens.
- There is a need to focus on integrated approaches to disease management.
- Commodity prices can impact rotation decisions, often to the detriment of disease management. There is a need for other cropping options that provide economic returns and readily fit into producer's cropping programs.

Diseases

Table 4. Occurrence of diseases in spring wheat in Canada[1, 2]

Diseases	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	Atlantic Provinces
Seedling rots and blights; root rots						
Take-all						
Barley Yellow Dwarf Virus						
Stem rust						
Leaf rust						
Stripe rust						
Powdery Mildew						
Ergot						
Fusarium head blight (scab)						
Common bunt						
Loose smut	F					
Leaf spot complex						
Tan spot						
Septoria/ Stagonospora leaf blotch						

Widespread yearly occurrence with high pest pressure

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

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

F -This pest is present in this province but its frequency is unknown.

Pest not present

DNR - data not reported

[1]Source: Wheat stakeholders in reporting provinces.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 5. Adoption of disease management practices for spring wheat in Canada[1]

Practice / Pest		Seedling rots and blights	Leaf spot complex	Rusts	Ergot	Fusarium head blight
Avoidance	resistant varieties	■	■	■		■
	planting / harvest date adjustment	■	■	■		■
	crop rotation	■	■	■	■	■
	choice of planting site	■	■	■	■	■
	trap crops - perimeter spraying					■
	use of disease-free seed or transplants	■	■	■	■	■
	optimizing fertilization	■	■	■	■	■
	reducing mechanical damage / insect damage					
	thinning / pruning					
Prevention	equipment sanitation	■	■	■	■	■
	mowing / mulching / flaming				■	
	removal of alternative or wild hosts	■	■		■	■
	row or plant spacing (plant density)	■	■	■	■	■
	seeding depth	■	■	■	■	■
	water / irrigation management	■				■
	pruning out / elimination of infected crop residues	■	■	■	■	■
Monitoring	scouting - trapping	■	■	■	■	■
	records to track diseases	■	■	■	■	■
	soil analysis				■	
	weather monitoring for disease forecasting	■	■	■	■	■
	grading out infected produce	■	■	■	■	■
Decision Making Tools	economic threshold	■	■	■		■
	weather / weather-based forecast / predictive model	■	■			■
	recommendation from crop specialist	■	■	■	■	■
	first appearance of pest or pest life stage		■	■		
	observed crop damage	■	■	■	■	■
	crop stage	■	■	■	■	■
	calendar spray					■
Suppression	biological pesticides					
	beneficial organisms & habitat management					
	environmental management (as in greenhouses)	■	■			■
	pesticide rotation for resistance management	■	■	■	■	■
	soil amendments	■	■			
	controlled atmosphere storage					
New Practices (on a provincial basis)	**Alberta** - integration of strategies	■	■	■	■	■
	Saskatchewan - tank mixing fungicide modes of action to delay resistance development	■	■			■
	Quebec - green manure - intercropping					
	Quebec - management of soil	■				

■ **This practice is used to manage this pest in at least one reporting province.**

This practice is not used or not applicable for the management of this pest, or information regarding the practice for this pest is unknown.

[1]Source: Wheat stakeholders in producing provinces (AB, SK, MB, ON, QC and Atlantic provinces).

Table 6. Fungicides registered for disease management in spring wheat in Canada

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
azoxystrobin	methoxy-acrylate	C3. respiration	11	R	septoria leaf spot, stripe rust (Puccinia striiformis), tan spot (Pyrenophora tritici-repentis), leaf rust (Puccinia triticini)
carbathiin + thiram (seed treatment)	oxathiin carboxamides + dithio-carbamate and relatives	C2. respiration + multi-site contact activity	7 + M3	RE + RE	loose smut, stinking smut or bunt, seed borne dwarf bunt, leaf stripe, seed borne *Septoria* spp., seed rot and seedling blight (*Pythium* spp. and *Penicillium* spp.), seed rot and seedling blight (*Fusarium* spp. and *Cochliobolus sativus*), seed rot (*Aspergillus* spp. and *Alternaria* spp.) **Diseases suppressed:** root rot (*Cochliobolus sativus* and *Fusarium* spp.)
chlorothalonil	chloronitrile (phthalonitrile)	Multi-site contact activity	M5	RE	fusarium head blight (scab) (suppression), septoria glume blotch, septoria leaf spot, tan spot
difenoconazole + metalaxyl M (seed treatment)	triazole + acylalanine	G1: sterol biosynthesis in membranes + A1: nucleic acid synthsis	3 + 4	R	general seed rots (fusarium, pythium, penicillium and aspergillus), damping off (fusarium, pythium), seedling blight (fusarium, pythium), common bunt, dwarf bunt, loose smut, seed borne *Septoria* spp., septoria leaf blotch **Diseases suppressed:** common root rot (*Cochliobolus* spp.), fusarium crown and foot rot, take-all

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
fludioxonil (seed treatment by commercial seed treatment applicators)	phenylpyrrole	E2: signal transduction	12	R	damping off diseases, seed decay, seedling blights
ipconazole (seed treatment)	triazole	G1: sterol biosynthesis in membranes	3	R	general seed rots (penicillium, aspergillus), damping off, seedling blight (fusarium, *Cochliobolus sativus*), common bunt, loose smut **Diseases suppressed:** common root rot (*Cochliobolus sativus*), crown and foot rot (*Fusarium* spp.)
mancozeb	dithio-carbamate and relatives	Multi-site contact activity	M3	RE	leaf rust, septoria blotch, stinking smut or bunt, tan spot
maneb	dithio-carbamate and relatives	Multi-site contact activity	M3	DI	common bunt, seedling blight (including fusarium), root rot
metalaxyl-M (seed treatment)	acylalanine	A1: nucleic acids synthesis	4	R	Pythium damping off
metconazole	triazole	G1: sterol biosynthesis in membranes	3	R	leaf rust (*Puccinia recondita*), septoria leaf spot (*Septoria tritici* or *S. nodorum*), tan spot (*Pyrenophora tritici-repentis*) **Diseases suppressed:** spot blotch (*Cochliobolus sativus*)

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
metaconazole + pyraclostrobin	triazole	G1: sterol biosynthesis in membranes	3 + 11	R	tan spot (*Pyrenophora tritici-repentis*), septoria leaf spot (*Septoria tritici* or *Stagonospora nodorum*), leaf rust (*Puccinia recondita*), stripe rust (*Puccinia striiformis*), powdery mildew (*Erysiphe graminis* f. sp. *tritici*)
propiconazole	triazole	G1: sterol biosynthesis in membranes	3	R	stem rust, leaf rust, powdery mildew, septoria leaf spot, septoria glume blotch, stripe rust, tan spot
prothioconazole	triazole	G1: sterol biosynthesis in membranes	3	R	glume blotch (*Stagonospora nodorum*), speckled leaf blotch (*Septoria tritici*), leaf rust (*Puccinia recondita*), powdery mildew (*Erysiphe graminis*), tan spot (*Pyrenophora tritici-repentis*) **Diseases suppressed:** fusarium head blight (*Fusarium* spp.) or scab (*Gibberella zeae, Fusarium graminearum*)
prothioconazole (seed treatment)	triazole	G1: sterol biosynthesis in membranes	3	R	seed rot / damping-off / seedling blight (*Fusarium* spp. and *Cochliobolus sativus*), seedling blight (*Aspergillus* spp.), common bunt (*Tilletia foetida*) **Diseases suppressed:** loose smut (*Ustilago tritici*), fusarium root and crown rot, root rot (*Cochliobolus sativus*), seedling blight (*Penicillium* spp.)

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
prothioconazole + tebuconazole	triazole	G1: sterol biosynthesis in membranes	3 + 3	R	leaf rust, stem rust, stripe rust, leaf and glume blotch (*Septoria tritici, Stagonospora nodorum*), tan spot (*Pyrenophora tritici-repentis*), powdery mildew (*Erysiphe graminis*) **Diseases suppressed:** Fusarium head blight (*Gibberella zeae, Fusarium graminearum*)
pyraclostrobin	methoxy-carbamate	C3. respiration	11	R	leaf rust (*Puccinia recondita*), powdery mildew (*Erysiphe graminis* f. sp. *tritici*), septoria leaf spot (*Septoria tritici* or *Leptosphaeria nodorum*), spot blotch (*Cochliobolus sativus*), stripe rust (*Puccinia striiformis*), tan spot (*Pyrenophora tritici-repentis*)
tebuconazole	triazole	G1: sterol biosynthesis in membranes	3	R	leaf rust *(Puccinia triticina*), stem rust (*Puccinia graminis*), stripe rust (*Puccinia striiformis*), septoria glume blotch (*Stagonsopora nodorum*), septoria leaf blotch (*Septoria tritici*), tan spot (*Pyrenophora tritici-repentis*), powdery mildew (*Erysiphe graminis*)**Diseases suppressed:** Fusarium head blight (scab) (*Giberella zeae, Fusarium graminearum*)
tebuconazole (seed treatment)	triazole	G1: sterol biosynthesis in membranes	3	R	loose smut, stinking smut or common bunt, seed rots, seedling blights **Diseases suppressed:** common root rot, crown and root rot (caused by Fusarium spp.)

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
tebuconazole + metalaxyl (seed treatment)	triazoles	G1: sterol biosynthesis in membranes	3 + 4	R	common bunt or stinking smut, damping-off (*Pythium* spp.), loose smut, seed rot and damping-off (*Fusarium* spp.), seed-borne *Septoria nodorum* **Diseases suppressed:** Fusarium root and crown rot, common root rot (*Cochliobolus sativus*), seed rot and damping-off (*Cochliobolus sativus*), seedling blight caused by seed-borne *Cochliobolus sativus*
tebuconazole + prothioconazole + metalaxyl (seed treatment) (L1397 seed treatment)	triazoles	G1: sterol biosynthesis in membranes	3 + 3 + 4	R	seed rot, damping-off, seedling blight (*Fusarium* spp., *Cochliobolus sativus* and *Pythium* spp.), loose smut, common bunt **Diseases suppressed:** Fusarium root and crown rot, common root rot (*Cochliobolus sativus*), seedling blight (*Penicillium* spp.)
tebuconazole + thiram (seed treatment)	triazole	G1: sterol biosynthesis in membranes	3 + M3	R	seed rot (*Fusarium* spp.), seedling blight (*Fusarium* spp.), seed rot caused by saprophytic fungi (penicilliun, aspergillus and alternaria), seed-borne septoria, common bunt (seed and soil borne), loose smut, pythium seed rot**Diseases suppressed:** fusarium root and crown rot
tebuconazole + trifloxystrobin	triazole	G1: sterol biosynthesis in membranes	3 + 11	R	leaf rust, stem rust, stripe rust, powdery mildew, septoria leaf blotch, tan spot

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
triadimenol	triazole	G1: sterol biosynthesis in membranes	3	R	loose smut, powdery mildew, stinking smut (common bunt)
trifloxystrobin	oximino acetates	C3. respiration	11	R	leaf blight (*Septoria tritici*), powdery mildew (*Erysiphe graminis*), rust (*Puccinia* spp.), tan spot (*Pyrenophora tritici-repentis*)
triticonazole (seed treatment)	triazole	G1: sterol biosynthesis in membranes	3	R	seed rot caused by *Fusarium* sp., seedling blight caused by seedborne *Fusarium* sp., loose smut, common bunt**Diseases suppressed:** fusarium crown and root rot, common root rot and seedling blight (*Cochliobolus sativus*)
Triticonazole + thiram (seed treatment)	triazole + dithio-carbamate and relatives	G1: sterol biosynthesis in membranes + multi-site contact activity 3 + M3	R + RE	R + RE	seed rot and seedling blights caused by *Fusarium* sp., loose smut, common bunt, pythium damping off **Diseases suppressed:** fusarium crown and root rot, *Cochliobolus* (common) root rot, seedling blights caused by *Cochliobolus*

[1]As generated through the Homologa Directory of Registered Plant Protection Products and their allowed Maximum Residue Levels in food (www.homologa.com) (January 16, 2012) and confirmed on the PMRA website (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

[2]Source: FRAC Code List: Fungicides sorted by mode of action (including FRAC code numbering) published by the Fungicide Resistance Action Committee (February 2011) (www.frac.info/frac/index.htm).

[3] PMRA registration status: R- full registration as of January 27, 2012; PMRA re-evaluation status as of March 31, 2011: RE – under re-evaluation (yellow), DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation. Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels should be consulted for up to date accurate information concerning the use of these pesticides and specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php.

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

Fusarium head blight *(Fusarium graminearum and Fusarium* spp.*)*

Pest information

Damage: Fusarium head blight (FHB) causes premature bleaching of infected spikelets and the production of orange/pink, spore-bearing structures on infected wheat heads. Fusarium infection of crown and root tissues often coincides with head blight. FHB reduces yield and grade, and may also contaminate the grain with deoxynivalenol (DON) vomitoxin. DON renders the grain unfit for human food or animal feed. The disease is caused by several species of fusarium, but *Fusarium graminearum* is the most predominant and aggressive species involved.

Life Cycle: The species involved in FHB are facultative parasites capable of infecting all plant parts. Fusarium is found on a wide range of hosts including wheat, barley, oats, corn, rye and wild grasses. FHB pathogens overwinter in crop residue, soil, grass, weeds and in the seed. Seedlings can be infected at emergence. Spores produced in early infection sites are spread by rain or wind and cause new infections on structures on the flower and wheat head. Infections are most frequent and severe at flowering. The disease thrives under warm, humid conditions during flowering. FHB may be introduced into new areas on contaminated seed.

Pest management

Cultural Controls: In areas where the disease is not yet present, intensive monitoring of seed supplies and fields will restrict its introduction. In areas where the disease is prevalent, cultural controls including the use of disease free seed, controlling other hosts such as quackgrass and barnyard grass and rotating wheat with non-host crops, will help reduce levels of disease. In high risk areas, seeding wheat into corn residue should be avoided.

Resistant Cultivars: Most spring wheat varieties have very poor to fair resistance to FHB. However, red spring wheat varieties are less susceptible to FHB than other spring wheat or durum classes and a few red spring wheat varieties are rated to have moderate resistance to FHB.

Chemical Controls: Seed treatments control seed borne inoculum and protect against seedling blight, but do not prevent infection from inoculum later in the growing season. Foliar fungicides registered for the suppression of FHB. These products have a narrow window of application. Refer to Table 6.

Issues for fusarium head blight

1. There is a need for the development of resistant varieties to be used as part of an over-all integrated disease management approach for Fusarium head blight.
2. There is a need for reduced risk pesticide alternatives for control of the foliar phase of the disease.
3. There is a need to develop fungicidal treatments with different modes of action than the triazole family for resistance management.
4. There is a need to facilitate grower adoption of an integrated approach to this disease including: the use of rotations, early seeding, resistant cultivars and timely harvesting.

Seedling rots and blights, root rots (*Fusarium* spp., *Pythium* sp., *Cochliobolus sp. and Rhizoctonia* sp.)

Pest information

Damage: This group of diseases affects plants while they are germinating or in initial growth stages. Infected seedlings fail to emerge, or may look yellow with brown or red-brown decay on the lower stem. Plants attacked at later stages of growth develop root rot. Severe disease can cause significant yield losses, particularly when conditions do not favour seedling emergence (eg. cold soils, deep planting).

Life Cycle: Spores produced in diseased tissue are spread by cultivation, wind, water and on infected seeds. These spores germinate in the soil and infect germinating seedlings. New spores are produced in infected tissues and result in secondary spread of the disease.

Pest management

Cultural Controls: Delaying seeding until soils have warmed up to the point where rapid emergence can occur, is used to avoid early infection. The use of clean, disease-free seed helps minimize the incidence of the diseases. Shallow seeding reduces infection of the sub-crown internode. Rotating wheat with non-host crops like flax, canola and legumes can reduce levels of cochliobolus spores in the soil. Several non-cereal crops are also hosts for fusarium so rotating with these crops will not reduce these species. Maintenance of adequate fertility levels can help to reduce disease severity.

Resistant Cultivars: None available.

Chemical Controls: There are several seed treatments that will control this group of diseases. Refer to Table 6.

Issues for seedling rots and blights, root rots

1. There is a need to develop fungicidal treatments having different modes of action than the triazole fungicides, for resistance management.
2. There is a need for the development of cultivars with resistance to seedling blight diseases.

Take-all (*Gaeumannomyces graminis*)

Pest information

Damage: Take-all affected plants become stunted with few tillers and develop whiteheads. Conspicuous patches of whiteheads containing shrivelled or no kernels are common with this disease. Dark runner hyphae may be observed on the roots. While whiteheads can have many causes, take-all can usually be distinguished by a shiny black appearance of infected lower stems and fungal growth under the leaf sheaths. Light levels of infection often go unnoticed but yield losses of up to 30% have been observed in severely affected fields.

Life Cycle: The pathogen overwinters as mycelium in infected plants or crop residues. Hyphae growing from residue fragments initiate the disease in wheat. Once infected, runner hyphae grow from root to root. Infection can occur throughout the growing season. Soil temperatures from 12°-20°C and high soil moisture favour the development of take-all.

Pest management

Cultural Controls: Crop rotations with non-host crops such as corn, flax, canola or oats can reduce disease severity. Preceding wheat with legumes such as beans, soybean or alfalfa, is less effective. Maintaining adequate phosphorus and potassium fertility reduces disease severity. Grassy weeds and volunteer wheat help maintain take-all in the field and should be controlled.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for take-all

None identified.

Barley yellow dwarf virus (BYDV)

Pest information

Damage: Barley yellow dwarf virus (BYVD) infection in wheat causes leaves to become various shades of yellow, red or purple from tip to base and from margin to midrib. In addition, plant growth may be stunted and have fewer tillers. Hot, dry weather causes discoloured leaves to die. BYDV may reduce head size in infected plants and the apical and basil spikelets may become sterile.

Life Cycle: This disease is transmitted by aphids. The development of this disease often depends on the arrival of aphids that are blown-in on air currents from the southern United States. Infections can occur throughout the growing season but are higher later in the growing season when aphid populations are highest. BYDV can overwinter on winter wheat and perennial grasses that were infected in the fall.

Pest management

Cultural Controls: Planting date affects the potential for severity of the disease and yield loss. Late planted spring cereals may be subject to high aphid populations at early growth stages, resulting in greater yield loss. Controlling volunteer cereal crops and perennial grassy weeds will help eliminate late season hosts.

Resistant Cultivars: None available.

Chemical Controls: None available

Issues for Barley Yellow Dwarf Virus

None identified.

Leaf spot complex: Tanspot/ Septoria / Stagonospora leaf and Glume blotch *(Pyrenophora tritici-repentis, Septoria tritici, Stagonospora nodorum)*

Pest information

Damage: Leaf spot complex diseases cause yield loss by reducing the green photosynthetic area of the leaves. Disease can spread from the leaves to the head and cause kernel discolouration and shrivelled seed, leading to downgrading. Disease is more severe during wet seasons. All classes of wheat can be infected by leaf spots.

Life Cycle: The pathogens overwinter on crop residue, in the soil and to a lesser extent on seed. Spores produced in infected residues are wind-blown to new plants where they cause new infections. Warm, humid (wet) weather is favourable for infection. Spores spread from mature infections to new leaves through wind or rain splash.

Pest management

Cultural Controls: Disease levels can be minimized with two year crop rotations and by burying crop residue. While these methods are helpful, they do not completely control leaf spot diseases in wheat crops.

Resistant Cultivars: A few western red spring and prairie spring red wheat varieties have good resistance to the leaf spot disease complex. However, the varieties in the other spring wheat classes have only limited resistance to leaf spots.

Chemical Controls: Foliar fungicides are available that will control the diseases and keep them from spreading to the glumes. Refer to Table 6. Yield reductions can be minimized if the disease is controlled before the flag leaf is infected.

Issues for leaf spot complex

1. There is a need for the development of resistant varieties for all spring wheat classes.
2. There is a need to establish the best crop stage and timing for fungicide application to maximize efficacy of treatments.

Rust (*Puccinia spp.)*

Pest information

Damage: Heavy infections of leaf rust can result in the death of the whole leaf and reduced crop yields and crop quality. Stem rust affects wheat stems and has the potential to reduce crop yields as infection results in fewer tillers and fewer seeds per head. Stem rust results in a reduction in quality (shrivelled seed) to a greater degree than leaf rust. Stripe rust attacks all the above-ground parts of the wheat plant. Stripe rust results in defoliation and shrivelling of the seed.

Life Cycle: Rust over-winters as mycelium or uredinia on wheat plants in the southern United States. It is blown into Canada on prevailing winds. Leaf rust spores infect the leaf, causing the development of small, brown, circular pustules while stem rust pustules develop on stems and

to a limited extent on leaves. Stripe rust is characterized by yellow-orange pustules which form in stripes on the leaf surface. Rust spores are produced in pustules in infected foliage and stems. When the pustules rupture, spores are released into the air and spread to other plants, eventually infecting the whole crop. High moisture and humidity levels cause the diseases to spread more quickly. Rusts rely on alternate hosts to complete their sexual reproductive stage. A barberry species is necessary as an alternative host for both stem and stripe rust. *Thalictrum* (meadow rue) is the preferred alternate host for leaf rust. However, since these alternative hosts are rare in North America, asexual reproduction is responsible for the majority of wheat rust infections. During mild winters, stripe rust can overwinter on winter wheat in parts of Canada.

Pest management

Cultural Controls: Removing common barberry, stem and stripe rust's alternate host, will reduce disease incidence. Conditions which favour early emergence of the crop can help to reduce the impact of rusts on the crop.

Resistant Cultivars: The use of varieties that are resistant to races of stem, leaf and stripe rust is a key component to managing the disease. Most spring wheat varieties in all wheat classes are rated to have good or very good resistance to stem rust. With leaf rust, while there are many resistant varieties in the western red spring and amber durum classes, there are fewer choices in other classes especially the white wheat classes. Stripe rust is a more recent pest to Canada, so there are only a few varieties rated to have good resistance.

Chemical Controls: Foliar fungicides are available to control stem, leaf and stripe rust. Refer to Table 6.

Issues for rust diseases

1. The potential introduction of the stem rust pathogen, strain Ug99, is a major concern.
2. New, virulent forms of rust constantly render current resistant genes ineffective. The continued development of resistant varieties is important.
3. The development of improved resistant varieties to stripe rust is needed as new virulent forms of this disease are suspected.
4. There is a need to provide producer education concerning rust diseases.

Powdery mildew *(Podosphaera* spp.*)*

Pest information

Damage: Powdery mildew produces characteristic greyish–white fungal growth on the surface of foliage, beginning on the lower leaves. Infection moves up the plant under favourable conditions. Damage occurs from reduced photosynthetic ability when green surfaces are shaded and the host is robbed of moisture and food by fungal growth. Yields may be reduced by 20 per cent or more. Plants affected by mildew produce fewer tillers and grains per head and the grains may be poorly filled. The disease will seriously reduce yields if the flag and penultimate leaves are affected.

Life Cycle: The fungus survives and overwinters on crop residues and infected winter wheat plants. In the spring, ascospores are spread by wind to growing plants. New infections develop and produce new conidia. The disease thrives when it is wet or humid but is susceptible to weather

conditions that promote drying of the crop environment, such as hot, dry, sunny weather. Powdery mildew spores can germinate without free water. However, the spores require nearly 100% relative humidity and temperatures between 15°C and 21°C to germinate. Fungal growth stops when temperatures exceed 25°C. Heavy crop canopies help create the humid environmental conditions that favour disease development.

Pest management

Cultural Controls: A crop rotation with non-host crops for one or two years reduces inoculum levels. Since powdery mildew thrives where high rates of nitrogen have been used, using balanced applications of nitrogen and phosphorus is recommended. The burial of residues combined with crop rotation minimizes the disease impact.

Resistant Cultivars: The use of resistant varieties is a key component of managing the disease.

Chemical Controls: Foliar fungicides are available to control powdery mildew when disease levels exceed acceptable levels. Refer to Table 6.

Issues for powdery mildew

1. Mildew on wheat is becoming a major issue in some provinces. The incorporation of powdery mildew resistance into new cultivars must continue. Varieties registered for the prairies are not currently rated for powdery mildew resistance.

Ergot (*Claviceps purpurea*)

Pest information

Damage: Ergot infects the developing grains of spring wheat. Ergot symptoms become evident during kernel formation, when ergot bodies (sclerotia) are formed in place of kernels. Ergot bodies are toxic to humans and livestock, so ergot is a serious disease even though its effect on yield is minimal. Contamination levels greater than 0.01% ergot will result in downgrading.

Life Cycle: Sclerotia on or near the soil surface germinate and produce drumstick-like structures that release ascospores. Wind-blown ascospores land on florets where they infect the ovary. Secondary infection occurs when conidia in honeydew produced from inflected florets is spread by insects or rain splash to other florets.

Pest management

Cultural Controls: Crop rotation away from susceptible crops will reduce inoculum levels. Mowing perennial grasses in adjacent fields and roadsides before they flower reduces honeydew formation and the opportunity for secondary infection from infected grasses. Planting spring wheat adjacent to winter cereals, especially fall rye should be avoided. Using clean, ergot-free seed will help reduce inoculum levels. Following management practices that favour good crop establishment and balanced fertility will help ensure that crop development is uniform and less susceptible to infection. Copper fertilization on copper deficient soils will reduce ergot infections.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for ergot

1. This disease can pose serious problems in some regions with few management options available to growers.

Common bunt (*Tilletia tritici*)

Pest information

Damage: The kernels of infected plants are replaced by bunt balls containing teliospores of the pathogen. Wheat heads may be partially or fully infected. Affected plants may be stunted and may remain green longer than healthy plants. Bunt balls resemble wheat kernels but are slightly rounder. They have a bluish-green colour that changes to grayish-brown at maturity. Bunt is often inconspicuous until the crop nears maturity. Yield losses correspond to the number of infected heads. Quality losses can be more significant. Grain contaminated with low levels of bunt balls (0.05% by weight) has a pungent, fishy odour that results in downgrading.

Life Cycle: Common bunt is predominantly a seed borne disease. The teliospores released at harvest stick to the surface of otherwise healthy grain. Teliospores can also survive in the soil for up to one year. Teliospores germinate with moisture and infect the germinating seedlings before emergence. Mycelia invade developing heads where they proliferate and replace the developing seed with teliospores.

Pest management

Cultural Controls: Use of disease free seed reduces seed-borne transmission. Crop rotation helps reduce soil-borne transmission. Late seeding of spring wheat helps reduce disease incidence.

Resistant Cultivars: Resistant varieties are available for most spring wheat classes.

Chemical Controls: Seed treatments are available that control common bunt. Refer to Table 6.

Issues for common bunt

1. This disease is controlled effectively with host resistance. There is a need for continued emphasis on the incorporation of resistance into commercial varieties.

Loose smut (*Ustilago tritici*)

Pest information

Damage: All parts of an infected wheat head except the central stem are replaced by a mass of dark brown spores. Loose smut spores are usually dispersed by rain or wind prior to harvest. Yield loss is in direct proportion to the number of infected heads. Grain quality is not affected.

Life Cycle: Infection occurs at flowering when spores landing on a floret germinate and infect the ovary. Fungal mycelia are established in the developing embryo and become dormant in the maturing kernel. When the seed germinates, the mycelia break dormancy and invade the seedling's growing point. As the head forms, the fungus invades, resulting in a mass of spores

developing instead of spikelets. The spores are mature at the time of heading when wind disperses them to healthy plants.

Pest management

Cultural Controls: The use of disease-free seed can reduce the incidence of this disease. Seed tests are available through seed labs to test seedlots for loose smut.

Resistant Cultivars: Resistant varieties are available for several spring wheat classes. Notable exceptions are for amber durum, soft white and prairie spring wheat classes which have no varieties rated to have good resistance.

Chemical Controls: Seed treatments are available that control loose smut. Refer to Table 6.

Issues for loose smut

1. This disease is controlled effectively with host resistance. There is a need for continued emphasis on the incorporation of resistance into commercial varieties.

Insect and Mite Pests

Key Issues

- There is a need for pest management strategies that target specific insect or mite pests but do not harm beneficial insects.
- New product registrations are needed to control insects and mites.

Table 7. Occurrence of insect and mite pests in spring wheat in Canada[1, 2]

Insect pests	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	Atlantic Provinces
Grasshoppers						
Cutworms						
Armyworm						
Cereal leaf beetle	3	I				
Wheat stem sawfly					F	
Hessian fly	I					
Wheat midge						
Cereal aphids	F					
Brown wheat mite	F			0	F	
Wireworms						
European chafer						
Thrips						

Widespread yearly occurrence with high pest pressure

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

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

F -This pest is present in this province but its frequency is unknown.

I -This pest is present in this province but its pressure is unknown.

3. Cereal leaf beetle is a new pest in Alberta with potential to become a serious pest. The frequency of outbreaks is unknown.

Pest not present

DNR - data not reported

[1]Source: Wheat stakeholders in reporting provinces.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 8. Adoption of insect and mite pest management practices for spring wheat in Canada[1]

Practice / Pest		Grass-hoppers	Cut-worms	Cereal leaf beetle	Wheat stem sawfly	Wheat midge	Cereal aphids	Wire-worms	European chafer
Avoidance	resistant varieties				■	■			
	planting / harvest date adjustment	■			■	■	■	■	
	optimizing fertilization					■	■	■	
	reducing mechanical damage				■		■		
	thinning / pruning								
	trap crops / perimeter spraying	■	■		■				
	repellents							■	
Prevention	equipment sanitation								
	mowing / mulching / flaming								
	removal of alternative hosts (weeds / volunteers)		■			■	■	■	
	row or plant spacing (plant density)					■	■	■	
	seeding depth						■	■	
	water / irrigation management								
	crop residue removal / management		■		■				
	pruning out / removal of infested material								
Monitoring	scouting - trapping	■	■	■	■	■	■	■	■
	records to track pests	■	■	■	■	■	■	■	■
	soil analysis	■	■			■		■	
	weather monitoring for degree-day modelling	■				■			
	grading out infected produce					■			
Decision Making Tools	economic threshold	■	■	■	■	■	■	■	■
	weather / weather-based forecast / predictive model	■		■		■			
	recommendation from crop specialist	■	■	■	■	■	■	■	■
	first appearance of pest or pest life stage	■	■	■	■	■	■	■	■
	observed crop damage	■	■	■	■	■	■	■	■
	crop stage	■	■	■	■	■	■	■	■
	calendar spray					■		■	
Suppression	biological pesticides	■							
	environmental management (as in greenhouses)								
	pesticide rotation for resistance management	■	■	■		■	■	■	
	soil amendments								
	ground cover / physical barriers							■	
	pheromones (eg mating disruption)		■			■		■	
	sterile mating technique								
	beneficial organisms and habitat management	■	■	■	■	■	■	■	
	trapping	■				■	■	■	

Practice / Pest		Grass-hoppers	Cut-worms	Cereal leaf beetle	Wheat stem sawfly	Wheat midge	Cereal aphids	Wire-worms	European chafer
New Practices (on a provincial basis)	**Alberta** - crop rotation								
	Alberta - mapping - provincial								
	Alberta - crop salvage								
	Saskatchewan - tolerant variety								
	Saskatchewan - Nolo Bait PCP#29197 (ai *Nosema locustae*)								
	Manitoba - release or redistribution of parasitoids								
	Quebec - virus resistance								

This practice is used to manage this pest in at least one reporting province.

This practice is not used or not applicable for the management of this pest, or information regarding the practice for this pest is unknown.

[1]Source: Wheat stakeholders in producing provinces (AB, SK, MB, ON, QC and Atlantic provinces).

Table 9. Insecticides and miticides registered for pest management in spring wheat in Canada

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
aluminium phosphide	Phosphine	Mitochondrial complex IV electron transport inhibitor	24A	RE	stored grain insects
carbaryl	Carbamate	Acetylcholinesterase inhibitor	1A	RE	alfalfa caterpillar, alfalfa weevil, armyworm, blister beetles,cereal leaf beetle, flea beetles, grasshoppers, sweet clover weevil, three cornered alfalfa hopper, webworms
chlorpyrifos	Organophosphate	Acetylcholinesterase inhibitor	1B	RE	army cutworm, armyworm (including Bertha armyworm), brown wheat mite, darksided cutworm, pale western cutworm, redbacked cutworm, Russian wheat aphid, grasshoppers, orange wheat blossom midge
cypermethrin	Pyrethroid, Pyrethrin	Sodium channel modulator	3A	RE	grasshoppers
deltamethrin	Pyrethroid, Pyrethrin	Sodium channel modulator	3A	RE	cutworms, grasshoppers

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
dimethoate	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	aphids, Russian wheat aphid, grasshoppers, orange blossom wheat midge, Say stink bug, thrips
imidacloprid	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4A	R	wireworms
lambda-cyhalothrin	Pyrethroid, Pyrethrin	Sodium channel modulator	3A	RE	armyworm
malathion	Organophosphate	Acetylcholinesterase inhibitor	1B	RE	armyworm, cereal leaf beetle, English grain aphid, grasshoppers, greenbug, stored grain insects (general)
methomyl	Carbamate	Acetylcholinesterase inhibitor	1A	RE	common armyworm, thrips, pale western cutworm
spinetoram	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activator	5	R	armyworm
thiamethoxam	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4	R	European chafer, wireworms (suppression), stored grain insects (refer to product labels)

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
trichlorfon	Organophosphate	Acetylcholinesterase inhibitor	1B	DI	armyworm (true), Bertha armyworm, beet webworm, variegated cutworm, western yellowstriped armyworm

[1]As generated through the Homologa Directory of Registered Plant Protection Products and their allowed Maximum Residue Levels in food. (www.homologa.com) (January 16, 2012) and confirmed on the PMRA website (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

[2]Source: IRAC MoA Classification Scheme (Volume 7.1, issued June 2011) published by the Insecticide Resistance Action Committee (IRAC) International MoA Working Group (www.irac-online.org).

[3] PMRA registration status: R- full registration as of January 27, 2012: PMRA re-evaluation status as of March 31, 2011: RE – under re-evaluation (yellow), DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation. Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels should be consulted for up to date accurate information concerning the use of these pesticides and specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php .

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient and detailed information on the use of these pesticides.

Grasshoppers: lesser migratory grasshopper *(Melanoplus sanguinipes),* two striped grasshopper *(Melanoplus bivitattus),* clear-winged grasshopper *(Camnula pellucida))*

Pest information

Damage: Grasshoppers are voracious feeders, attacking all of the above ground portions of the plant. As the weather warms and dries, the insects become more active. Populations and damage rise dramatically and can cause up to 50% crop loss. Grasshopper damage is strongly related to weather conditions. Under dry, hot conditions a small grasshopper population may do as much damage as a large grasshopper population will under cool, wet conditions.

Life Cycle: Pest species of grasshoppers lay eggs in field margins, pastures, or any area with green vegetation in late summer and fall. Eggs hatch in the spring. Grasshoppers develop through five instars in the spring and early summer. As they get bigger, they feed more and become more difficult to control.

Pest management

Cultural Controls: Early seeding of crops, crop rotation, tillage and trap strips help minimize the impact of this pest. Tillage of egg-laying areas also helps reduce populations but can lead to soil erosion. Parasites and predators naturally reduce grasshopper populations when weather is wet. Scouting is commonly deployed in areas where grasshopper forecasts indicate that the pest is imminent. Grasshopper forecast maps are produced annually by provincial agriculture ministries.

Resistant Cultivars: None

Chemical Controls: A number of insecticides are available to control grasshoppers in wheat. Refer to Table 9. The use of spreadable bran baits has great promise in selectively killing grasshoppers.

Issues for grasshoppers

1. There is a need for an integrated control program for control of grasshoppers in wheat.
2. There is a need for reduced risk alternatives to the organophosphate insecticides that will function under high temperatures.

Cutworms: red-backed (*Euxoa ochrogaster*), pale western (*Agrotis orthogonia*), dark-sided (*Euxoa messoria*), army (*Euxoa auxiliaris*)

Pest information

Damage: Cutworms are sporadic pests that can severely affect wheat in "outbreak" years. Larvae eat the roots, shoots and foliage of wheat seedlings and depending on the species, they may clip plants. Older larvae of red-backed, dark-sided and pale western cutworms will also feed on stems, often clipping stems near the soil surface. Army cutworms feed only on leaves. Damage can be 75% or more in isolated patches through individual fields. Sites with

early season weed growth, heavy plant residue or dense foliage near the crop, are likely to sustain more injury.

Life Cycle: Adult moths lay eggs on or near the soil surface in the fall. The red-backed, pale western and dark-sided cutworms overwinter as eggs. Army cutworm overwinters as partly-grown larvae. Once hatched, the larvae live in the soil but come above-ground to feed. Larvae pupate in the late spring. The new moths emerge in the summer. There is one generation per year.

Pest management

Cultural Controls: Early planting of spring wheat can help reduce the impact of cutworms. Older plants that are growing vigorously can withstand more damage than younger plants. There are many insects and birds that prey on cutworms naturally.

Resistant Cultivars: None available.

Chemical Controls: A number of insecticides are registered for use in wheat for cutworm control. Refer to Table 9. Producers scout for the insects and usually will not apply chemicals unless a threshold of 3-4/m^2 pale western cutworms or 5-6/m^2 red-backed and army cutworms has been reached.

Issues for cutworms

1. There is a need for improved resources to assist in the identification of cutworm larvae to facilitate scouting for these pests.

True armyworm (*Pseudaletia unipuncta*)

Pest information

Damage: True armyworms do most of their feeding damage to cereals in July. Larvae feed on the leaves, stripping the leaf margins and move up the plants to feed on the panicles and flowers, stripping off the awns and kernels.

Life Cycle: True armyworms over-winter as partially grown larvae. In early spring, the moths emerge and lay their eggs in grassy vegetation, including cereals, grassy forages and rye cover crops. Larvae hatch from the eggs and feed at night or on overcast days for approximately a month. During the day, they rest at the base of the host plants. There are six larval instars. It takes three to four weeks for the larvae to reach maturity. When mature, the larvae pupate a few centimetres below the surface of the soil for about two weeks. There are usually two generations per summer in Canada with the first (spring) generation doing the greatest damage to spring wheat.

Pest management

Cultural Controls: Controlling grassy weeds prior to seeding will minimize the risk of attracting egg-laying moths and subsequent infestations.

Resistant Cultivars: None available.

Chemical Controls: Several insecticides are available for armyworm control. Refer to Table 9. Applications should be made in the late-evening or early morning when the armyworms are feeding.

Issues for true armyworm

1. There is limited producer knowledge about armyworm.
2. There is a need for the registration of microbial insecticides for armyworms to ensure that Canadian producers have access to the same pesticides as their US competitors.

Cereal leaf beetle (*Oulema melanopus*)

Pest information

Damage: Both cereal leaf beetle adults and larvae feed on the leaves of host plants. Both adults and larvae cause damage by chewing long strips of tissue between the leaf veins, leaving the top layer of the leaf intact. This creates a window-paning or "skeletonizing" effect. Most of the injury is caused by the larvae in June. Heavily damaged fields appear silver. Yield reductions of 55% in spring wheat have been recorded.

Life Cycle: Adult beetles overwinter in and along the margins of grain fields in protected places such as in crop residues and tree litter. They favour sites adjacent to shelterbelts and forests. They emerge in the spring and are active for about 6 weeks. Egg laying begins about 14 days after the emergence of the adults. Eggs are laid singly or in pairs along the mid-vein on the upper side of the leaf. Each female may lay several hundred eggs. The larvae feed for about 3 weeks, passing through 4 instars before pupating. The pupal stage lasts 2 to 3 weeks. Adult beetles emerge and feed for a few weeks before seeking overwintering sites. There is one generation per year.

Pest management

Cultural Controls: Natural enemies are highly effective at controlling this pest. For the safety of these natural enemies, chemical control is not recommended unless the pest population exceeds the application threshold. Clean plowing increases the risk of damage by this pest, because the over-wintering sites of the natural enemies are destroyed.

Resistant Cultivars: None available

Chemical Controls: A few insecticides are available to control cereal leaf beetle. Refer to Table 9. As noted in the *Cultural Controls* section above, the use of insecticides is not recommended unless pest populations are high.

Issues for cereal leaf beetle

1. There is a need for the registration of insecticides that are not harmful to the parasitoid, *Tetrastichus julis*, which has been released to manage this pest in some provinces.
2. There is a need for the development of treatment thresholds and less complex scouting techniques.

Wheat stem sawfly (*Cephus cinctus*)

Pest information

Damage: Tunnelling of larvae of the wheat stem sawfly inside the stem reduces yield and grade, but most importantly can result in losses due to lodging. This can result in as much as a 15% yield loss and loss of grade. Dry weather and short rotations contribute to high sawfly populations. However cool, wet weather extends the emergence period of the insect, resulting in more damage.

Life Cycle: The pest has only one generation per year. Adults emerge in June and lay eggs in the stems of wheat close to the site of emergence. Larvae feed within the stem for about 30 days after hatching. They then girdle the stem, plug it, and burrow into the stem below the soil line where they pupate to over-winter.

Pest management

Cultural Controls: The most effective way to reduce damage is through the use of non-susceptible crops in a crop rotation. Oats, barley and broadleaf crops, such as canola, flax and alfalfa, are not susceptible to wheat stem sawfly. Naturally occurring populations of parasitic wasps can affect populations of sawfly.

Resistant Cultivars: Solid stem varieties are available which are resistant to wheat stem sawfly.

Chemical Controls: None available.

Issues for wheat stem sawfly

None identified.

Wheat midge (*Sitodiplosis mosellana*)

Pest information

Damage: The larvae feed on wheat seed, causing reduced yield and shrivelling and cracking of seed.

Life Cycle: Adults pupate in the soil and emerge from mid-June to mid-July, at the same time as the wheat heads emerge from the sheath and begin to flower. Eggs are laid on the developing wheat kernels and after hatching, the young larvae feed on the developing wheat kernels for 2 to 3 weeks before dropping to the soil to pupate and overwinter.

Pest management

Cultural Controls: Crop rotation and the avoidance of continuous wheat cropping, will prevent the build-up of pest populations. When there are high pest populations in the soil of a particular field, rotation out of wheat for a number of years is advisable. Seeding early maturing varieties, increasing seeding rates and seeding as early as possible can lessen damage from a wheat midge infestation. Pest populations are reduced by a small parasitic wasp called *Macroglenes penetrans.* This wasp emerges the same time as wheat and lays its eggs inside those of the pest. In southern British Columbia, another small parasitic wasp, *Euxestonotus error*, attacks the wheat midge in similar fashion to *M. penetrans*.

Resistant Cultivars: Several midge-resistant cultivars of red spring wheat are available as "varietal blends" (VB). These VBs are a blend of both resistant (90%) and susceptible (10%) cultivars. The susceptible varieties are used as refuge crops to maintain the resistance. To use this seed, farmers must sign an agreement limiting them to only using farm-saved seed for one generation past certified seed.

Chemical Controls: Chemical controls are available for this pest. Refer to Table 9. An insecticide application is recommended only if the economic threshold has been reached.

Issues for wheat midge

1. Midge resistance is based on a single gene increasing the risk that the resistance will breakdown in a few years. New lines of resistance are needed.
2. There is a need for the registration of alternatives to organophosphate insecticides, including biological controls, for the management of this insect. Insecticides that are not harmful to the parasitoid, *Macroglenes penetrans* are needed.
3. The economic impact of wheat midge needs to be determined.
4. There is a need for the development of economic thresholds and simple scouting techniques for wheat midge.

Cereal aphids (*Aphididae*)

Pest information

Damage: Aphids feed on wheat by sucking sap. Feeding by high populations of aphids impairs kernel development. Infestations may appear as a discoloured or bronzed area in the field. Aphids also produce large amounts of honeydew that support the growth of dark, saprophytic fungi on the plants. The oat-birdcherry aphid prefers the stems and lower leaves, whereas the English grain aphid is found mostly on the head and upper leaves of the plant. The oat-birdcherry aphid is the main vector of barley yellow dwarf virus on the prairies.

Life Cycle: The life cycles of aphids may involve winged, wingless, sexual, and asexual forms. After mating, females lay eggs in the fall. Female nymphs, called "stem mothers", capable of asexual reproduction, hatch in the spring. Throughout the summer, female aphids give birth to several generations of already-pregnant female nymphs. In response to shorter day length in the fall, female aphids begin to give birth to males to restart the cycle. Aphid eggs, usually do not survive over winter in Canada. Female aphids are typically blown in from the United States throughout the growing season.

Pest management

Cultural Controls: Early seeding will enable the wheat crop to mature before the aphid population reaches damaging levels. Avoiding planting spring wheat crops next to infested fall sown crops will prevent possible aphid migration into the new crop. Lacewings and ladybird beetles are active and aggressive feeders on aphids and can control the insect.

Resistant Cultivars: None available.

Chemical Controls: Insecticides are available for use against aphids in wheat. Refer to Table 9. An insecticide application can be used until about two weeks after flowering, only if economic thresholds are reached.

Issues for aphids

1. Selective insecticides for control of aphids, that are not harmful to natural parasitoids and predators, are needed.

Brown wheat mite (*Petrobia latens*)

Pest information

Damage: Brown wheat mite feeding causes leaves to take on a water-stressed appearance, turning first dusty gray and then yellow. Infested wheat plants appear scorched or bronzed and withered, much like drought symptoms in appearance.

Life Cycle: Female mites lay two types of eggs in the soil. In the spring and early summer, they lay red eggs that hatch after a short incubation period producing multiple generations. In the late-summer, the mites begin to lay white eggs which are a resting stage that remains dormant until the weather cools in the fall. Since male mites have not been found, it is believed that the brown wheat mite reproduces parthenogenetically (without mating).

Pest management

Cultural Controls: Brown wheat mite favours dry conditions and populations decrease under irrigation or wetter climatic conditions. Controlling alternative host plants including volunteer wheat in adjacent fields before seeding can help as a preventative measure.

Resistant Cultivars: None available.

Chemical Controls: Insecticides are available to control brown wheat mite. Refer to Table 9.

Issues for brown wheat mite

None identified.

Wireworms (*Elateridae*)

Pest information

Damage: Wireworms feed on shoots and roots causing plants to appear stunted, wilt or die. Infestations usually do not exceed 5% of a field; however damage of up 50% has been reported. Wireworms are often found more abundantly in medium textured, well-drained soils and in fields that were recently broken sod.

Life Cycle: Wireworms are the larvae of the click beetle. Eggs are laid in the soil near the roots of their host plants. Larvae remain in the soil feeding on roots. The larval stage requires up to six years before pupation and adult emergence. Larvae pupate about 5 to10 cm below the soil surface. Pupation lasts for less than a month, but adults do not emerge until the following spring.

Pest management

Cultural Controls: Early seeding, crop rotation, and tillage help control wireworm.

Resistant Cultivars: None available.
Chemical Controls: Seed treatments are usually used to control wireworms. Refer to Table 9.

Issues for wireworms

1. There is a need to develop monitoring techniques and establish economic thresholds for wireworms.

Hessian fly (*Mayetiola destructor*)

Pest information

Damage: Hessian fly larvae feed on the stem where the leaf blade meets the stem. Feeding weakens the stem, predisposing it to breakage, improper elongation of the plant and yield loss. Damage is often confused with sawfly injury.

Life Cycle: The Hessian fly has two generations per year, one in the spring and one in the fall. The flies lay eggs in the fall. Larval development continues into the fall, with pupation and emergence of a second generation of adults the following spring. The spring generation lays eggs on spring wheat crops. When the eggs hatch, the larvae will feed on the young plant for 2 to 3 weeks prior to pupating, which initiates a new cycle.

Pest management

Cultural Controls: Since the insect is a weak flier, crop rotation will help control the insect. The use of delayed seeding also helps control this pest. Avoiding planting spring wheat adjacent to winter wheat fields will reduce the opportunity for Hessian flies to migrate between crops.

Resistant Cultivars: Resistant varieties are available.

Chemical Controls: None available.

Issues for Hessian fly

1. There is a lack of chemical controls for Hessian fly.
2. There is a need for studies on the economic impact of Hessian fly.
3. There is a need for the registration of seed treatments to ensure that Canadian producers have access to the same seed treatments as US producers.

European chafer (*Rhizotrogus majalis*)

Pest information

Damage: European chafer is an annual grub that feeds on the roots of spring wheat seedlings in the early spring. Root pruning may stunt growth, cause poor emergence and seedling death.

Life Cycle: Adults emerge in early-June to early-July to mate. Females lay eggs in cool, moist soil. Larvae hatch in early-August and feed on roots until late-fall when they migrate below the frost line to overwinter. European chafer overwinters as larvae (grubs) in the soil. In April, the grubs migrate to close to the soil surface and start feeding on roots. Grubs stop feeding by mid-May to pupate. There is one generation per year.

Pest management

Cultural Controls: Delaying seeding until mid-May may avoid larval feeding. Quickly establishing a vigorous crop may help the crop to tolerate low to moderate feeding. Naturally occurring soil organisms may infect the larvae and reduce crop damage. While not likely economical for spring wheat, predatory nematodes (*Heterorhabditis bacteriophora*) are available that attack grubs like European chafer.

Resistant Cultivars: None available.

Chemical Controls: Insecticidal seed treatments are available. Refer to Table 9.

Issues for European chafer

None identified.

Thrips (*Thripidae*)

Pest information

Damage: Thrips feed by rasping the leaves and other tissues of plants to release sap that they feed on. They are usually found behind the sheath of the flag leaf, feeding on the stem. Thrips may attack leaves, stem or heads. Damaged tissue may take on a silver colouration.

Life Cycle: Adults lay eggs on the host plant. The generation time is very short with several generations each year.

Pest management

Cultural Controls: Thrips rarely cause serious damage to wheat. It is unusual to find infestations that warrant control. Many predatory insects will feed on thrips and suppress their numbers.

Resistant Cultivars: None available.

Chemical Controls: Insecticides are available to control thrips. Refer to Table 9.

Issues for thrips

None identified.

Weeds

Table 10. Occurrence of weeds in spring wheat in Canada[1,2]

Key Issues

- Weed resistance to a number of herbicide classes is building.
- Rotational strategies that incorporate non-chemical weed management approaches are needed to limit the development of resistance. This is particularly challenging under no-till regimes.

Weeds	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	Atlantic Provinces
Annual broadleaf weeds						
Annual grass weeds						
Perennial broadleaf weeds						
Perennial grass weeds						
Volunteer crops						

Widespread yearly occurrence with high pest pressure

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

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

Pest not present

Data not reported

[1]Source: Wheat stakeholders in reporting provinces.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 11. Adoption of weed management practices for spring wheat in Canada[1]

Error! Bookmark not defined. Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Avoidance	planting / harvest date adjustment				
	crop rotation				
	choice of planting site				
	use of weed-free seed				
	optimizing fertilization				
Prevention	equipment sanitation				
	mowing / mulching / flaming				
	row or plant spacing (plant density)				
	seeding depth				
	water / irrigation management				
	weed management in non-crop lands				
	weed management in non-crop years				
	tillage / cultivation				
Monitoring	scouting - field inspection				
	field mapping of weeds / record of resistant weeds				
	soil analysis				
	grading of grain / produce for weed contamination				
Decision Making Tools	economic threshold				
	weather / weather-based forecast / predictive model				
	recommendation from crop specialist				
	first appearance of weed or weed growth stage				
	observed crop damage				
	crop stage				
	calendar spray				
Suppression	biological pesticides				
	arthropod biological control agents				
	habitat / environment management				
	pesticide rotation for resistance management				
	soil amendments				
	ground cover / physical barriers				
	inter-row cultivation				
	mechanical weed control				
New Practices (on a provincial basis)	**Saskatchewan** - tank mixing herbicide modes of action for resistance management.				
	Saskatchewan - low disturbance seeding				
	Saskatchewan - competitive variety selection				

This practice is used to manage this pest in at least one reporting province.

This practice is not used or not applicable for the management of this pest, or information regarding the practice for this pest is unknown.

[1]Source: Wheat stakeholders in producing provinces (AB, SK, MB, ON, QC and Atlantic provinces).

Table 12. Herbicides registered for weed management in spring wheat in Canada

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
2,4-D	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	broadleaf weeds
2,4-DB	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	broadleaf weeds
bentazon (bendioxide) (spring wheat only excluding durum)	Benzothiadiazinone	Inhibition of photosynthesis at photosystem II	6	R	broadleaf weeds
carfentrazone-ethyl	Triazolinone	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	burclover, carpet weed, cocklebur, common purslane, corn spurry, eastern black nightshade, field pennycress, hairy nightshade, Jimsonweed, kochia, lamb's-quarters, round-leaved mallow, morning glory, Pennsylvania smartweed, prickly lettuce, prostrate pigweed, redroot pigweed, smooth pigweed, tall waterhemp, tansy mustard, tumble pigweed, velvetleaf, Venice mallow, volunteer canola
chlorsulfuron	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	broadleaf weeds

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
clodinafop-propargyl (spring wheat only, including durum)	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	barnyard grass, green foxtail, Persian darnel, volunteer (tame oats), volunteer canary seeds, wild oats
clopyralid	Pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	R	annual mustard, annual sow thistle, burdock, Canada thistle, cocklebur, common groundsel, dandelion, field horsetail, flixweed, kochia, lamb's-quarters, perennial sow-thistle, pigweed, plantain, prickly lettuce, ragweed, redroot pigweed, Russian pigweed, scentless chamomile, shepherd's purse, smartweed, stinkweed, sunflower (wild and volunteer), tartary buckwheat, vetch, volunteer canola, wild buckwheat, wild radish
dicamba	Benzoic acid	Action like indole acetic acid (synthetic auxins)	4	R	ball mustard, burdock, Canada thistle, cleavers, cocklebur, volunteer canola, common ragweed, corn spurry, cow cockle, false ragweed, flixweed, giant hemp-nettle, hare's-ear mustard, Indian mustars, kochia, lady's thumb, lamb's-quarters, perennial sow-thistle, prostrate pigweed, redroot pigweed, Russian pigweed, Russian thistle, shepherd's purse, stinkweed, tartary buckwheat, tumble mustard, volunteer sunflowers, wild mustard, wild radish, wormseed mustard

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
dichlorprop	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	annual sow-thistle, ball mustard, bluebur, burdock, Canada thistle, cocklebur, curled dock, dog mustard, flixweed, hare's-ear mustard, Indian mustard, kochia, lady's thumb, lamb's-quarters, night flowering catchfly, oak-leaved goosefoot, perennial sow-thistle, ragweed, redroot pigweed, round-leaved mallow, Russian thistle, shepherd's purse, smartweed, stinkweed, stork's bill, tartary buckwheat, tumble mustard, volunteer rapeseed (canola), volunteer sunflower, wild buckwheat, wild mustard, wormseed mustard
diclofop-methyl	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	barnyard grass, fall panicum, green foxtail, silky bentgrass, volunteer corn, wild oats, witchgrass, yellow foxtail
difenzoquat	Pyrazolium	Unknown	8	RE	control of wild oats in selected varieties of spring wheat and winter wheat
fenoxaprop-P-ethyl (spring wheat only)	Aryloxyphenoxy-propionate 'FOP'	Inhibition of acetyl CoA carboxylase (ACCase)	1	RE	barnyard grass, green foxtail (wild millet), wild oats, yellow foxtail
florasulam	Triazolopyrimidine	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	cleavers, common chickweed, shepherd's purse, smartweed, stinkweed, volunteer canola (excluding CLEARFIELD® canola), wild buckwheat, wild mustard **Weeds suppressed:** annual sow-thistle, hemp-nettle, perennial sow-thistle, redroot pigweed

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
flucarbazone-sodium (spring wheat only)	Sulfonylaminocarbonyl-triazolinone	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	green foxtail, green smartweed, redroot pigweed, shepherd's purse, stinkweed, volunteer canola (excluding CLEARFIELD® canola), volunteer tame oats, wild mustard (*Brassica kaber*), wild oats
fluroxypyr (spring wheat only)	Pyridine carboxylic acid	Action like indole acetic acid (synthetic auxins)	4	R	cleavers, kochia, round-leaved mallow, volunteer flax **Weed suppressed:** common chickweed, hemp-nettle, stork's-bill, wild buckwheat
imazamethabenz-methyl (spring wheat and durum only)	Imidazolinone	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	RE	stinkweed, volunteer canola (EXCEPT imazethapyr tolerant varieties (SMART®)), wild mustard, wild oats
imazamox (only on wheat with the CLEARFIELD® trait)	Imidazolinone	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	stinkweed, barnyard grass, cow cockle, green foxtail, green smartweed, Persian darnel, redroot pigweed, shepherd's purse, stinkweed, volunteer barley, volunteer canary seed, volunteer canola (non-CLEARFIELD® canola only), volunteer durum wheat, volunteer spring wheat (non-CLEARFIELD® wheat), volunteer tame oats, wild mustard, wild oats, yellow foxtail Weeds suppressed: cleavers, Japanese brome grass*, lamb's-quarters, wild buckwheat

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
linuron + MCPA	Urea + phenoxy-carboxylic-acid	Inhibition of photosynthesis at photosystem II + action like indole acetic acid (synthetic auxins)	7 + 4	RE + R	cocklebur, common burdock, common ragweed, cow cockle, giant ragweed, goat's beard, hare's-ear mustard, hemp-nettle, Indian mustard, kochia, lady's thumb, lamb's-quarters, prickly lettuce, prostrate pigweed, redroot pigweed, Russian pigweed, shepherd's purse, stork's bill, tartary buckwheat, tumble mustard, wild buckwheat, wild mustard, wild radish, wormseed mustard **Weeds suppressed:** field horsetail
MCPA	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	annual sowthistle, annual sunflower, biennial wormwood, blue lettuce, bluebur, burdock, Canada thistle, cocklebur, dandelion, docks, dog mustard, field bindweed, field horsetail, field pennycress, field peppergrass, flixweed, goatsbeard, gumweed, hairy galinsoga, hedge bindweed, hemp-nettle, hoary cress, kochia, lady's thumb, lamb's-quarters, mustard (except dog and green tansy), oakleaf goosefoot, perennial sow-thistle, plantain, prickly lettuce, ragweeds, redroot pigweed, Russian pigweed, shepherd's purse, smartweed, sweet clover, tansy, tartary buckwheat, tumble weed, vetch, wild radish

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
MCPB + MCPA	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	RE + R	annual broadleaf weeds, ball mustard, lamb'-quarters, ragweed, redroot pigweed, shepherd's purse, stinkweed, volunteer rapeseed (including canola), wild mustard, wormseed mustard **Weeds suppressed:** annual sow-thistle, bull thistle, Canada thistle, creeping buttercup, curled dock, field bindweed, hemp-nettle, horsetail, perennial sow-thistle, plantain, tall buttercup, wild radish
mesosulfuron-methyl (spring wheat and durum only)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	wild oats
metribuzin (spring wheat and winter wheat (Norstar only))	Triazinone	Inhibition of photosynthesis at photosystem II	5	R	night flowering catchfly, ball mustard, common chickweed, common groundsel, corn spurry, green smartweed, henbit, lady's thumb, lamb's-quarters, redroot pigweed, Russian thistle, stinkweed, tartery buckwheat, volunteer non-triazine tolerant canola, wild mustard, wormseed mustard, dryland winter wheat (Norstar only), downy brome, flixweed, shepherd's purse, stinkweed

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
metsulfuron-methyl (spring wheat and durum only)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	ball mustard, prostrate pigweed, redroot pigweed, bluebur, chickweed, scentless chamomile, shepherd's purse, common groundsel, corn spurry, stinkweed, cow cockle, stork's-bill, flixweed, tartary buckwheat, hemp-nettle, kochia, lady's-thumb, wild mustard, volunteer rapeseed: excluding imazathapyr tolerant canola varieties (eg. canola varieties with the Pursuit SMART® trait) **Weeds suppressed:** Canada thistle, lamb's-quarters, Russian thistle, annual sow-thistle, perennial sow-thistle, toadflax, wild buckwheat
picloram + 2,4-D	Pyridine carboxylic acid + phenoxy-carboxyclic-acid	Action like indole acetic acid (synthetic auxins) + action like indole acetic acid (synthetic auxins)	4 + 4	R + R	Canada thistle, cocklebur, dandelions, green smartweed, lamb's-quarters, perennial sow-thistle, redroot pigweed, Russian thistle, stinkweed, tartary buckwheat, wild buckwheat, wild mustard, and other broadleaved weeds
picolinafen (spring wheat and durum only)	Pyridinecarboxamide	Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)	12	R	redroot pigweed, stinkweed, wild mustard

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
quinclorac (also group L) (spring wheat and durum only)	Quinoline carboxylic acid	Action like indole acetic acid (synthetic auxins)	4 and 26	R	cleavers, barnyard grass, green foxtail, volunteer flax **Weeds suppressed:** annual sow-thistle, perennial sow-thistle
sulfosulfuron (spring wheat and select varieties of durum wheat only)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	cleavers, common chickweed, foxtail barley, redroot pigweed, stinkweed, volunteer canola (including glyphosate tolerant canola, ie Roundup Ready®; will not control imazethapyr tolerant canola, ie Clearfield® canola), wild mustard, wild oats **Weeds suppressed:** barnyard grass, dandelion, green foxtail, perennial sow-thistle, quackgrass
thifensulfuron-methyl	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	chickweed, corn spurry, cow cockle, green smartweed, hemp-nettle, kochia, lady's-thumb, lamb's-quarters, redroot pigweed, Russian thistle, stinkweed **Weeds suppressed:** wild buckwheat, wild mustard

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
thifensulfuron methyl + tribenuron methyl	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	ball mustard, chickweed, common groundsel, common volunteer rapeseed (including imazamox and imazethapyr tolerant canola, e.g. Clearfield* canola), corn spurry, cow cockle, flixweed, green smartweed, hemp-nettle, kochia, lady's-thumb, lamb's-quarters, narrow-leaved hawk's beard, redroot pigweed, Russian thistle, shepherd's purse, stinkweed, tartary buckwheat, volunteer sunflower, wild buckwheat, wild mustard **Weeds suppressed:** Canada thistle, cleavers, round-leaved mallow, scentless chamomile, sow-thistle, stork's-bill, toadflax
tralkoxydim	Cyclohexanedione 'DIM'	Inhibition of acetyl CoA carboxylase (ACCase)	1	R	barnyard grass, green foxtail, Persian darnel, volunteer oats, wild oats, yellow foxtail
triallate (spring and durum wheat only)	Thiocarbamate	Inhibition of lipid synthesis - not ACCase inhibition	8	RE	green foxtail (wild millet), yellow foxtail, wild oats

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
tribenuron-methyl (spring wheat only)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	RE	broadleaf weeds
trifluralin	Dinitroaniline	Microtubule assembly inhibition	3	RE	annual bluegrass, barnyard grass, bromegrass, carpetweed, cheat, chickweed, cow cockle, crabgrass, goosegrass, green & yellow foxtail (wild millet), knotweed, lamb's-quarters, Persian darnel, pigweed, purslane, redroot pigweed, Russian thistle, stinkgrass **Weeds suppressed:** wild buckwheat, wild oats

[1]As generated through the Homologa Directory of Registered Plant Protection Products and their allowed Maximum Residue Levels in food (www.homologa.com) (January 16, 2012) and confirmed on the PMRA website (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

[2]Source: Herbicide Resistance Action Committee, Classification of Herbicides According to Site of Action (January 2005) at: www.hracglobal.com/

[3] PMRA registration status: R- full registration as of February 14, 2012; PMRA re-evaluation status as of March 31, 2011: RE – under re-evaluation (yellow), DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation. Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels should be consulted for up to date accurate information concerning the use of these pesticides and specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php.

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

Annual grasses

Pest information

Damage: If not controlled early, annual grassy weeds can cause yield losses as high as 25% by competing with the crop for moisture and nutrients. In addition to yield losses, there may be dockage losses, loss in grade and cleaning costs associated with the presence of these weed species in the crop.

Life Cycle: Annual grasses reproduce from seeds which are produced annually in great numbers. Some annual grassy weeds, like downy bromegrass, exhibit a winter annual growth habit, germinating in the fall, overwintering and completing their life cycle in the spring. Seed can remain viable in the soil for several years. Green foxtail will not germinate if buried deeper than 7.5 cm.

Pest management

Cultural Controls: Integrated crop management using diverse crop rotations, increased seeding rates and varying seeding dates can help reduce grassy weed pressures and aid in herbicide rotation. Getting the crop off to a quick start, to emerge ahead of the weeds, reduces yield losses. Subsurface banding of fertilizers increases crop competition by providing preferential access to nutrients.

Resistant Cultivars: None available.

Chemical Controls: Annual weeds can be partially controlled with a pre-seeding burn off with a glyphosate product. An in-crop application of an ACCase inhibitor can give good control of grassy weeds. However, due to rapidly increasing weed resistance to this group of herbicides, integrated pest management is important. A number of herbicides are available that can be used in rotation to aid in resistance management. Refer to Table 12.

Issues for annual grass weeds

1. Resistance problems to commonly used herbicides, like ACCase resistant wild oats (*Avena fatua*) and *Setaria* spp., are a growing concern, especially since the number of herbicide groups registered on wheat is very limited. Resistance to dinitroanaline herbicides has been reported in setaria species. Cross-resistance and multiple-resistance has also been documented. The potential for further development of herbicide resistant weeds is a concern.
2. The trend to increased (wider) crop row spacing could increase weed infestations in crops.
3. Increased resources to monitor and map resistant weeds are needed. There is a need for faster and less costly techniques for the diagnosis of herbicide resistance.
4. Sustainable approaches to herbicide resistance management must be further developed and promoted to facilitate adoption.
5. There are few herbicides available for the management of downy brome (*Bromus tectorum*) and Japanese brome (*B. japonicus*), which are difficult to control.

Annual Broadleaf Weeds

Pest information

Damage: Broadleaf weeds can cause yield losses if not controlled early in the growing season. Commonly found broadleaf weed species in wheat producing areas are redroot pigweed (*Amaranthus retroflexus*), lamb's-quarters (*Chenopodium album*), wild buckwheat (*Polygonum convolvulus*), wild mustard (*Sinapsis arvensis*), cow cockle (*Saponaria vaccaria),* kochia (*Kochia scoparia*), ladys' thumb/smartweed (*Polygonum persicaria*), stinkweed (*Thlaspi arvense*), flixweed (*Descurainlia sophin)* and shepherd's purse (*Capsella bursa-pastoris*). The more favourable the growing conditions, the more pressure the weeds put on the crop. They compete with the crop for moisture and nutrients, which can affect both yield and quality. Broadleaf weeds are common across all wheat growing areas.

Life Cycle: Annual weeds complete their development from seed germination, through vegetative growth, flowering and seed development, in one growing season. Some annual broadleaf weeds exhibit a winter annual growth habit, germinating in the fall, overwintering and completing their life cycle in the spring.

Pest management

Cultural Controls: Fields with low weed pressure, especially of the hard to control broadleaf weeds, should be selected as planting sites. Integrated crop management using diverse crop rotations, increased seeding rates and varying seeding dates, can help reduce broadleaf weed pressures and aid in herbicide rotation. Getting the crop off to a quick start, to emerge ahead of the weeds, reduces yield losses. Subsurface banding of fertilizers increases crop competition by providing preferential access to nutrients.

Resistant Cultivars: None available.

Chemical Controls: Annual weeds can be partially controlled with a pre-seeding burn off with a glyphosate product. The use of various in-crop broadleaf herbicides will control a wide range of broadleaf weeds when applied as a post emergent treatment. Due to increasing weed resistance to ALS/AHAS inhibitor herbicides, integrated pest management is important. Refer to Table 12.

Issues for annual broadleaf weeds

1. Resistance problems to commonly used herbicides, like ALS/AHAS inhibitor resistant kochia (*Kochia scoparia*) is a growing concern. The potential for the further development of herbicide resistant weeds is a concern.
2. Increased resources to monitor and map resistant weeds are needed. There is a need for faster and less costly techniques for the diagnosis of herbicide resistance.
3. Sustainable approaches to herbicide resistance management must be further developed and promoted to facilitate adoption.
4. There is a need for improved controls for sow thistle.

Perennial Grass Weeds

Pest information

Damage: The most commonly found weedy perennial grass species in wheat producing areas is quackgrass (*Elytrigia repens*). Perennial grass weeds compete with the crop for moisture and nutrients and can affect both yield and quality. These weeds are hard to control since the entire plant, including roots, must be killed in order to prevent re-growth.

Life Cycle: Perennial weeds such as quackgrass have extensive creeping rootstocks. These frequently produce shoots that give rise to new plants. The weed readily regenerates through seed germination or root fragments. Other perennial grasses, like foxtail barley (*Hordeum jubatum*), are bunchgrasses that spread by only by seed. Most perennial weed seeds will germinate within a year, but some may remain viable in the soil for 20 years or more.

Pest management

Cultural Controls: The selection of fields with low weed pressure is important in perennial weed management since no in-crop chemical control agents exist. Control of perennial grasses should be done in the year previous to wheat production. Foxtail barley seedlings are poor competitors and usually get established in areas with poor crop establishment. Establishing a competitive crop can help reduce establishment of this species. Foxtail barley can be easily controlled with tillage. Delayed seeding will allow for improved pre-seed weed control with glyphosate.

Resistant Cultivars: None available.

Chemical Controls: Season long control of quackgrass can be achieved using glyphosate in the spring, pre-harvest or fall. Spring and fall applications of glyphosate will also control foxtail barley. Refer to Table 12 for available herbicides.

Issues for perennial grass weeds

1. Minimum tillage systems have led to increased problems with perennial weeds in general.

Perennial Broadleaf Weeds

Pest information

Damage: Weeds compete with the crop for moisture and nutrients and can affect both yield and quality. Perennial weeds are hard to control since the entire plant, including roots, must be killed in order to prevent re-growth.

Life Cycle: Perennial broadleaf weeds tend to have extensive rootstocks which make them very difficult to kill. They can readily regenerate from root fragments.

Pest management

Cultural Controls: Since there are limited in-crop chemical control options, fields with low weed pressure are the preferred planting sites. Control of perennial weeds is best done in the year prior to wheat production.

Resistant Cultivars: None available.

Chemical Controls: Pre-harvest and post-harvest glyphosate treatments in the year prior to wheat production will provide control of several perennial broadleaf weeds including Canada thistle (*Cirsium arvense*) and perennial sow-thistle (*Sonchus arvensis*). In-crop chemicals are available for controlling Canada thistle. Refer to Table 12.

Issues for perennial broadleaf weeds

1. Minimum tillage systems have led to increased problems with perennial weeds in general.
2. The trend to increased (wider) crop row spacing could increase the risk of perennial weed infestations.
3. There is a need for improved controls for Canada thistle.

Volunteer Crops

Pest information

Damage: Volunteer crops compete with the crop for moisture and nutrients and can affect the quality of the seeds harvested. When different wheat classes such as western red spring and amber durum, are grown in rotation, high levels of volunteer off-type wheat in the grain sample may result in downgrading. Winter wheat volunteers can act as a "green bridge" for disease and insect pests in spring wheat.

Life Cycle: Volunteer crops grow from seeds that are the result of harvest and shattering losses. Similar to other annual weeds, they complete their development from seed germination, through vegetative growth, flowering and seed development, in one growing season.

Pest management

Cultural Controls: Volunteer crops typically do not exhibit significant seed dormancy so most seeds germinate within one year of harvesting the crop. Integrated crop management using diverse crop rotations, increased seeding rates and varying seeding dates, can help reduce problems with volunteers. Getting the crop off to a quick start, to emerge ahead of the volunteers, reduces yield losses. Subsurface banding of fertilizers increases crop competition by providing preferential access to nutrients.

Resistant Cultivars: None available.

Chemical Controls: A commonly found volunteer crop in wheat producing areas is volunteer canola (*Brassica spp.*). Volunteer canola is prevalent across all wheat growing areas of western Canada. Volunteer canola is easily controlled by most broadleaf wheat herbicides.

Issues for volunteer crops

1. Glyphosate-tolerant varieties of volunteer canola can be difficult to eradicate.

2. Volunteers of other wheat classes or cereal grain species cannot be controlled with herbicides in spring wheat.

Resources

IPM / ICM resources for production of spring wheat in Canada

2008 – 2009 Field Crop Protection Guide – Guide to Best Management Practices in British Columbia for cereals, canola, field corn, field peas, grasses and legumes for forage and seed production
www.al.gov.bc.ca/cropprot/fieldcrop/

Guide to Field Crop Protection (Manitoba)
www.gov.mb.ca/agriculture/crops/forages/bja03s13.html

Field Crop Protection Guide 2011 – 2012. OMAFRA Publication 812
www.omafra.gov.on.ca/english/crops/pub812/p812toc.html

Agronomy Guide for Field Crops OMAFRA Publication 811
www.omafra.gov.on.ca/english/crops/pub811/p811order.htm

Best Management Practices – Field Crop Production (Ontario)
www.omafra.gov.on.ca/english/environment/field/fieldcrop.htm

Saskatchewan Agriculture crop publications
www.agriculture.gov.sk.ca/crops

Insects, Diseases, Weeds & Pests Publications, Alberta Agriculture and Rural Development
www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3919#general

Crops Publications, Alberta Agriculture and Rural Development
www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3882

Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ)
www.craaq.qc.ca

Manitoba Agriculture, Food and Rural Initiatives
www.gov.mb.ca/agriculture/crops

Ontario Ministry of Agriculture, Food and Rural Affairs
www.omafra.gov.on.ca/english/crops/field/cereal.html

Provincial Cereal Crop Specialists and Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Alberta	Alberta Agriculture and Rural Development	Jim Broatch Jim.broatch@gov.ab.ca	Jim Broatch jim.broatch@gov.ab.ca
Saskatchewan	Saskatchewan Agriculture	Blaine Recksiedler blaine.recksiedler@gov.sk.ca	Sean Millerr sean.miller@gov.sk.ca
Manitoba	Manitoba Agriculture, Food and Rural Initiatives	John Gavloski, john.gavloski@gov.mb.ca	Jeanette Gaultier jeanette.gaultier@gov.mb.ca
Ontario	Ontario Ministry of Agriculture and Food	Peter Johnson ,Cereal Crop Specialist, peter.johnson@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministére d'Agriculture, Pêcheries et Alimentation du Québec (www.mapaq.gouv.qc.ca)	Claude Parent, claude.parent@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca
New Brunswick	New Brunswick Department of Agriculture and Aquaculture	Peter K. Scott, Development Officer peter.scott@gnb.ca	Kelvin Lynch kelvin.lynch@gnb.ca
Nova Scotia	Nova Scotia Department of Agriculture and Fisheries (www.gov.ns.ca/nsaf.ca)	-	Lorne Crozier crozielm@gov.ns.ca
	AgraPoint International (www.agrapoint.ca)	Jack Van Roestel j.vanroestel@agrapoint.ca	
Prince Edward Island	Prince Edward Island Department of Agriculture	Donald (Doon) Pauly, dgpauly@gov.pe.ca	Shauna Mellish, smmellish@gov.pe.ca

National and Provincial Wheat Grower Organizations

Canadian Grains Council (CGC)
www.canadagrainscouncil.ca

Canadian Federation of Agriculture (CFA)
www.cfa-fca.ca

Canadian Wheat Board (CWB)
www.cwb.ca

Canada Grain Commission
www.grainscanada.gc.ca

Grain Growers of Canada
www.ggc-pgc.ca

Atlantic Grains Council
http://www.atlanticgrainscouncil.ca/

British Columbia Grain Producers Association
www.bcgrain.com

Centre de recherche sur les grains (CEROM)
www.cerom.qc.ca

Ontario Federation of Agriculture
www.ofa.on.ca

Grain Farmers of Ontario
www.gfo.ca

Ontario Soils and Crop Improvement Association (OSCIA)
www.ontariosoilcrop.org

Appendix 1: Explanation of colour coding of disease, insect and mite and weed occurrence tables (Tables 4, 7 and 10)

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in the Tables 4, 7 and 10, respectively of the crop profile. The colour coding in the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart (definitions of terms are provided at the bottom of the table):

Pest Frequency	Distribution	Pest Importance	Colour Code
If the pest is present 7 or more years out of 10 (yearly)	widespread	high	Red
		moderate	Orange
		low	Yellow
	localized	high	Orange
		moderate	White
		low	White
If the pest is present 6 years or less out of 10 (sporadic)	widespread	high	Orange
		moderate	yellow
		low	white
	localized	high	yellow
		moderate	White
		low	White
Pest not present			black
Data not reported			grey

Definition of terms describing pest distribution, frequency and importance:

Distribution: Localized: Present only in limited areas of the province

Widespread: Present throughout the province

Frequency (number of years the pest is present at levels requiring controls)

Sporadic: Present 6 years or less/ 10

Yearly: Present 7 years or more /10

Pest importance (based on crop impact and the need for controls when present)

Low: If present, potential for spread and crop loss is low and controls must be implemented only under specific conditions.

Moderate: If present, potential for spread and crop loss is moderate; pest situation must be monitored and controls may be implemented.

High: If present, potential for spread and crop loss is high and controls must be implemented even for small populations.

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www.statcan.gc.ca

Manitoba Agriculture, Food and Rural Initiatives
www.gov.mb.ca/agriculture/crops

Alberta Agriculture, Food and Rural Development
www.agric.gov.ab.ca

Ontario Ministry of Agriculture, Food and Rural Affairs
www.omafra.gov.on.ca/english/crops/field/cereal.html

Saskatchewan Agriculture, Food and Rural Revitalization
www.agriculture.gov.sk.ca

British Columbia Ministry of Agriculture
www.gov.bc.ca/agri/

Prince Edward Island Department of Agriculture
www.gov.pe.ca/agriculture/

Nova Scotia Department of Agriculture
www.gov.ns.ca/agri/

USDA Regional IPM Centres
www.ipmcenters.org

Canada Grain Commission
www.grainscanada.gc.ca

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