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Crop Profile for Winter Wheat in Canada, 2010

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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 winter 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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Crop Profile for Winter Wheat in Canada

Winter wheat (*Triticum aestivum*) is an important crop in Canada, comprising over 700,000 hectares. Winter wheat has a different life cycle from spring-planted crops like spring wheat or corn. Winter wheat is planted in the fall, overwinters as a seedling and completes its life cycle by mid-summer. There are several benefits associated with winter wheat including:

- Generally this production system provides higher crop yields compared to spring wheat,
- It can break up pest cycles for spring-planted crops,
- This approach helps avoid many of the pest problems associated with spring wheat,
- It evens out the workload for producers at both harvest and seeding.

The crop is consumed throughout Canada and in more than 70 countries worldwide. The bulk of breeding for winter wheat is conducted by public scientists at Canadian Universities and Agriculture and Agri-Food Canada (AAFC) Research Centres. Breeding programs are funded through a variety of means including AAFC, Universities, producer group levies and Ducks Unlimited Canada. Over 100 varieties categorized into four winter wheat types are grown in Canada. These include:

Canada Eastern Hard Red Winter (CEHRW)
Canada Eastern Soft Red Winter (CESRW)
Canada Eastern White Winter (CEWW)
Canada Western Red Winter (CERW)

Winter wheat is processed into flour, cereal food and feed, bread and bakery products. The winter wheat classes are known for their medium protein, medium kernel hardness and medium dough strength properties, which are desirable for special end uses. Furthermore, due to its higher starch content and lower protein concentration, winter 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

Most Canadian winter wheat production occurs in Ontario and the three prairie provinces with the distribution of national production as presented in Table 2.

Table 2. Distribution of winter wheat production in Canada[1]

Production Regions	Winter wheat (000's of ha's)	Cultivated area of winter wheat (percent national hectares)
British Columbia	-	-
Alberta	70.8	12.2%
Saskatchewan	76.9	13.2%
Manitoba	97.1	16.7%
Ontario	329.8	56.6%
Quebec	4	0.69%
Atlantic Provinces	3.8	0.65%
Canada	582.4	100%

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

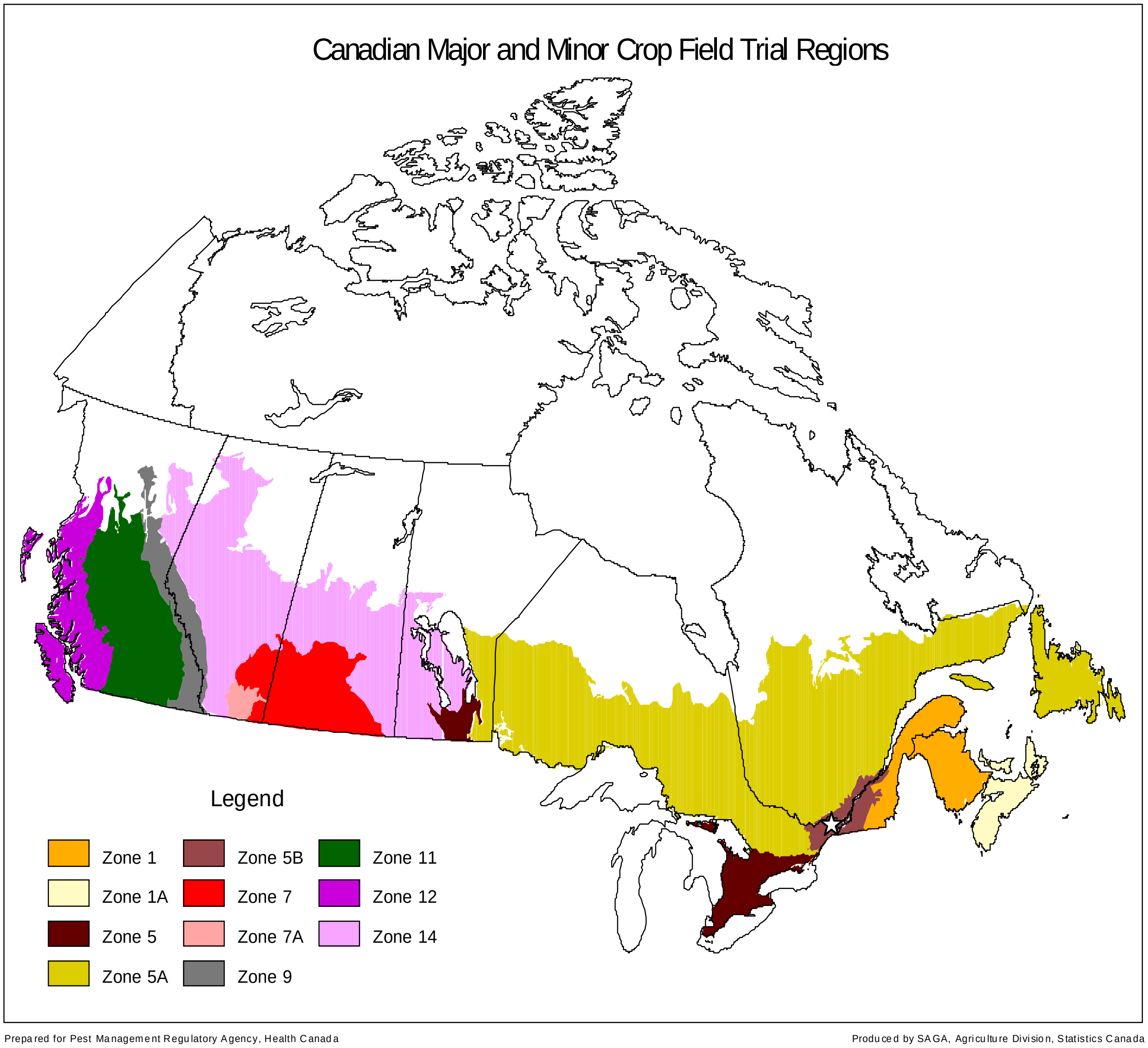

Figure 1. Common Zone Map: Canadian Major and Minor Field Trial Regions

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 Practices

In the prairie region, winter wheat is typically grown as part of diverse crop rotations that include canola, pulse crops, and other spring cereal crops. To minimize winterkill, winter wheat seeded on the prairies is seeded into standing crop residue using a no-till seeder. This practice helps ensure there is adequate snow cover (12 cm) to insulate seedlings from cold winter temperatures. Winter wheat on the prairies should not be seeded following crops such as peas or lentils which do not have the stubble height to adequately trap snow to protect winter wheat.

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

After harvest, winter wheat fields are typically left fallow until the following spring. However, some producers use cover crops immediately after the winter wheat harvest as a soil conservation practice.

Winter 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. Winter wheat can be established in a wide range of soil moisture conditions, including very dry conditions. Seeding near the optimum seeding date is more important than soil conditions for establishing winter wheat. Optimum seeding dates for winter wheat vary by region. Seeding outside of the optimum seeding date range can result in increased risk of poor establishment, reduced yields, and increased risk of damage from disease and insect pests.

The ability to seed winter wheat often depends on being able to harvest the preceding spring-seeded crop early enough to allow planting of winter wheat in the fall. Any delays with the spring crop's development will delay seeding. This may move winter wheat seeding outside of the optimum seeding window, resulting in lower yields and reduced winter hardiness. If the spring crop is delayed too long, it may prevent winter wheat from being seeded.

In central Canada, winter wheat is typically planted following soybean. On the prairies, winter wheat is typically planted following canola.

In cases of severe winterkill, producers have an opportunity to switch to a spring-seeded crop.

Weeds are controlled either with a pre-seed herbicide application or with tillage prior to seeding. This reduces both competition and eliminates the "green bridge" from spring seeded crops for several pests. Winter wheat is normally seeded at a uniform depth between of 1.5 and 2.5 cm. Depending on the growing region, target plant populations for winter wheat range from 300 plants/ m^2 to 450 plants/ m^2, with populations tending to increase from drier to more humid climates.

Applying large amounts of nitrogen (N) fertilizer at the time of seeding can reduce the winter hardiness of winter wheat. Ideally most N fertilizer should be broadcast in early-spring to minimize nitrogen losses. Urea-ammonium nitrate (UAN) liquid fertilizer is the preferred N fertilizer for this purpose. Since wet spring conditions can prevent timely field operations, western Canadian producers often subsurface-band 30-50% of the crops N requirement at seeding in the fall to extend their fertilizer application window in the spring.

Table 3. Winter wheat production and pest management schedule in Canada

TIME OF YEAR	ACTIVITY	ACTION
August	Plant Care	Calibrate seeding equipment.
	Soil care	Harrow fields after harvest for residue management
	Weed Management	Scout fields for weeds and volunteer crops. Apply pre-seed glyphosate herbicide treatment or till to remove weeds if warranted.
September	Plant Care	Seed winter wheat
	Soil care	Apply P and K fertilizers along with a small amount of N fertilizer at seeding.
October	Soil care	Conduct soil tests
	Weed Management	Scout fields for winter annual weeds; apply herbicide if warranted.
Winter (November to late March)	Planning	Crop planning to facilitate winter wheat planting in the fall.
April	Weed Management	Scout fields for weeds; apply herbicide if warranted.
	Plant Care	Monitor crop development. Check for winter-kill.
	Soil Care	Conduct soil tests. Broadcast Nitrogen fertilizer.
May	Plant care	Monitor crop development.
	Insect Management	Scout fields for all insects; apply insecticide if warranted.
	Disease Management	Scout fields for all diseases; apply fungicide if warranted
June	Insect Management	Scout fields for all insects; apply insecticide if warranted.
	Disease Management	Scout fields for all diseases; apply fungicide if warranted
	Plant care	Monitor crop development.
July	Plant care	Monitor crop development. Harvest when crop has reached maturity

Abiotic Factors Limiting Production

Flooding

Spring flooding, if excessive, can damage winter wheat seedlings and reduce crop yield, however winter wheat can often overcome such damage with aggressive tillering once growth resumes in the spring.

Frost

Late spring frost can damage winter wheat seedlings, with severity dependent upon the growth stage of the wheat, and the duration of the low temperatures. Reduction in yield can range from minor to moderate.

Cold winter temperatures

Canada's cold winter temperatures are a major abiotic stress for winter wheat. Cold temperature tolerance limits the area of winter wheat production. Cold temperatures result in winterkill and/or delayed development to varying degrees every year. Winter hardiness is affected by both genetic and climatic factors. This stress is the main factor limiting winter wheat production in many regions. While breeders have made significant gains in improving winter hardiness of varieties, in many areas, winter wheat growers need to use other agronomic practices to address this risk.

On the prairies, snow trapping is required to maintain a minimum of 12 cm of snow cover that insulates seedlings through the coldest winter periods. Low snow trapping potential limits the area in winter wheat production. Increased seeding rates are also used to ensure adequate spring plant populations. Even using these practices, maintaining 12 cm of snow cover is difficult in areas on the prairies that receive low levels of snowfall or have mid-winter snowmelt periods.

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 winter 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 spring and summer negatively affects winter wheat yields. Dry weather in the fall may delay crop development, reduce yields and reduce winter hardiness. In extreme cases, fall drought may delay fall germination to the point where the crop does not vernalize and develop properly the following spring.

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 which 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 UV_A and UV_B damage.

In addition, other causes of leaf spotting are nutrient deficiencies and herbicide injury.

Diseases

Key Issues

- There is a need for the development of winter wheat varieties with resistance to many diseases including leafspots and snow moulds.
- Effective controls, including resistant varieties and fungicides, are required for fusarium head blight.
- There is a need for alternatives to triazole fungicides to facilitate resistance management of fusarium head blight pathogen populations.

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

Diseases	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	Atlantic Provinces
Seedling blights; root rots					4	I
Take-all						
Ergot						
Stem rust	F, D, high*					
Leaf rust						
Stripe rust				0		
Powdery mildew						I
Wheat streak mosaic virus	F					
Barley yellow dwarf virus						I
Fusarium head blight (scab)						
Loose smut						I
Grey snow mould and speckled snow mould			D			
Pink snow mould						
Snow scald			I			
Tan spot						
Septoria/ Stagonospora leaf blotch						I

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 - Pest is present in province but the frequency of its occurrence is unknown.
D - Pest is present in province but its distribution is unknown.
I - Pest is present in province but its pressure is unknown.
F, D, high* - the frequency and distribution are unknown however this disease has high importance in Alberta.
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 5. Adoption of disease management practices for winter wheat in Canada[1]

Practice / Pest		Leaf spot complex	Rusts	Streak mosaic virus	Ergot	Fusarium head blight	Dwarf bunt	Snow molds
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							

Practice / Pest		Leaf spot complex	Rusts	Streak mosaic virus	Ergot	Fusarium head blight	Dwarf bunt	Snow molds
New Practices (on a provincial basis)	**Alberta** - integration of strategies							
	Saskatchewan - tank mixing of fungicide modes of action to delay 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 6. Fungicides registered for disease management in winter 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)	triazole	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)	triazole	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	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 as of January 27, 2012: R – full registration; 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.

Ergot (*Claviceps purpurea*)

Pest information

Damage: Ergot infects the developing grains of winter 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. Avoid planting winter wheat adjacent to other winter cereals, especially fall rye. 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

None identified.

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. In most years, environmental conditions that favour FHB development do not coincide with susceptible growth periods of winter wheat.

Life cycle: The fusarium 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 on seedlings, crop residue, soil, grass and weeds. 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 winter wheat into corn residue should be avoided.

Resistant cultivars: Most winter wheat varieties are susceptible to FHB; however, there are a few moderately resistant varieties available.

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 are 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 varieties with greater resistance to FHB.
2. There is a need to develop fungicidal treatments with different modes of action than the triazole family, for resistance management.
3. There is a need to educate growers on IPM approaches available for the management of FHB.

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 mycelium is established in the developing embryo and becomes dormant in the maturing kernel. When the seed germinates, the mycelium breaks dormancy and invades 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: Only disease-free seed should be planted. Seed tests are available through seed labs to test seedlots for loose smut.

Resistant cultivars: Wheat lines are not routinely tested for resistance to loose smut.

Chemical controls: Seed treatments are available that control loose smut.

Issues for loose smut

None identified.

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 infected 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: The use of clean, disease-free seed helps minimize the impact of these diseases. Shallow seeding reduces infection of the sub-crown internode. Rotating wheat with non-host crops such as flax, canola and legumes can reduce levels of cochliobolus spores in the soil. Several non-cereal crops (eg. corn) are also hosts for fusarium so rotating with these crops will not reduce these species. Avoiding rotations where wheat follows corn can reduce disease risks. Maintenance of adequate fertility levels reduces the risk of increases in disease severity.

Resistant cultivars: None available.

Chemical controls: There are several seed treatments that will control this group of diseases.

Issues for seedling rots and blights, root rots

1. There is concern that the continued use of triazole fungicides may result in resistance development in some pathogens. There is a need to develop fungicidal treatments with modes of action that differ from the triazole family for resistance management.

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 balanced crop nutrition including adequate phosphorus and potassium reduces disease severity. Grassy weeds and volunteer wheat help maintain take-all inoculum in the field and should be controlled.

Resistant cultivars: None available.

Chemical controls: None available.

Issues for take-all

1. There have been few studies on this disease given that it is soil-borne.

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 winter wheat seedlings, crop residue and in the soil. In some regions, extensive lesions can develop on winter wheat leaves under snow cover. Spores produced in infected residues are wind-blown to new plants where they cause new infections. Warm, humid (wet) weather is favourable for infection. Conidia 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: None available.
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: tanspot/ septoria/ stagononospora leaf and glume blotch

1. There is a need for the development of winter wheat varieties with resistance to the leafspot diseases.

Rust (*Puccinia spp.*): stem rust (*Puccinia graminis*), leaf rust (*Puccinia triticina*), stripe rust (*Puccinia striiformis*)

Pest information

Damage: Heavy infections of leaf rust can result in the death of the whole leaf and reduce 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 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 levels. Conditions which favour early development of the crop can help to reduce the impact of rusts.
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, however there are few choices in winter wheat

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 available.

Chemical controls: Foliar fungicides are available to control stem, leaf and stripe rust.

Issues for rusts

1. New virulent forms of rust constantly render current resistant genes ineffective. The continued development of resistant varieties is important.
2. New, virulent strains of stripe rust are suspected in winter wheat.
3. The potential introduction of the stem rust pathogen strain Ug99 is a concern. Resistant varieties are required.

Powdery Mildew (*Blumeria graminis* f. sp. *tritici*)

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 leaf are affected.

Life cycle: The fungus survives and overwinters on crop residues and overwinters on infected winter wheat plants. In the spring, ascospores from conidia on infected plants 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. There is a need for the continued maintenance of powdery mildew resistance in new cultivars.

Barley yellow dwarf virus (BYDV)

Pest information

Damage: Barley yellow dwarf virus (BYVD) infection in wheat causes leaves to become 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 off. BYDV may reduce head size in infected plants, and the apical and basal spikelets may be sterile.

Life cycle: This disease is transmitted by aphids. The development of this disease often depends on the arrival of aphids blown-in on air currents from the southern USA. Infections can occur throughout the growing season but are higher later in the growing season when aphid populations are highest. Aphids carrying BYDV infect winter wheat in the late-summer and fall. Winter wheat can act as an overwintering reservoir for the virus. BYDV also overwinters on perennial grasses that were infected in the fall.

Pest management

Cultural controls: Planting date affects the severity risk of the disease and yield loss. Seeding earlier than the optimal seeding date will increase BYDV disease risk. Aphids are sensitive to low temperatures and their numbers drop off as cool fall temperatures arrive. Early seeding allows aphids more time to infect plants in the fall. Controlling volunteer wheat two or more weeks prior to seeding reduces aphid populations. Seed-applied insecticides can minimize the risk of spread of BYDV but will not eliminate the risk.

Resistant cultivars: None available.

Chemical controls: None available.

Issues for barley yellow dwarf virus

None identified.

Wheat streak mosaic virus (WSMV)

Pest information

Damage: When winter wheat resumes growth in the spring, light green to yellow streaks appear on the leaves. Damage often first appears in field margins as a result of mite migration. The yellowing expands until the leaves die. Diseased plants are stunted to varying degrees depending on when the plant was infected. The disease results in yield loss and shrivelled grain.

Life cycle: WSMV is transmitted by the wheat curl mite (*Aceria tosichella*). Both the virus and its vector can survive only on living plants. Virus-infected mites infest winter wheat in the fall where they overwinter. The mites multiply in the spring and are readily spread by wind to nearby plants including spring crops. Spring cereals carry the virus and mites through the late summer after winter wheat crops have matured. If winter wheat is sown before spring wheat matures, mites will carry the virus to the new crop.

Pest management

Cultural controls: Fields, to be seeded to winter wheat, should be free from volunteer wheat plants for at least one week prior to seeding. Avoid planting winter wheat adjacent to spring wheat fields. Late seeding often helps avoid any overlap with spring cereals.

Resistant cultivars: A few mite resistant varieties are available.

Chemical controls: None available.

Issues for wheat streak mosaic virus

1. There are no pesticides available to control the mite vector. Pesticides are not effective against virus diseases.

Snow moulds: grey snow mold and speckled snow mold (*Typhula* spp.), pink snow mold (*Monographella nivalis)*, and snow scald (*Myriosclerotinia borealis*)

Pest information

Damage: Snow mould symptoms appear soon after snow melt. Individual plants, groups of plants or large areas can be affected. Symptoms are usually most pronounced in areas with heavy snow cover. The most obvious symptom is dead plants that are slimy, brown and rotted. Partially infected plants have necrotic symptoms on one or more leaves. Warm, dry weather in the spring will stop disease development and promote rapid plant growth. Plants with considerable damage often recover from the disease with little or no impact on yield.

Life cycle: Snow moulds are a group of organisms that infect overwintering winter wheat seedlings under snow cover. Gray and speckled snow moulds and snow scald over-summer in the soil as sclerotia. Pink snow mould over-summers on crop residue and seed. Grey and speckled snow mould hyphae, growing from sclerotia, infect seedlings under the snow. Pink snow mould and snow scald infections start when airborne spores are released in the fall. Snow mould growth on leaves becomes apparent when the snow melts in the spring. Sclerotia of gray and speckled snow moulds, and snow scald form by spring. Pink snow mould spore bodies develop over the winter. These spore bodies may initiate subsequent infections of upper plant parts and seed coats.

Pest management

Cultural controls: Rotating winter wheat with spring crops for several years reduces disease. Early seeding of winter wheat increases the risk of snow mould.

Resistant cultivars: Although no winter wheat cultivar is resistant to the disease, cultivars do differ in tolerance.

Chemical controls: Effective seed treatments are available for snow moulds that reduce seed borne inoculum.

Issues for snow moulds

1. There is a need to assess winter wheat varieties for snow mould susceptibility.
2. There is a need for the development of cultivars with greater resistance to the snow mould pathogens.

Insect and Mite Pests

Key Issues

- There is a need for pest management strategies that target specific pests but do not harm beneficial insects.
- New product registrations are needed to control insects and mites.
- More varieties resistant to the wheat curl mite are needed.

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

Insect pests	Alberta	Saskatche-wan	Manitoba	Ontario	Quebec	Atlantic Provinces
Grasshoppers						
Cutworms	D					
Armyworm		I				
Cereal leaf beetle			F			
Wheat stem sawfly	F				F	
Hessian fly	F					
Wheat midge						
Cereal aphids (general)						
English grain aphid					4	
Oat bird cherry aphid						
Wireworms						
European chafer						

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 - Pest is present in province but the frequency of its occurrence is unknown.

D - Pest is present in province but its distribution is unknown.

I - Pest is present in province but its pressure is unknown.

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

Practice / Pest		Grass-hoppers	Cut-worms	Cereal leaf beetle	Hessian fly	Wheat stem sawfly	Cereal aphids	Wire-worm	Euro-pean 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								

Practice / Pest		Grass-hoppers	Cut-worms	Cereal leaf beetle	Hessian fly	Wheat stem sawfly	Cereal aphids	Wire-worm	Euro-pean chafer
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						■	■	
New Practices (on a provincial basis)	**Alberta** - importing parasitoids fron the US			■					
	Alberta - possible swathing height to allow the benefical braconids to survive better					■			
	Saskatchewan - Nolo Bait PCP # 29197 (ai *Nosema locustae*)	■							
	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 winter 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
dimethoate	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	aphids, Russian wheat aphid, grasshoppers, orange blossom wheat midge, Say stink bug, thrips

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted pests[1]
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)
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 as of January 27, 2012: R – full registration; 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.

Cereal aphids - English grain aphid *(Macrosiphum avenae);* oat-birdcherry aphid (*Rhapalosiphum padi);* Russian wheat aphid *(Diuraphis noxia)*

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. Aphids seldom cause direct problems with winter wheat. However, aphids are the vector for barley yellow dwarf virus. 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, which hatch in the spring, are capable of asexual reproduction. 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 overwinter in Canada. Female aphids are typically blown in from the USA throughout the growing season.

Pest management

Cultural controls: Aphids are sensitive to low temperatures and their numbers drop off as cool fall temperatures arrive. Early seeding allows aphids more time to infect plants with BYDV in the fall. Controlling volunteer wheat 2-3 weeks before planting greatly helps to reduce aphid populations. Avoiding planting winter wheat crops next to infested spring wheat 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: Seed-applied insecticides to control aphids can minimize, but not eliminate, the risk of spread of BYDV. If economic thresholds are reached, an insecticide application is recommended until about two weeks after flowering.

Issues for aphids

1. There is a need for the registration of insecticides selective for the control of aphids that are not harmful to natural parasitoids and predators.

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. The loss of photosynthetic area may result in significant yield losses.

Life cycle: Adult beetles overwinter in and along the margins of grain fields in protected places like heavy 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 - 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. Clean ploughing increases the risk of infestations of this pest, because the over-wintering sites of beneficial organisms are destroyed.

Resistant cultivars: None available.

Chemical controls: A few insecticides are available to control cereal leaf beetle (reger Table 9), however, in order to protect the natural enemy population, chemical control is not recommended unless the pest population exceeds the application threshold.

Issues for cereal leaf beetle

1. Cereal leaf beetle is a new pest in Alberta. Growers in Alberta require information on the management of this pest.
2. There is a need for the registration of insecticides that will not harm the parasitoid *Tetrastichus julis*, which has been released to manage cereal leaf beetle in some provinces.

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

Pest information

Damage: Cutworms are sporadic pests 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. 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: Due to its growth habit, winter wheat is more tolerant of cutworm feeding than spring wheat. Older plants that are growing vigorously can withstand more damage than younger plants. There are many insects and birds that prey on cutworms.

Resistant cultivars: None available.

Chemical controls: A number of insecticides are registered for use in wheat for cutworm control. Refer Table 9.

Issues for cutworms

1. Resources are required to assist producers in identifying cutworm species to facilitate scouting and making spray decisions.

European chafer (*Rhizotrogus majalis*)

Pest information

Damage: European chafer is an annual grub that feeds on the roots of winter wheat seedlings in the fall and early spring. Root pruning may cause poor emergence, stunted growth 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 resume feeding on roots. Grubs stop feeding by mid-May to pupate. There is one generation per year.

Pest management

Cultural controls: 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 winter wheat, predatory nematodes (*Heterorhabditis bacteriophora*) are available that attack grubs such as European chafer. Early scouting for the grub stage is extremely important.

Resistant cultivars: None available.

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

Issues for European chafer

None identified.

Grasshoppers: lesser migratory grasshopper (*Melanoplus sanguinipes*), two striped grasshopper (*Melanoplus bivitallus*), 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 result in up to 50% crop loss. Grasshopper damage is strongly related to weather conditions. Under hot, dry conditions a small grasshopper population may do as much damage as a large grasshopper population will under cool, wet conditions. In winter wheat production, damage can occur at two key times: crop emergence in the fall just prior to grasshopper die off; or in the spring. In the fall, winter wheat is small and one of the few green plants available for grasshoppers to eat. In the spring, damage is not as pronounced as the crop is early and will be larger and growing much faster than the feeding injury caused by the grasshoppers.

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

Pest management

Cultural controls: Crop rotation, tillage and trap strips help minimize the impact of this pest. 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 some provincial agriculture ministries.

Resistant cultivars: None available.

Chemical controls: A number of insecticides are available to control grasshoppers in wheat. Refer Table 9. The use of spreadable bran baits has great promise in selectively killing grasshoppers while minimizing effects on non-targets.

Issues for grasshoppers

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

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 and causing stunting of tillers and yield loss.

Damage can occur in both spring and fall, although it is the fall population that is the main concern for winter wheat.

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

Pest management

Cultural controls: Delayed seeding of winter wheat until after the adult flies are no longer flying and laying eggs, helps to reduce damage caused by this pest. Since the insect is a weak flier, crop rotation will help control the insect. 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. There is a need for the registration of seed treatments to provide growers access to the same insecticides as their competitors in the US.
2. There is a need to evaluate the economic impact of Hessian fly in some regions.

True armyworm (*Pseudaletia unipuncta*)

Pest information

Damage: There are usually two generations per year in Canada. The fall generation will feed on winter wheat seedlings. With the spring generation, 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.

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 a need for the registration of microbial insecticides for armyworms to provide Canadian producers access to the same pesticides as their US competitors.

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.After hatching, the young larvae feed on the developing wheat kernels for 2-3 weeks and then drop to the soil to pupate and overwinter. On the prairies, wheat midge emergence is timed with spring wheat. In most years, damage to winter wheat is minimal since its flowering period occurs a few weeks before midge flies are laying eggs.

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. 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 B.C., another small parasitic wasp, *Euxestonotus error*, attacks the wheat midge in similar fashion to *M. penetrans*.

Resistant cultivars: Resistance to wheat midge is present in winter wheat cultivars, and this trait has been transferred through breeding efforts into spring wheat classes.

Chemical controls: An insecticide application is recommended only if the economic threshold has been reached. Refer to Table 9.

Issues for wheat midge

1. There is a need for the registration of alternative pesticides to the organophosphates for the management of wheat midge.
2. Resistant varieties are based upon a single resistance trait, which may be vulnerable to the development of resistance within the pest population.

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. Losses may be as high as a 15% in yield as well as 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 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 help to reduce populations of sawfly.

Resistant cultivars: Resistant, solid stem varieties are available.

Chemical controls: None available.

Issues for wheat stem sawfly

None identified.

Wireworms (*Elateridae*)

Pest information

Damage: Wireworms feed on shoots and roots causing plants to appear stunted, to wilt or to die. Wireworms are often found more abundantly in medium textured, well-drained soils and in fields that are recently broken sod. Wireworms are rarely a problem in winter wheat.

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 5-10 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 available to control wireworms. Refer to Table 9.

Issues for wireworms

1. There is a need for the development of monitoring techniques and economic thresholds for wireworm in wheat in general.
2. Wireworms are managed somewhat through rotations however further research is required in this area.
3. There is a need for the registration of seed treatments for wireworm given the loss of lindane.

Weeds

Key Issues

- Resistance within weed populations to numerous classes of herbicides is a concern in wheat production.
- 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.
- Growers often use farm saved seed, therefore need to ensure that weed seed content is low in harvested wheat seed.

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

Weeds	Alberta	Saskatche -wan	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 winter wheat in Canada[1]

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)	**Alberta** - sub-surface banded fertilizer	■	■	■	■
	Saskatchewan - tank mixing herbicides for resistance management	■	■	■	■
	Saskatchewan - low disturbance seeding	■	■	■	■

■ **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 winter 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), tartery 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-methy (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
tribenuron-methyl (spring wheat only)	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	RE	broadleaf weeds

Active ingredient[1]	Classification[2]	Mode of action[2]	Resistance group[2]	Registration status[3]	Targeted weeds[1]
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 as of February 14, 2012: R – full registration; 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

Weed 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. Spring annual grassy weeds often cannot effectively compete with winter wheat, so yields losses are limited. Winter annual grassy weeds, like downy and Japanese brome, are very competitive with winter wheat and can cause significant yield losses.

Life cycle: Annual grasses reproduce from seeds which are produced in great numbers. Some annual grassy weeds, like downy brome, exhibit a winter annual growth habit, germinating in the fall, overwintering and completing their life cycle in the spring. Seed of some species can remain viable in the soil for several years.

Pest management

Cultural controls: Integrated crop management using diverse crop rotations, especially with spring-seeded crops, increased seeding rates and varying seeding dates, can help reduce grassy weed pressures and aid in herbicide rotation. Sanitation of field borders can prevent annual brome invasions. Tillage can help with weed management, for instance, green foxtail will not germinate if buried deeper than 7.5 cm. 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. Using pedigreed seed can prevent invasion of annual brome species into new areas.

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 spring annual 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 for a list of registered herbicides.

Issues for annual grassy 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. There also is resistance to dinitroanalines in setaria species. Cross-resistance and multiple-resistance has also been documented. Research and extension efforts to develop and promote effective and sustainable solutions must be made a top priority.
2. Increased resources are needed to assess, monitor and map resistance. Also, quicker and less costly techniques are required to diagnose herbicide resistance.
3. The trend to wider row spacing could increase dependence on herbicides and thus increase the rate of resistant weed development.
4. Few herbicides are labelled for downy bromegrass (*Bromus tectorum*) and Japanese bromegrass (*Bromus japonicus*), two difficult to control weed species. More herbicide options are needed to control downy and Japanese brome in winter wheat.

5. Weed surveys are required in a number of regions to establish levels of weed infestations.
6. Wild oats are a major problem in winter wheat.

Annual broadleaf weeds

Weed information

Damage: Broadleaf weeds, particularly winter annuals, can cause yield losses if not controlled. Commonly found 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. Spring annual broadleaf weeds often cannot effectively compete with winter wheat, so yields losses are limited. Winter annual broadleaf weeds, such as stinkweed, flixweed and shepherd's purse, are very competitive with winter wheat and can cause significant yield losses.

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. Due to increasing weed resistance to ALS/AHAS inhibitor herbicides, integrated pest management is important. Refer to Table 12 for list of registered herbicides.

Issues for annual broadleaf weeds

1. The potential for the further development of herbicide resistant weed species is of concern.
2. The trend to wider row spacing could increase dependence on herbicides and thus increase the rate of resistant weed development.
3. Improved controls are required for winter annuals such as stinkweed, shepherd's purse and flixweed.

4. Weed surveys are required in a number of regions to establish levels of weed infestations.

Perennial grass weeds

Weed 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 difficult 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 root systems. 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 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 controls exist. Control of perennial grasses should be done prior to winter wheat production. Foxtail barley seedlings are poor competitors and usually become established only in areas with poor crop stand. Establishing a competitive crop can help reduce pressure from this weed species. Foxtail barley can be easily controlled with tillage.

Resistant cultivars: None available.

Chemical controls: Glyphosate treatments prior to winter wheat production, including pre-harvest treatments in preceding spring crops and a pre-seed burn-off, will provide control of several perennial grassy weeds including quackgrass and foxtail barley. Refer to Table 12 for available herbicides.

Issues for perennial grass weeds

1. Weed surveys are required in a number of regions to establish levels of weed infestations.
2. Minimum tillage systems have led to increased problems with perennial weeds in general.

Perennial broadleaf weeds

Weed 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 root systems 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: Glyphosate treatments prior to winter wheat planting, including pre-harvest treatments in preceding spring crops and a pre-seed burnoff, will provide control of several perennial broadleaf weeds including Canada thistle and perennial sow-thistle. In-crop chemicals are available for controlling Canada thistle. There are in-crop herbicides registered for top-growth control or suppression of perennial broadleaf weeds, but not for season-long control. Refer to Table 12 for list of registered herbicides.

Issues for perennial broadleaf weeds

1. Weed surveys are required in a number of regions to establish levels of weed infestations.
2. Minimum tillage systems have led to increased problems with perennial weeds in general.

Volunteer crops

Weed 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 occur, resulting in downgrading. Spring wheat volunteers can act as a "green bridge" for disease and insect pests in winter wheat.

Life cycle: Volunteer crops grow from seeds that are the left behind as a 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: The use of glyphosate, prior to seeding, can be used to control volunteer crops except for those which are glyphosate resistant.

Issues for volunteer crops

1. Glyphosate-tolerant varieties of volunteer canola, soybean and corn cannot be eradicated with glyphosate prior to seeding.
2. Volunteers of other wheat classes or cereal grain species cannot be controlled with herbicides in winter wheat.

Resources

IPM / ICM resources for production of winter 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

Winter Wheat Production Manual 2002, a practical guide to successful winter wheat production. D. B. Fowler Crop Development Centre, University of Saskatchewan, Saskatoon.
www.usask.ca/agriculture/plantsci/winter_cereals/Winter_wheat/contents.php

Varieties of Grain Crops 2012, Saskatchewan Agriculture, Regina SK.

www.agriculture.gov.sk.ca/Varieties_Grain_Crops

Agronomic Management of Winter Wheat in Alberta (2007)
Alberta Agriculture & Rural Development
www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11601/$file/112_10-1.pdf?OpenElement

Quebec Ministry of Agriculture, Fisheries and Food crop protection webpage:
www.mapaq.gouv.qc.ca/fr/Productions/Protectiondescultures/Pages/Protectiondescultures.aspx

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 Miller 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 peter.johnson@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec	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	-	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

Alberta Winter Wheat Producers Commission
www.wintercereals.ca

L'Union des producteurs agricoles (UPA)
http://www.upa.qc.ca/en/Home/Home.html

Saskatchewan Winter Cereals Development Commission
www.swcdc.info

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	
		moderate	
		low	
	localized	high	
		moderate	
		low	
If the pest is present 6 years or less out of 10 (sporadic)	widespread	high	
		moderate	
		low	
	localized	high	
		moderate	
		low	
Pest not present			
Data not reported			

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.

References

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Statistics Canada
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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www.gocereals.ca

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www.usask.ca/agriculture/plantsci/winter_cereals/Winter_wheat/contents.htm

Winter Cereals Canada
www.wintercereals.ca