Crop Profile for Wheat in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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

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Crop Profile for Wheat in Canada

Wheat (Triticum aestivum and T. turgidum L. var. durum (Desf.) Mk.) has a special place as a crop in Canada in that it was first grown by pioneers, opening up the agricultural areas of Canada in the1800's. It currently is one of the most important crops in Canada, comprising over 10 million hectares. The crop is consumed throughout Canada and in more than 70 countries worldwide. Because of the enormous acreage involved in wheat production, the crop has received much attention from industry and government scientists with respect to the development of crop varieties. The bulk of breeding for wheat is funded through a $3 million per year check-off paid by growers and administered through Western Grains Foundation. Over 200 varieties categorized into seven wheat types are grown in Canada. These include:

Canada Western Red Spring (CWRS)
Canadian Prairie Spring Red (CPSR)
Canadian Prairie Spring White (CPSW)
Canadian Western Extra Strong (CWES)
Canadian Western Amber Durum (CWAD)
Canadian Western Soft White Spring (CWSWS).
Canada Western Red Winter (CWRW)

Wheat is processed into flour, cereal food and feed, bread, pasta and bakery products. The durum wheat's are used for pasta or semolina. The high quality hard red spring wheat is used for high quality breads, while the prairie spring classes are used for feed wheat.

Unique among crops, federal law requires that western Canadian producers market their wheat through the Canadian Wheat Board (CWB). The CWB is a farmer-controlled organization that markets all of the wheat and barley grown by western farmers. Based in Winnipeg, Manitoba, the CWB has a 20 per cent market share of world wheat exports.

General Production Information

Canadian Production (2003)	23,442,400 metric tonnes 10,621,300 hectares
Farm gate value (2003)	$4,097 million
Domestic consumption (2002)	7,300,00 metric tonnes
Export (2002)	$1900 million
Imports (2002)	$32 million
Source(s): Statistics Canada	

Production Regions

Approximately 85,000 grain farmers in Western Canada produce between 22 and 24 million tonnes of wheat every year. Most of the Canadian production of wheat occurs in the west with the distribution of national production as follows: Saskatchewan (6,137,000 hectares or 46%) and Alberta (2,717,000 hectares or 27%), Manitoba (1,469,000 hectares or18%). Small amounts are grown in Ontario (352,000 hectares or 8%) and Quebec (46,000 hectares or 1%). Spring wheat accounts for approximately 8,000,000 ha (75 %)of production, and durum wheat for

2,000,000 ha (19 %). Winter wheat makes up only about 5 percent of production because varieties that can withstand harsh winters are not yet available.

Cultural Practices

Wheat can be grown on various soil types, but is best suited to well-drained soils that have not been seeded to the crop in the year prior. Spring planted wheat is grown throughout Canada, but the majority of production is in the Prairie region. Winter wheat (fall planted) is primarily grown in the warm, southwestern region of Ontario and in certain areas throughout the remaining regions. Fluctuations in acreage are not large with the crop because it is an essential component of crop rotations. Yield variability is the result of weather conditions, in particular drought.

The grade and quality of the wheat determines how it will be used. The main uses for wheat include (a) flour (b) pasta flour and (c) livestock feed. Wheat flour is used to produce a variety of breads, cereals, baked goods and feed. High protein, high quality cereals are used for high quality breads. Pasta or semolina flour is processed into several types of noodles. Feed varieties of the Canada Prairie Spring class of wheat are used in livestock feed.

Production Issues

Drought can be a limiting factor for wheat production in some years. Pest issues continually arise and it is important that crop protection, through resistant varieties, not be taken for granted. Rusts continue to change and adapt. New diseases such as fusarium head blight have increased in the main wheat growing areas. Weed resistance to several groups of herbicides has become an issue.

Given the extensive acreage of wheat, breeding programs for the development of new varieties have been critical . The goals of most breeding programs include (a) continued pest resistance to new strains of rust, (b) the development of new varieties that are resistant to fusarium head blight and wheat midge and (c) continued improvement in quality. Recently, the use of biotechnology as a breeding tool has become controversial, with the wheat marketing system registering concerns about consumer acceptance of glyphosate tolerant wheat.

Table 1. Canadian wheat production and pest management schedule

TIME OF YEAR	ACTIVITY	ACTION
Winter (November to late March)	None	None
April	Initial Preparation	Prepare seed and fertilizer for planting. Conduct soil tests.
May	Weed Management	Pre-seeding glyphosate application.
June	Plant Care	Seed spring wheat
	Soil Care	Fertilize according to soil test
	Weed Management	Cultivation prior to seeding for weed control.
July	Plant care	Monitor flowering; seed winter wheat
	Disease Management	Scout fields for all diseases; apply fungicide if warranted
	Insect Management	Scout fields for all insects; apply insecticide if warranted
August	Plant Care	Monitor seed set to estimate yield potential
	Disease Management	Continuation of field scouting for all diseases; fungicide application if warranted
	Insect Management	Continuation of field scouting s for all insects; insecticide application if warranted
September	Plant Care	Harvest when 75% of seeds have reached maturity
	Soil care	Tillage directly after harvest for disease, weeds and straw management

Template adapted from BC Ministry of Agriculture, Food and Fisheries apple crop profile

Abiotic Factors Limiting Production

Key Issues

- Poor winter survival limits acreage of winter wheat.

Cold winter temperatures

The growth of acreage of winter wheat in the west has been capped for many years by the lack of a good variety with tolerance to cold winter temperatures. With improved cold tolerance, winter wheat could play an important role both in soil conservation by providing winter cover and organic matter to soils and in integrated pest management.

Drought

Summer droughts negatively impact yield.

Diseases

Key Issues

- Effective controls, including resistant varieties and fungicides are required for fusarium head blight.
- There is a need for alternatives to the triazole fungicides to facilitate resistance management.

Table 2. Degree of occurrence of diseases in Canadian wheat production

	Degree of occurrence				
Major diseases	**AB**	**SK**	**MB**	**ON**	**QC**
Fusarium head blight	**D**	**D**	**D**	**E**	**E**
Lesser Diseases	**AB**	**SK**	**MB**	**ON**	**QC**
Seedling rots/blights	**E**	**E**	**E**	**E**	**E**
Leaf spot diseases (Septoria and tanspot)	**E**	**E**	**E**	**E**	**E**
Rusts	**E**	**E**	**E**	**E**	**E**
Powdery Mildew				**E**	**E**

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

E – established

D – invasion expected or dispersing

Source(s): Industry Interviews – Pearse, Penny, pers. communication

Major Diseases

Fusarium Head Blight *(Fusarium graminearum and Fusarium* spp.*)*

Pest information

Damage: Fusarium head blight causes bleaching of infected spikelets and the production of orange/pink, spore-bearing structures at the base of the glumes. *Fusarium* head blight reduces yield and grade and may also contaminate the grain with toxins (mycotoxins). The disease is caused by several species of fusarium but *Fusarium graminearum* is the most important species involved. The disease has been severe in the wheat growing areas of Ontario and Manitoba. The causal agents for the disease are now found in eastern regions of Saskatchewan. The disease thrives under humid conditions during flowering.

Life Cycle: The pathogen s over-winter in crop residue, soil, grass weeds and in the seed. Seedlings can be infected at emergence. Spores produced in early infection sites are spread by rain or wind and cause new infections on structures on the flower and wheat head. Infections are most frequent and severe at flowering.

Pest Management

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. In recent years, an emergency registration for the foliar fungicide tebuconazole was granted for the suppression of FHB, but this product has a very narrow window of application.

Cultural Controls: In areas where the disease is not yet present, intensive monitoring of seed supplies and fields will restrict it's introduction. This method has been successful in preventing the introduction of FHB into Alberta. 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 avoiding seeding cereals more than once every two years in the same field, help reduce levels of disease.

Alternative Controls: None

Resistant Cultivars: None

Issues for Fusarium Head Blight

1. There is a need for resistant varieties.
2. There is a need for a reduced risk alternative fungicide to tebuconazole for foliar control of the disease.

Minor Diseases

Seedling Rots and Blights *(Fusarium* spp*, Alternaria* sp*, Septoria* sp.*, Pythium* sp*, Cochliobolus sp,and Rhizoctonia* sp*)*

Pest information

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

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

Chemical Controls: There are a number of seed treatments that will control this group of diseases. Registered compounds include metalaxyl-M, metalaxyl, triadimenol, triticonazole, difenaconazole, fludioxonil, tebuconazole, maneb, carbathiin, and thiram.

Cultural Controls: Delaying seeding until soils have warmed up to the point where rapid emergence can occur is used to avoid early infection. The use of clean, disease-free seed helps minimize the impact of the diseases.

Alternative Controls: None

Resistant Cultivars: None

Issues for Seedling Rots and Blights

1. There is concern the continued use of triazole fungicides, may result in resistance development in some of the pathogens.

Leaf Spot Complex - Tanspot and Septoria Leaf and Glume Blotch *(Pyrenophora tritic-repentis, Septoria nodorum, S. tritici)*

Pest information

Damage: Leaf spots 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, leading to downgrading. All classes of wheat can be infected with leaf spots. Durum wheat is more susceptible to tanspot. Septoria is more prevalent in the bread wheat's. These diseases can be found in wheat crops across western Canada, with the severity being dependent on local environmental conditions

Life Cycle: The pathogens overwinter on crop residue and to a lesser extent on seed. Spores produced in infected residues are wind blown to new plants where they cause new infections.. Warm, humid (wet) weather is favourable to infection.

Pest Management

Chemical Controls: Foliar fungicides are available that will control the diseases and keep them from spreading to the glumes. Registered active ingredients include chlorothalonil, mancozeb, propiconazole, pyraclostrobin, and trifloxystrobin. The use of seed treatments will prevent the disease from being introduced into a new field via seed.

Cultural Controls: Disease levels can be minimized with 2 year crop rotations and by burying crop residue. While these methods are helpful, they do not completely control leaf spot diseases in wheat crops.

Alternative Controls: None

Resistant Cultivars: None of the cultivars currently registered in western Canada have good resistance to the leaf spot disease complex.

Issues for Tanspot and Septoria Leaf and Glume Blotch

1. There is a need for resistant varieties.

Rust (*Puccinia spp.)*

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 and a reduction in quality (shrivelled seed) to a greater degree than leaf rust.

Life Cycle: Rust over-winters in the southern United States and is blown into Canada on prevailing winds. Leaf rust spores infect the leaf, developing small, brown, circular pustules while stem rust pustules develop on stems and to a limited extent on leaves. 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

Pest Management

Chemical Controls: Foliar fungicides will control both stem and leaf rust. Products that are effective on stem rust include propiconazole and trifloxystrobin. Leaf rust is controlled by these products and by pyraclostrobin and mancozeb.

Cultural Controls: Conditions which favour early emergence of the crop, can help to reduce the impact of rusts.

Alternative Controls: None

Resistant Cultivars: The use of varieties that are resistant to races of stem and leaf rust is a key component to managing the disease. All wheat varieties (except winter wheat) have good resistance to stem rust. There were 33 varieties of wheat that were resistant to leaf rust in a count taken in August, 2004.

Issues for Rust

1. New virulent forms of rust constantly render current resistance genes ineffective. The continued development of resistant varieties is important.

Powdery Mildew *(Podospahera* spp.*)*

Pest information

Damage: Powdery mildew is present mainly in Ontario, where it produces characteristic grey – white fungal growth on the surface of foliage, beginning on the lower leaves. Infection moves up the plant under favourable conditions. Affected crops may lodge or be improperly filled.

Life Cycle: The fungus survives on crop residues, winter wheat seedlings, volunteer cereals and in the crop. 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 also thrives where high rates of nitrogen have been used.

Pest Management

Chemical Controls: Foliar fungicides are available to control powdery mildew when disease levels exceed thresholds..

Cultural Controls: The burial of residues combined with crop rotation minimizes the disease impact. A two-year rotation is recommended.

Alternative Controls: None

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

Issues for Powdery Mildew

None identified

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Carbithiin; Thiram	**Anilide and oxathiin fungicide**	**7**	**R**	Seedling rots/blights	A	
Chlorothalonil	**Aromatic fungicide**	**M[2]**	**R**	Leaf spot complex		
				Fusarium head blight		
Difenoconazole	**Conazole fungicide (triazoles)**	**3**	**R**	Seedling rots/blights	A	Take-all is suppressed only
Fludioxonil	**Pyrrole fungicide**	**12**	**RR**	Seedling rots/blights	A	
Mancozeb	**Polymeric dithiocarbamate fungicide**	**M[2]**	**R**	Leaf Spot Complex	A	
				Leaf Rust	A	
Maneb	**Polymeric dithiocarbamate fungicide**	**M[2]**	**R**	Seedling rots/blights	A	
Metalaxyl-M; metalaxyl	**Acylamino acid and anilide fungicide**	**4**	**R**	Seedling rots/blights	A	
Propiconizole	**Conazole fungicide (triazoles)**	**3**	**R**	Rusts	A	Concerns over resistance developing.
				Leaf Spot Complex	A	
				Powdery Mildew		
Pyraclostrobin	**Strobilurin fungicide**	**11**	**RT**	Leaf Spot Complex	A	
				Leaf Rust	A	
				Powdery Mildew	A	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Tebuconazole	**Conazole fungicide (triazoles)**	**3**	**R**	Fusarium head blight (as foliar).	A	
				Seedling rots and blights (as seed treatment)	A	
Thiram	**Dithiocarbamate fungicide**	**M[2]**	**R**	Seedling rots/blights	A	
Triadimenol	**Conazole fungicide (triazoles)**	**3**	**R**	Seedling diseases	A	Take-all is suppressed only
Trifloxystrobin	**Strobilurin fungicide**	**11**	**RR**	Leaf and Stem Rust	A	
Triticonazole	**Conazole fungicide (triazoles)**	**3**	**RT**	Seedling rots/blights	A	

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-full registration (biological), RR- full registration (reduced risk), OP-full registration (organophosphate replacement), NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
Source(s): Provincial Crop Protection Guides {OMAF Pub 75, Guide to Crop Protection (Prairie Provinces co-publication)}and ELSE Database

Table 4. Availability and use of pest management approaches for major diseases in Canadian wheat production

	Practice \ Pest	Fusarium head blight
Prevention	tillage	
	residue removal / management	
	water management	
	equipment sanitation	
	row spacing / seeding depth	
	removal of alternative hosts (weeds/volunteers)	
	mowing / mulching / flaming	
Avoidance	resistant varieties	
	planting / harvest date adjustment	
	crop rotation	
	trap crops - perimeter spraying	
	use of disease-free seed	
	optimizing fertilization	
	reducing mechanical damage / insect damage	
	thinning / pruning	
Monitoring	monitor seed	
	records to track pathogen	
	monitor fields for disease	
	soil analysis	
	weather monitoring for disease forecasting	
Suppression	use of thresholds for application decisions	
	biological pesticides	
	beneficial organisms & habitat management	
	pesticide rotation for resistance management	
	ground cover / physical barriers	
	forecasting for applications	
no information regarding the practice is available		
available/used		
available/not used		
not available		
Source(s): Information in the crop profile for individual pests		

Insect and Mite Pests

Key Issues

- There is a need for pest management strategies that target specific pests but do not harm beneficials.
- Product registrations are needed to control insects and mites.

Table 5. Degree of occurrence of insect and mite pests in Canadian wheat production

	Degree of occurrence				
Major Pests	**AB**	**SK**	**MB**	**ON**	**QC**
Grasshoppers	**E**	**E**	**E**	**E**	**E**
Cutworm	**E**	**E**	**E**	**E**	**E**
Wheat Stem Sawfly	**E**	**E**	**E**	**E**	**E**
Wheat Midge	**E**	**E**	**E**	**E**	**E**
Minor Pests	**AB**	**SK**	**MB**	**ON**	**QC**
Aphids	**E**	**E**	**E**	**E**	**E**
Wireworms	**E**	**E**	**E**	**E**	**E**
Widespread yearly occurrence with high pest pressure					
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure					
Widespread yearly occurrence with low to moderate pest pressure					
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure					
Pest not present					
E – established					
D – invasion expected or dispersing					
Source(s): Saskatchewan Agriculture and Food					

Major Insect and Mite Pests

Grasshopper *(Melanoplus sanguinipes, Melanoplus bivitallus, Camnula pellucida)*

Pest information

Damage: Grasshoppers are voracious feeders, attacking all of the above ground portions of the plant. As the weather warms and dries, the insects become more active. Populations and damage rise dramatically and can cause up to 50% crop loss. The insect is of most concern in drier areas of the prairies.

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

Pest Management

Chemical Controls: Malathion, chlorpyrifos, dimethoate, carbaryl and synthetic pyrethroids are used to control grasshoppers in wheat. The synthetic pyrethroids do not work well when temperatures are high. Growth regulators such as dimilin, are also available and selectively kill grasshoppers. The use of spreadable bran baits has great promise in selectively killing grasshoppers.

Cultural Controls: Early seeding of crops, crop rotation, tillage and trap strips help control this pest. Tillage of egg-laying areas also helps reduce populations but can lead to soil erosion.

Alternative Controls: 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.

Resistant Cultivars: None

Issues for Grasshoppers

1. There is a need for an integrated control program for grasshoppers in wheat.
2. There is a need for a reduced risk alternative to the organophosphates, that will function under high temperatures.

Cutworm: Red-Backed (*Euxoa ochrogaster*), Pale Western (*Agrotis orthogonia*), Dark-Sided (*Euxoa messoria*), Army (*Euxoa auxiliaris*)

Pest information

Damage: Cutworms are sporadic pests that can severely affect most areas of Canada in "outbreak" years. Larvae eat the roots, shoots and foliage of wheat seedlings and they may clip plants. Damage can be 75% or more in isolated patches through individual fields. Sites with early season weed growth, heavy plant residue or dense foliage near the crop are likely to sustain more injury..

Life Cycle: Larvae hatch from eggs laid on plants and feed on the host plants. They moult several times, then tunnel into the soil where they pupate. The new moths emerge, and the cycle may be repeated, although most species have just 1 or 2 generations per year.

Pest Management

Chemical Controls: Synthetic pyrethroids and chlorpyrifos are registered for use in wheat for cutworm control. Producers scout for the insects and usually will not apply chemicals unless a threshold of three pale Western cutworms or five red-backed and army cutworms per meter squared has been reached.

Cultural Controls: Wheat should be seeded with treated seed as early as possible. Older plants that are growing vigorously can withstand more damage than younger plants.

Alternative Controls: There are many insects and birds that prey on cutworms naturally.

Resistant Cultivars: None

Issues for Cutworm

None identified

Wheat Stem Sawfly (*Cephus cinctus*)

Pest information

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

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

Pest Management

Chemical Controls: None

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

Alternative Controls: Naturally occurring populations of parasitic wasps can affect populations of sawfly.

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

Issues for Wheat Stem Sawfly

None identified.

Wheat Midge (*Sitodiplosis mosellana*)

Pest information

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

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

Pest Management

Chemical Controls: Chlorpyrifos is the most frequently used product for the control of wheat midge. An insecticide application is recommended only if the economic threshold of 1 adult midge per 8–10 wheat heads has been reached.

Cultural Controls: Crop rotation and the avoidance of continuous wheat cropping will prevent the build-up of pest populations. When there are high pest populations in the soil of a particular field, rotation out of wheat for a number of years is advisable. Seeding early maturing varieties, increasing seeding rates and seeding as early as possible can lessen damage from a wheat midge infestation.

Alternative Controls: Pest populations are reduced by a small parasitic wasp called *Macroglenes penetrans* (Kirby). This wasp emerges the same time as wheat and lays its eggs inside those of the pest.

Resistant Cultivars: None

Issues for Wheat Midge

1. Alternatives to the organophosphates insecticides are needed.
2. Biological controls are also required.
3. Resistant varieties are needed.

Minor Insect and Mite Pests

Cereal Aphids (Aphididae)

Pest information

Damage: Wheat is attacked by three species of aphids that 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.

Life Cycle: Moist soil conditions during May and June are necessary for larval development and pupation. Dry conditions may result in the larva remaining dormant for extended periods of time. Warm calm evenings during July are favourable for egg laying. The insects will decline in population after a heavy rain.

Pest Management

Chemical Controls: Malathion and dimethoate are registered for the control of aphids in Canada. An insecticide application is recommended until about two weeks after flowering, only if the economic threshold of 12 – 15 aphids per plant has been reached.

Cultural Controls: Early seeding will enable the wheat crop to mature before the aphid population reaches damaging levels. Avoiding planting spring cereal crops next to infested fall sown crops will prevent possible aphid migration into the new crop.

Alternative Controls: Lacewings and lady bugs are active and aggressive feeders on aphids and can control the insect.

Resistant Cultivars: None

Issues for Aphids

1. Some aphids act as a vector for Barley Yellow Dwarf Virus.
2. Insecticides selective for the control of aphids are needed.

Wireworms (Elateridae)

Pest information

Damage: Wireworms feed on shoots and roots causing plants to appear stunted, wilt or die. The insect is present in all wheat growing areas. Infestations usually do not exceed 5% of a field. Wireworms are often found more abundantly in poorly drained soils and in fields that have been left to sod.

Life Cycle: Wireworms are the larvae of the click beetle. Eggs are laid in the soil near the roots of their host plants. Larvae remain in the soil feeding on roots. The larval stage requires up to six years to complete. When fully grown, the 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

Chemical Controls: Seed treatments are usually used to control wireworms.
Cultural Controls: Early seeding , crop rotation, and tillage help control wireworm.
Alternative Controls: None
Resistant Cultivars: None

Issues for Wireworm

1. There is a lack of seed treatment options for controlling this insect due to the suspension of the use of lindane.

Hessian Fly *(Mayetiola destructor)*

Pest information

Damage: Hessian fly larvae feed on the stem where the leaf blade meets the culm (stem). Feeding weakens the stem predisposing it to breakage, improper elongation of the plant and yield loss. The fly is found sporadically in all wheat growing areas. It is found more often in winter wheat than in spring wheat.

Life Cycle: The Hessian fly has two generations per year. In winter wheat, the emergence of flies is triggered by September rains. The flies lay eggs and establish the fall generation that causes much of the feeding damage to the young wheat seedlings. Larval development continues into the fall, with pupation and emergence of a second generation of adults the following spring.

Pest Management

Chemical Controls: Disulfoton can be used to control the insect in winter wheat.
Cultural Controls: Since the insect is a weak flier, crop rotation will help control the insect. Planting resistant varieties and the use of delayed seeding also help control this pest.
Alternative Controls: None
Resistant Cultivars: Resistant varieties are available.

Issues for Hessian Fly

1. There is a lack of chemical controls for the Hessian fly

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Carbaryl	Carbamate	1A[1]	RE	Grasshopper		
				Army worm		
Chlorpyrifos	Organophosphate	1B[1]	RE	Grasshopper	A	
				Army worm	A	
Cyhalothrin Lambda	Synthetic pyrethroid	3	R	Grasshopper	A	
Cypermethrin	Synthetic pyrethroid	3	R	Grasshopper	A	
				Cutworm		
Deltamethrin	Synthetic pyrethroid	3	R	Grasshopper	A	
				Cutworm		
Dimethoate	Organophosphate	1B[1]	R	Aphids	A	
				Wheat midge		
				Grasshopper		
Disulfoton	Organophosphate	1B[1]	DI (2005)	Hessian Fly	A	
Malathion	Organophosphate	1B[1]	RE	Grasshopper	A	
				Aphids		

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-full registration (biological), RR- full registration (reduced risk), OP-full registration (organophosphate replacement), NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
Source(s): Provincial Crop Protection Guides {OMAF Pub 75, Guide to Crop Protection (Prairie Provinces co-publication)}and ELSE Database

Table 7. Adoption of pest management approaches for major insect pests in Canadian wheat production

	Practice \ Pest	grasshopper	cutworms	wheat stem sawfly	wheat midge
Prevention	tillage				
	residue removal / management				
	water management				
	equipment sanitation				
	seeding rate				
	removal of alternative hosts (weeds/volunteers)				
	mowing / mulching / flaming				
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	trap crops - perimeter spraying				
	treated seed				
	optimizing fertilization				
	thinning / pruning				
Monitoring	scouting - trapping				
	records to track pests				
	soil analysis				
	weather monitoring for forecasting				
	grading out infected produce				
Suppression	use of thresholds for application decisions				
	biological pesticides				
	pheromones				
	sterile mating technique				
	beneficial organisms & habitat management				
	pesticide rotation for resistance management				
	ground cover / physical barriers				
	controlled atmosphere storage				
	forecasting for applications				
no information related to the practice is available					
available/used					
available/not used					
not available					
Source(s): Information in the crop profile for individual pests					

Weeds

Key Issues

- Weed resistance to a number of different herbicide classes is building. There is a concern with the amount of ACCase resistant wild oat and (in some areas) *Setaria* species. Kochia and hemp nettle have become resistant to ALS/AHAS inhibitors in some areas.
- Growers tend to use farm saved seed requiring special care to ensure weed content is low.
- Economic thresholds of weed communities that take into account the issues surrounding harvesting problems and seed set, are needed.
- Rotational strategies that incorporate non-chemical weed management are needed to limit the development of resistance.

Table 8. Degree of occurrence of weeds in Canadian wheat production

	Degree of occurrence				
Major Weeds	**AB**	**SK**	**MB**	**ON**	**QC**
grassy weeds (wild oats, green foxtail, volunteer cereals)	E	E	E	E	E
wild mustard	E	E	E	E	E
wild buckwheat	E	E	E	E	E
stinkweed, flixweed, shepherds purse.	E	E	E	E	E
perennials (Canada and sow thistle, quackgrass)	E	E	E	E	E
cleavers, hemp nettle, chickweed.	E	E	E	E	E
Minor Weeds	**AB**	**SK**	**MB**	**ON**	**QC**
lambsquarters	E	E	E	E	E
ragweed	E	E	E	E	E

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

E – established

D – invasion expected or dispersing

Source(s): Adapted from 2001 Alberta Weed Survey, 1995 Saskatchewan Weed Survey, 2002 Manitoba Weed Survey (AG Thomas et al AAFC)

Major Weeds

Annual Grasses Green Foxtail *(Setaria viridis)* & Wild Oat *(Avena fatua L.)*

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.

Life Cycle: Annual grasses reproduce from seeds which are produced annually in great numbers. Seed can remain viable in the soil for several years. Green foxtail will not germinate if buried deeper than 7.5 cm.

Pest Management

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

Cultural Controls: By delaying the seeding, the initial flush of weeds can be controlled.

Alternative Controls: None.

Resistant Cultivars: None.

Issues for Annual Grass Weeds

1. Resistance problems to commonly used herbicides, like ACCase resistant wild oats (*Avena fatua*) and *Setaria* spp, are a growing concern, especially since the number of herbicide groups registered on wheat is very limited. There also is resistance to dinitroanalines in *Setaria* species. Cross-resistance and multiple resistance has also been documented.
2. There are no current survey numbers available for actual weed infestation levels.

Annual Broadleaf Weeds

Weed information

Damage: Broadleaf weeds can cause yield losses if not controlled early in the growing season. 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, and can affect both yield and quality. Broadleaf weeds are common across all wheat growing areas.

Life Cycle: Annual weeds complete their development from seed germination, through vegetative growth, flowering and seed development, in one growing season.

Pest Management

Chemical Controls: Annual weeds can be partially controlled with a pre-seeding burn off with a glyphosate product. The use of various in-crop broadleaf herbicides such as Refine Extra (thifensulfuron methyl and tribenuron methyl) or Buctril M (bromoxynil and MCPA) will control a wide range of broadleaf weeds when applied as a post emergent treatment.

Cultural Controls: Fields with low weed pressure, especially of the hard to control broadleaf weeds, are selected as planting sites.

Alternative Controls: None.

Resistant Cultivars: None.

Issues for Annual Broadleaf Weeds

1. The potential for the further development of herbicide resistant weed species is of concern.
2. There are no effective controls for weeds such as kochia, redroot pigweed and lamb's quarters.
3. There are no current survey numbers available with respect to actual weed infestation levels.

Perennial Grass Weeds: Quackgrass (*Elytrigia repens)*

Weed information

Damage: The most commonly found weedy perennial grass species in wheat producing areas is quackgrass (*Elytrigia repens*). Quackgrass competes with the crop for moisture and nutrients and can affect both yield and quality. This plant is hard to control since the entire plant, including rootstock, must be killed in order to prevent re-growth. Perennial grassy weed problems are most common on the prairies.

Life Cycle: Perennial weeds such as quackgrass have extensive creeping rootstocks. These frequently produce shoots that give rise to a new plant. The weed readily regenerates through seed germination or root fragments. Most perennial weed seeds will germinate within a year, but some may remain viable in the soil for 20 years or more.

Pest Management

Chemical Controls: Season long control of quackgrass can be achieved using glyphosate in the spring, pre-harvest or fall.

Cultural Controls: The selection of fields with low weed pressure is important in perennial weed management since no in-crop chemical control agents exist. Control of perennial grasses should be done in the year previous to wheat production.

Alternative Controls: None.

Resistant Cultivars: None

Issues for Perennial Grass Weeds

1. There are no surveys available that provide accurate counts of infestation levels.
2. Minimum tillage systems have led to increased problems with perennial weeds.

Perennial Broadleaf Weeds: Canada Thistle (*Cirsium arvense*) and Sow Thistle (*Sonchus arvensis*)

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 rootstock, must be killed in order to prevent re-growth. Perennial broadleaf weeds are most common on the prairies.

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

Pest Management

Chemical Controls: Clopyralid is the most effective chemical in controlling Canada thistle. It is available in several formulated mixtures with other products e.g. Curtail M (clopyralid and MCPA).

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.

Alternative Controls: None.

Resistant Cultivars: None.

Issues for Perennial Broadleaf Weeds

1. There are no specific survey numbers available with respect to actual weed infestation levels.
2. Minimum tillage systems have led to increased problems with perennial weeds in general.

Minor Weeds

Barnyard grass (*Echinochloa crusgalli*), Yellow foxtail (*Setaria glauca*), Persian darnel (*Lolium persicum*)

Annual Grass Weed information

Barnyard grass (*Echinochloa crusgalli*) infests wheat fields primarily in areas of Manitoba and parts of Saskatchewan. It is normally not a significant problem and is controlled by many of the wheat graminicide products and trifluralin.

Yellow foxtail (*Setaria glauca*) is a C4 plant and therefore prefers warmer regions of Manitoba and parts of Saskatchewan. It is normally not a significant problem and is controlled by many of the wheat graminicide products and ethalfluralin.

Persian darnel (*Lolium persicum*) infests wheat fields primarily in areas of Saskatchewan and parts of Alberta. It is normally not a significant problem and is controlled by many of the wheat graminicide products and trifluralin.

Chickweed (*Stellaria media*), Hempnettle (*Galeopsis tetrahit L*), Common groundsel (*Senecio vulgaris*), Corn spurry (*Spergula arvensis*), Russian thistle (*Salsola kali*)

Annual Broadleaf Weed information

Chickweed (*Stellaria media*) infests wheat fields in cooler areas of the highly fertile, black soil zone predominantly in Alberta and parts of Saskatchewan. It is normally not a significant problem and is controlled by many of the wheat broadleaf herbicides including sulfonyl ureas products and ethalfluralin. There are documented resistance types of chickweed to sulfonyl urea's which, without proper integrated pest management could result in this weed becoming a much larger problem.

Hempnettle (*Galeopsis tetrahit L*) infests wheat fields in cooler areas of the black soil zone, predominantly in Alberta and parts of Saskatchewan. It is normally not a significant problem and is controlled by many of the wheat broadleaf herbicides.

Common groundsel (*Senecio vulgaris*) infests wheat fields in sandy, fertile soils. It is normally not a significant problem and is controlled by many of the wheat broadleaf herbicides.

Corn spurry (*Spergula arvensis*) infests cultivated areas and is not a strong competitor. It can be controlled by many of the in-crop wheat herbicides. The weed can be managed by reduced or no tillage.

Russian thistle (*Salsola kali*) infests wheat-growing regions with soils high in nitrogen. It is often referred to as tumbleweed. It can be controlled by many of the in-crop wheat herbicides.

Volunteer Crops

Volunteer crops compete with the crop for moisture and nutrients and can affect the quality of the seeds harvested. A commonly found volunteer crop in wheat producing areas is volunteer canola (*Brassica spp*). There are no current survey numbers available with respect to actual infestation levels, however based on the vast number of acres seeded to canola one can expect volunteer canola to be prevalent across all wheat growing areas of western Canada. Volunteer canola is easily controlled by most broadleaf wheat herbicides, however the use of glyphosate in the spring will not control glyphosate-tolerant varieties of volunteer canola.

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
2,4 – D[1]	phenoxyacetic herbicide	4	RE	Annual broadleaf	A	Resistant weeds recorded
Bromoxynil[1]	nitrile herbicide	6	R	Annual broadleaf	A	
Clodinafop propargyl[1]	aryloxyphenoxypropionic herbicide	1	R	Annual grasses	A	Resistant weeds recorded
Clopyralid[1]	picolinic acid and pyridine herbicide	4	R	Perennial broadleaf	A	
Dicamba[1]	benzoic acid herbicide	4	RE	Annual broadleaf	A	Resistant weeds recorded
Dichlorprop[1]	phenoxypropionic herbicide	4	R	Annual grasses	A	Resistant weeds recorded
Diclofop - methyl[1]	aryloxyphenoxypropionic herbicide	1	R	Annual grasses	A	Resistant weeds recorded
Difenzoquat[1]	quaternary ammonium herbicide	8	DI (2009)	Wild oats	A	Resistant weeds recorded
Fenoxaprop - p - ethyl[1]	aryloxyphenoxypropionic herbicide	1	R	Annual grasses	A	Resistant weeds recorded
Florasulam[1]	sulfonanilide and triazolopyrimidine herbicide	2	R	Annual broadleaf	A	
Flucarbazone-Na[1]	triazolone herbicide	5	RR	Annual grasses	A	
Fluroxypyr[1]	pyridine herbicide	4	R	Annual broadleaf	A	
Imazamethabenz[1]	imidazolinone herbicide	2	R	Wild oats, mustard, buckwheat	A	Resistant weeds recorded
Imazamox[1]	imidazolinone herbicide	2	RR	Annual grasses	A	Resistant weeds recorded

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
MCPA[1]	phenoxyacetic herbicide	4	RE	Annual broadleaf	A	Resistant weeds recorded
Metribuzin[1]	triazinone herbicide	5	R	Annual broadleaf	A	
Metsulfuron - methyl[1]	triazinylsulfonylurea herbicide	2	RR	Annual broadleaf	A	Resistant weeds recorded
Sulfosulfuron[1]	pyrimidinylsulfonylurea herbicide	2	R	Annual broadleaf	A	Resistant weeds recorded
Thifensulfuron - methyl[1]	triazinylsulfonylurea herbicide	2	R	Annual broadleaf	A	Resistant weeds recorded
Tralkoxydim[1]	cyclohexene oxime herbicide	1	R	Annual grasses	A	Resistant weeds recorded
Triallate[1]	thiocarbamate herbicide	8	R	Wild oats	A	Resistant weeds recorded
Triasulfuron[1]	triazinylsulfonylurea herbicide	2	R	Annual broadleaf	A	Resistant weeds recorded
Tribenuron - methyl[1]	triazinylsulfonylurea herbicide	2	R	Annual broadleaf	A	

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-full registration (biological), RR- full registration (reduced risk), OP-full registration (organophosphate replacement), NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
Source(s): Provincial Crop Protection Guides {OMAF Pub 75, Guide to Crop Protection (Prairie Provinces co-publication)}and ELSE Database

Table 10. Adoption of weed management approaches for Canadian wheat production

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

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

References used in this document

Production of wheat in Ontario, published by OMAFRA, 2003
Official Guide to Grain Grading, published by Canadian Grain Commission (Chapter 4. Wheat)
Gavloski, John Entomologist, Manitoba Agriculture and Food *(Personal communication)*
Pearse, Pathologist, Saskatchewan Agriculture and Food, (*Personal communication)*
Schaafsma, Art Pathologist, Ridgetown College *(Personal communication)*
Guide to weed control in Ontario, OMAFRA, 2004 (Pub 75)
Guide to Crop Protection 2004, published jointly by Manitoba Agriculture and Food, Saskatchewan Agriculture and Food and Alberta Agriculture
2002 Manitoba Weed Survey, Leeson, Thomas et al. Published by AAFC Saskatoon
2001 Alberta Weed Survey, Leeson, Thomas et al. Published by AAFC Saskatoon
1995 Saskatchewan Weed Survey, Thomas, Wise et al. Published by AAFC Saskatoon
Doug Billett, Weed Specialist, Saskatchewan Agriculture and Food *(Personal communication)*

The following websites were used to prepare statistics and information for this profile

Statistics Canada – www.statcan.ca
Manitoba Agriculture, Food and Rural Initiatives – www.gov.mb.ca/agriculture/crops
Alberta Agriculture, Food and Rural Development - www.agric.gov.ab.ca
USDA Regional IPM Centres – www.ipmcenters.org
Saskatchewan Agriculture, Food and Rural Revitalization – www.agr.gov.sk.ca
Canada Grain Commission -www.cgc.ca/main-e.htm
Wheat Leaf Rust http://res2.agr.ca/winnipeg/cd2b_e.htm
Statistics Canada CANSIM database - http://cansim2.statcan.ca/
FAOSTAT Database United Nations Food & Agricultural Organization http://apps.fao.org/default.jsp
Pest Management Regulatory Agency (ELSE Database), www.eddenet.pmra-arla.gc.ca/4.0/4.01.asp

IPM / ICM resources for production of wheat in Canada

Although there are no specific manuals on IPM in wheat, a manual is being prepared describing Pesticide-Free-Production of Wheat (www.pfpcanada.com). Provincial extension services provide the majority of IPM resources for wheat and these resources are disseminated from provincial government websites. It should be noted that extension services have largely moved to use of the web and PDF downloads.

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

Name	Organization	Pest type	Specific pests	Type of research
Bélanger R	Centre De Recherche sur les Grain	Diseases	Fusarium	The evaluation of disease control in wheat by the use of silicon as a fertilizer amendment
Beres B	Lethbridge Station	Insects	Wheat stem sawfly	Sustainable wheat production systems in western Canada
Boyetchko S	AAFC Saskatoon	Weeds	Canada thistle, green foxtail, others	Biological control of weeds using microorganisms
Collin J	Centre De Recherche sur les Grain	Diseases	Fusarium	Impact des résidus d'herbicides sur l'effet désherbant, les maladies des racines et le rendement du blé,
Dion, Y	Centre De Recherche sur les Grain	Diseases	Fusarium	Développement de lignées de blé panifiable tolérantes à la fusariose.
Hall L	Alberta Agricultural Research Institute	Weeds	Wild oats	Digital mapping and its usefulness in site specific control
Humphreys, G	Cereal Research Centre, AAFC Winnipeg	Disease and insect		Breeding
Kharbanda P D	Alberta Research Council	Diseases	Tanspot	Eval. of Genetic Material for Resistance to Tan Spot of Wheat
Knott D R	University of Saskatchewan	Diseases	Stem and leaf rust	The inheritance and use of leaf and stem rust resistance in wheat. Transfer of rust resistance from wild wheats to durum and bread wheats.
Menzies J	Winnipeg Cereal Research Centre AAFC	Diseases	Fusarium, leaf diseases, rusts	Breeding for diseases (general)

Name	Organization	Pest type	Specific pests	Type of research
Pandeya, R	Eastern Cereal and Oilseed Research Centre AAFC	Disease and abiotic stress	Fusarium	Breeding for: winter hardiness, Fusarium and pre-harvest sprouting resistance
Schaafsma A W	University of Guelph	Diseases	Fusarium	Integrated Management of Serious Field Crop Pests - Fusarium in Wheat
Sikkema P H	University of Guelph	Weeds	General	Weed Management in Field Crops including wheat
Tewari, J	University of Alberta	Diseases	Stripe rust	Resistance to stripe rust in spring wheat
Tremblay G	Centre De Recherche sur les Grain	Diseases	Fusarium	Effet de la fertilisation avec urée et nitrate sur l'incidence de la fusariose chez le blé.
Voldeng H	Eastern Cereal and Oilseed research Centre AAFC	Diseases	Fusarium	Fusarium Head Blight Resistance