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Crop Profile for Lentil in Canada

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

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Canada

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Pest Management Centre
Pesticide Risk Reduction Program
Agriculture and Agri-Food Canada
960 Carling Avenue, Building 57
Ottawa, Ontario
K1A 0C6
CANADA

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Mark Goodwin
Mark Goodwin Consulting Ltd.
524 Clifton Street, Winnipeg
Manitoba, Canada R3G 2X2

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Use of Information

Product trade names may be included and are meant as an aid for the reader to facilitate the identification of products in general use. The use of these trade names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

Information on pesticides and pest control techniques are provided for information purposes only. No endorsement of any of the pesticides or pest control techniques discussed is implied.

This publication is not intended to be used as a production guide. Provincial publications should be consulted by growers for crop production information for their region.

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.

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 objective of the program is to reduce the risks to the environment and to human health from pesticide use in agriculture. To achieve this objective, the PRRP works with grower groups, industry and provinces to develop issue specific pesticide risk reduction strategies. The crop profiles provide baseline information on crop production and pest management practices and document pest management needs and issues faced by growers, information used in the development of risk reduction strategies.

Information contained in the crop profiles is developed through extensive consultation with stakeholders. Pest management information is collected by provincial focus groups through the "Canadian Expert Poll on Crop Protection" a software tool developed by the PMRA.

Since 2002, the PRRP has been collaborating with Pulse Canada to identify priority pest management issues and develop risk reduction strategies for pulse crops. For lentil, grasshoppers have been identified as a key priority and a risk reduction strategy has been developed for this pest.

For detailed information on growing lentil, the reader is referred to provincial crop production guides, provincial ministry websites and other resources listed at the end of the document.

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

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

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The lentil (*Lens culinaris* L.) is a member of the Leguminosae family and is an important pulse crop in Western Canada. Lentil was first grown in Asia in 7,000 B.C. Today, India, Canada, Turkey, Australia, Nepal, United States, Bangladesh and China are the world's top producers of lentil. The crop is best adapted for production in cooler temperate zones.

Commercial production of lentil in Canada began in Saskatchewan in 1970, spreading to Manitoba and Alberta for a short period in the 1980's and early 1990's. Due to the wet conditions and heavier soil types in Manitoba and Alberta, disease became a problem and the cropped area retreated back to the more arid, drier regions within Saskatchewan's brown and dark brown soil zones. Lentil is not well adapted to saline soils, soils that are slow to warm up in the spring or to soils high in moisture.

Canada is an important producing and exporting nation for lentil. The largest importers of lentil include Turkey, Sri Lanka, Egypt, Algeria, Columbia and Spain. The most important exporting countries include Canada, India, Australia, Turkey, United States and China.

Most lentil production is consumed by humans as a protein source in a diverse range of products from deserts to soups. The lentil is 25% protein, second only to soybean as a source of usable protein. Lentil is an excellent source of vitamin A and provides fibre, potassium, B vitamins and iron. This protein source contains no cholesterol and virtually no fat. Lentil, eaten with a grain such as rice, wheat or barley, provides all the essential amino acids required by the human body in a balanced diet.

Crop Production

Industry Overview

Table 1. General Production Information

Canadian Production (2008)	919,500 metric tonnes 631,300 hectares
Farm gate value (2007)	$ 262.2 million
Domestic consumption	-
Export (2007)	$ 473 million
Import (2007)	$ 4.2 million

Source(s): Statistics Canada

Production Regions

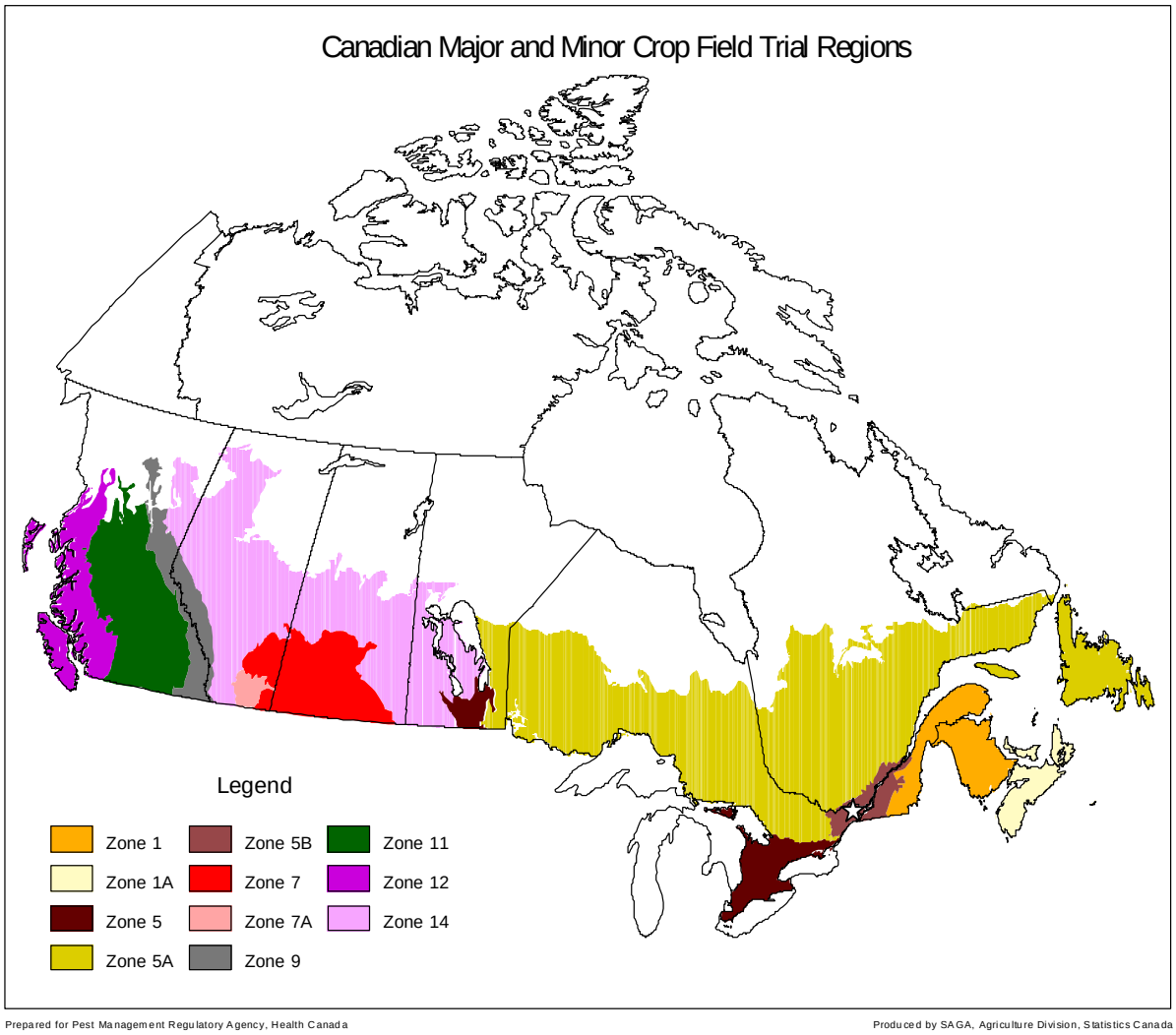
Table 2. Distribution of Lentil Production in Canada

Production Regions	Production 2007		% National Production
	hectares	tonnes	
Saskatchewan	534,200	673,900	100%
Canada	**534,200**	**673,900**	**100%**

Source: Statistics Canada

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

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



Cultural Requirements

Lentil seed is fragile and must be handled carefully to avoid damage to the seed coat. Cracking or splitting of the seed coat can lead to reduced germination and increased risk of disease. Lentil should be seeded 3 to 8 cm deep, preferably into a firm, moist, weed-free seedbed, to provide proper germination and assure inoculant survival. Seeding rates will vary based on seed size and percent germination, but typically range from 120 lbs/ha (for small seeded varieties) to 200 lbs/ha (for large seeded varieties). Lentil should be seeded as early as possible when the minimum average soil temperature reaches 5ºC. Rhizobium inoculants are used to increase the nitrogen fixing capacity of the plant. A well inoculated root system will be able to fix 60-80% of the nitrogen it requires from the atmosphere. Peat based inoculants are applied directly to the seed with the use of a 'sticker' while granular inoculants are applied adjacent to the seed in the seedbed. Newly emerged seedlings are relatively frost tolerant and spring frost is not an issue. A smooth, uniform soil surface facilitates harvest in the fall, as the lentil plant must be cut very close to the soil surface. Land rolling can be done before the plants reach the 5-7 node stage.

Table 3. Canadian lentil production and pest management schedule

Time of year	Activity	Action
October - March	-	No activities
April	Soil care	Soil test.
	Plant care	No activities
	Weed management	Check field for overwintering weeds, treat or cultivate
May	Plant care	Seed crop
	Soil care	Fertilize to recommended soil test
	Disease management	Seed the crop with seed treatments for root rots
	Insect & mite management	Check for cutworms
	Weed management	Identify and scout weeds
June	Insect & mite management	Check for cutworms
		Monitor grasshopper forecasts
	Weed management	Spray if necessary for grassy and broadleaf weeds and patch treat for perennials if practical.
July	Disease management	Scout for ascochyta, anthracnose; monitor provincial forecasts for these diseases.
	Insect & mite management	Monitor and spray for grasshoppers if necessary
	Weed management	Follow up on weed problems and observe results from control efforts
August	Plant care	Prepare for harvest and monitor timing of desiccant application
September	Plant care	Harvest

Abiotic Factors Limiting Production

Storage

Lentil varieties with green seed coats will discolour with age as tannins within the seed coat oxidize. High humidity and high temperatures can also cause rapid color change. Discoloration decreases the grade and price received for the crop. Lentils stored in cold, dark conditions with moisture content at or below 14%, have little to no color change. While market demand and price is key in making marketing decisions, lentils are sold as soon as possible after harvest.

Harvesting Problems

The main non-pest problem for lentil production is the relative difficulty in harvesting the crop. The crop is short and tends to lodge and therefore must be cut near the soil surface. Rolling the land at seeding to level ridges and bury small rocks, along with the use of mechanical tools to lift the crop in front of the cutter bar, can help ease this problem.

Maturity - Indeterminate Growth

Lentil has an indeterminate growth habit. Flowering and pod filling will continue simultaneously or alternately as long as temperature and moisture permits growth to occur. A moisture or nitrogen stress is required to encourage seed set and maturity, which is achieved using a chemical desiccant. If the lentil plants are immature when the first hard killing frosts come in the fall, the amount of green, immature seeds in the sample may be high, decreasing the quality and price of the crop.

Fall Frost

A killing frost in the fall on an immature lentil crop can result in a wrinkling of the seed coat and the production of immature seeds. This lowers the quality of the harvested crop, affecting the price.

Handling

Care needs to be taken when handling lentil seed so that the seed coat is not cracked. To prevent damage, handling should be minimized. The seed is particularly fragile when extremely cold conditions are experienced. Conveyors cause less damage than augers. Extremely dry seed can be tempered with water in the spring before seeding to decrease the risk of mechanical damage. Harvesting equipment should be adjusted to minimize damage with augers run at full capacity under lower speeds.

Heat Canker

Heat canker can occur in lentil when the soil surface heats to the point that it sears plant stems. This reduces seedling vigour and under extreme conditions can kill plants. This problem is more predominant in years of extremely low moisture. Standing stubble from the previous crop can partially protect the lentil seeds from the hot sun.

General Issues

1. There is a need for improved storability, which is the most important factor affecting quality. Developing varieties that store better or improving storage techniques so that oxidation/discoloration is slowed, could significantly improve quality.

Pest Management Overview

Lentils are attacked by a number of foliar and root diseases and defoliating insects such as cutworms and grasshoppers. Diseases such as anthracnose and ascochyta blight can cause significant foliar and pod spotting and pod shattering and drop resulting in yield loss. In seasons where there is significant moisture, fungicide applications may be necessary. Lentils are attacked by both grasshoppers and cutworms. Although cutworm damage is usually light, feeding by grasshoppers on buds, blossoms and pods can have a significant impact on yield. Lentils have a relatively shallow root system and are poor competitors with weeds. Measures to control weeds must be implemented in non-crop years.

The following disease, insect and mite and weeds sections provide detailed information on pests affecting lentil. Pest management issues are presented at the beginning of each section and also with the write-ups for each pest. In each section, the issues are followed by a series of tables that provide information on pest occurrence, IPM practices and chemical controls as follows;

Tables 4, 8 and 12: Disease, insect or weed occurrence and severity and is presented on a provincial basis.

Tables 5, 9 and 13; Integrated pest management information is provided on an individual pest basis.

Tables 6, 10 and 14: List all registered fungicides, insecticides and herbicides for lentil.

Tables 7, 11 and 15: List registered pesticides on a disease, insect or weed group basis, respectively and provide stakeholder comments on efficacy.

Further information for each pest is provided under individual pest write-ups following the tables in each section.

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

Diseases

Key Issues

- There is a need to enhance anthracnose control packages. Anthracnose is a rapidly growing and aggressive threat.
- There is a need for continued research into modeling and forecasting for disease.
- The use of fungicide rotations and the use of new strobilurin fungicides needs to be further investigated. The development of ascochyta resistance to strobiluron chemistry in chickpea has caused great concern in the lentil industry.
- Grower education is required on disease management, resistance management, disease identification and how to conduct field scouting.
- Since stemphylium blight is a new leafspot disease, there is need for initial extension and assessment of potential losses.

Table 4. Degree of occurrence of disease pests in Canadian lentil production

	Degree of occurrence
Diseases	**SK**
Anthracnose	E
Ascochyta blight	E
Botrytis grey mould	E
Root rot	E
Sclerotinia white mold	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	
DNR - Data not reported	
Source(s) - "Canadian Expert Poll on Crop Protection" Focus Group for Saskatchewan (2007).	

Table 5. Availability and use of disease pest management approaches for Canadian lentil production

	Practice \ Pest	Anthracnose	Ascochyta blight	Botrytis grey mould	Sclerotinia white mould	Seed rot, seedling blight, damping off, root rot
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					
	choice of planting site					
Prevention	tillage					
	residue removal / management					
	water management					
	equipment sanitation					
	row spacing					
	seeding depth					
	removal of alternative hosts (weeds/volunteers)					
	mowing / mulching / flaming					
Monitoring	scouting - trapping					
	records to track pests					
	field mapping of weeds					
	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					
	pheromones					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management					
	ground cover / physical barriers					
	controlled atmosphere storage					

no information regarding the practice is available

available/used

available/not used

not available

Source: *Canadian Expert Poll on Crop Protection* focus group for Saskatchewan (2007).

Table 6. Fungicides registered on lentil in Canada.

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
azoxystrobin (Quadris Flowable Fungicide)	methoxyacrylate	respiration C3: complex III-cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) / 11	RR	Anthracnose (*Colletotrichum* spp.)
				Ascochyta blight (*Ascochyta* spp.)
				Mycosphaerella blight (*Mycosphaerella pinodes*)
				Asian (Soybean) Rust (*Phakopsora pachyrhyizi*)
azoxystrobin/ propiconazole (Quilt Fungicide)	methoxyacrylate / triazole	respiration C3: complex III -cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) / 11 and sterol biosynthesis in membranes G1: C14-demethylase in sterol biosynthesis (erg11/cyp51) / 3	R	Asian (Soybean) Rust (*Phakopsora pachyrhyizi*)
***Bacillus subtilis* QST 713 (Serenade Max)**	bacteria	biological	BI	White mould or Sclerotinia stem rot (*Sclerotinia sclerotiorum*)
				Botrytis pod rot or Botrytis blight (*Botrytis cinerea*)
boscalid (Lance WDG Fungicide)	pyridinecarboxamide	respiration C2: complex II - succinatedehydrogenase/ 7	RR	Grey mould (*Botrytis cinerea*)
				White mould (*Sclerotinia sclerotiorum*)
				Ascochyta blight (*Ascochyta* spp.)
captan (Captan Flowable Seed Treatment Fungicide)	phthalimide	multi-site contact activity / M4	R	Storage rot
				Seed decay
				Root rot
				Seedling blights and seed rots
				Damping-off

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
carbathiin/ thiabendazole (Crown Systemic and Contact Seed Protectant)	anilide (oxathiin) / benzimidazole	affect mitochondrial transport chain /7 and mitosis and cell division B1: ß-tubuline assembly in mitosis / 1	RE	Seed borne ascochyta (*Ascochyta lentis*) Post-emergence damping off Seed rots (including *Botrytis cinerea*, *Fusarium*)
carbathiin / thiram (Vitaflo-280 Fungicide, Anchor Systemic & Contact Seed Protectant)	anilide (oxathiin) / dithiocarbamate and relatives	affect mitochondrial transport chain / 7 and multi-site contact activity / M3	RE	Seed rot, early season root rot and seedling blight caused by *Botrytis cinerea*, *Fusarium*, *Pythium* and *Rhizoctonia solani*
chlorothalonil (Bravo 500 Agricultural Fungicide)	chloronitrile (phthalonitrile)	multi-site contact activity / M5	R	Ascochyta blight Anthracnose
fludioxonil (Maxim 480 FS Colorless Seed Treatment)	phenylpyrrole	signal transduction E2: MAP/Histidine-Kinase in osmotic signal transduction (os-2, HOG1) / 12	RR	Seed-borne and soil-borne diseases caused by *Fusarium* spp. (including seedling diseases due to *F. graminearum*) and *Rhizoctonia* spp.
fludioxonil / metalaxyl-m and s-isomer (Apron Maxx RTA Seed Treatment Fungicide)	phenylpyrrole / acylalanine	signal transduction E2: MAP/Histidine-Kinase in osmotic signal transduction (os-2, HOG 1) / 12 and nucleic acids synthesis A1: RNA polymerase I / 4	RE, RR	Seed-borne Ascochyta blight caused by *Ascochyta lentis* Seed rot/pre-emergence damping-off, post-emergence damping-off and Seedling blight caused by *Fusarium* spp., *Pythium* spp. and *Rhizoctonia* spp. Seedling root rot caused by *Fusarium* spp. Seed rot and seedling blight caused by seed-borne *Botrytis* spp.
mancozeb (Dithane F-45 Fungicide, Dithane DG Rainshield NT Fungicide, Manzate DF Fungicide)	dithiocarbamate and relatives	multi-site contact activity /M3	R	Anthracnose Ascochyta blight

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
metalaxyl (Apron FL Seed Treatment)	acylalanine	nucleic acids synthesis A1: RNA polymerase I / 4	RE	*Pythium* seed rot
metalaxyl-m and s-isomer (Apron XL LS Fungicide)	acylalanine	nucleic acids synthesis A1: RNA polymerase I / 4	RE, RR	*Pythium* damping off
propiconazole (Tilt 250E Fungicide)	triazole	sterol biosynthesis in membranes G1:C14-demethylase in sterol biosynthesis (erg11/cyp51) / 3	R	Asian (Soybean) Rust (*Phakopsora pachyrhyizi*) Powdery Mildew (*Microsphaera diffusa, Erysiphe pisi, E. polygoni*)
prothioconazole (Proline 480 SC Foliar Fungicide)	triazole	sterol biosynthesis in membranes G1:C14-demethylase in sterol biosynthesis (erg11/cyp51) / 3	R	Ascochyta blight (*Ascochyta* spp.)
pyraclostrobin (Headline EC Fungicide)	methoxycarbamate	respiration C3: complex III - cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) / 11	R	Anthracnose (*Colletotrichum* spp.) Ascochyta blight (*Ascochyta* spp.)

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

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

[5]Source: Pest Management Regulatory Agency

Table 7. Performance and use of fungicides for the control of diseases on lentil in Canada

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Anthracnose (*Colletotrichum* spp.)	azoxystrobin	11	A	This chemical is an important component of resistance management in lentils.
	chlorothalonil	M5	A[P]	Controls the disease but penetration of canopy is an issue. Provides an alternative to the use of strobilurin chemistry. Rotation to alernative modes of action is key.
	mancozeb	M3	A[P]	Must be applied when the crop is dry; is an important option in fungicide rotations.
	pyraclostrobin	11	A	Is an important component of a resistance management program.
Ascochyta blight (*Ascochyta* spp.)	azoxystrobin	11	A	This product must be used as part of a fungicide rotation strategy. Ascochyta strains that are resistant to strobilurin chemistry are present in Saskatchewan.
	boscalid	7		
	carbathiin/ thiabendazole	7;1	A	Provides control of seedborne ascochyta.
	chlorothalonil	M5	A[P]	Canopy penetration is an issue. Plays an important role in a resistance management strategy.
	fludioxonil/ metalaxyl-m and s-isomer	12;4		
	mancozeb	M3	A	Is a rotational option in resistance management.
	prothioconazole	3		
	pyraclostrobin	11	A	Must be applied at first sign of disease or disease conditions. There are strains of ascochyta that are resistant to strobilurin chemistry.
Asian (Soybean) Rust (*Phakopsora pachyrhyizi*)	azoxystrobin	11		
	azoxystrobin/ propiconazole	11; 3		
	propiconazole	3		

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Botrytis blight; botrytis pod rot; grey mould (*Botrytis cinerea*)	*Bacillus subtilis* (QST 713)	biological		
	boscalid	7		Not used.
Damping-off	captan	M4		
	carbathiin/ thiabendazole	7;1		
	metalaxyl-m and s-isomer	4		
Powdery Mildew (*Microsphaera diffusa, Erysiphe pisi, E. polygoni*)	propiconazole	3		
Seed decay and seedling blight	captan	M4		
	carbathiin/ thiabendazole	7;1	A[P]	
	carbathiin/ thiram	7; M3	A	Combined with seeding into a firm seedbed, will give control of seedling blights.
	fludioxonil	12	A	Must be applied professionally.
	fludioxonil/ metalaxyl-m and s-isomer	12;4		
	carbathiin/ thiabendazole	7;1	A[P]	
Storage rot	captan	M4		
Root rot	captan	M4		
White mould or Sclerotinia stem rot (Sclerotinia sclerotiorum)	*Bacillus subtilis* (QST 713)	biological		
	boscalid	7		Not used.

[1] List includes all active ingredients registered as of February 19, 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of active ingredient for recommended uses. A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control).

[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for Saskatchewan (2007).

Anthracnose (*Colletotrichum truncatum*)

Pest information

Damage: The disease can be devastating, disrupting water relations and causing necrosis in green tissue. About 40% of the cropping area is affected, depending on regional weather conditions. Yield losses can exceed 90%.

Life Cycle: There are two races of the pathogen present in western Canada. The disease can be soil, residue and seed borne. Microsclerotia can survive in the soil or in infected crop residue for some time. Spores are dispersed from plant debris near the soil surface to new plants by splashing rain droplets. The number of rain events is more important for the spread of anthracnose than the amount of rainfall. High humidity and temperatures between 22 and 28°C favour disease.

Pest Management

Cultural Controls: Infected lentil straw should be left on the soil surface to promote the breakdown of the pathogen. Disease incidence can be minimized by using disease free seed, adhering to proper rotations and not planting near areas where previous crops have recently been infected. Extended crop rotations of at least 4 years should be used for diseased fields. Monitoring should begin early in the season, well before flowering.

Resistant Cultivars: There are resistant varieties, but because there are two races of the pathogen, a particular variety may be resistant to one and susceptible to the other and still become diseased.

Chemical Controls: In crop fungicides, such as chlorothalonil, applied at early flower with a second application at podding when needed can reduce damage. Preventative fungicides are active for 10-14 days and will only protect healthy plant tissue. They will not stop infections once they have started. Pyraclostrobin and azoxystrobin have recently been registered for use on lentils for the control of this pathogen. Mancozeb is also registered for the control of anthracnose.

Issues for Anthracnose

1. There is concern that newly registered strobilurins will become ineffective over time if they are overused. Rotations and integrated disease management are critical in the effort to avoid the development of resistance.

Ascochyta Blight *(Ascochyta lentis)*

Pest information

Damage: The disease can be devastating, causing stems, leaves and pods to be covered with necrotic spots. Heavily infected leaves turn brown and drop to the ground. Although stems may wilt, the vascular system is rarely affected by the pathogen. Yield losses can be as high as 50% if the crop is not treated.

Life Cycle: The disease can be seed or residue borne. The pathogen can cause economic loss in years with high moisture. The fungus infects stems, leaves and pods, producing spores that spread by rain-splash to surrounding plants. Only 24 hours of humid conditions are required for spores to germinate and infect new plants. The pathogen can survive in crop residue for several years.

Pest Management

Cultural Controls: Infected lentil straw should be bailed and removed from the field or be left on the surface of the soil to promote breakdown of the inoculum. Cultural practices that can reduce disease include planting disease free seed, using proper rotations and planting in fields that are not in proximity to fields that were infected the year before. Monitoring should begin early in the season, with checks done 7-9 days after rainfall. Low levels of infection on the bottom leaves should be considered acceptable. A fungicide decision support system has been developed and is available on the Internet (http://paridss.usask.ca/specialcrop/pulse_diseases/fungicide/step1lentil.html). This system allows producers to calculate each of their field's risk based on plant stand, rainfall, weather forecast and symptoms.

Resistant Cultivars: None available.

Chemical Controls: Carbathiin/ thiabendazole is registered as a seed treatment for the control of seed-borne ascochyta blight. An application of an in-crop fungicide such as chlorothalonil, boscalid, mancozeb, azoxystrobin, prothioconazole or pyraclostrobin at early flower, with a second application at podding, when required, can help reduce damage. Chlorothalonil and mancozeb are preventative fungicides and will not stop infections once they have started.

Issues for Ascochyta Blight

1. There is concern that newly registered strobilurins will become ineffective over time if they are overused. This concern has been heightened with the development of strobiluron resistance in chickpea. Rotations and integrated disease management are critical in the effort to avoid resistance development.

Botrytis Grey Mould *(Botrytis cinerea)*

Pest information

Damage: Leaves of infected plants wilt and drop off, pods can fail to fill and infected areas turn grey or brown. The pathogen can potentially cause yield loss up to 70%. A reduction in seed quality is also possible due to discoloration.

Life Cycle: The pathogen survives in seed, on crop residue and in the soil. Infection can occur at any growth stage, with infected seed being the primary cause of infection. Infected plants produce spores that become airborne and spread infection rapidly to other plants. The pathogen is opportunistic and will take advantage of poor weather conditions, physical injuries and pod abortions. Dense canopies that reduce airflow with late season rain and moisture, create optimum conditions for the disease.

Pest Management

Cultural Controls: Having a thinner canopy may be less conducive to disease, but it may also increase pressure from weeds. Damage can be reduced by following proper rotations, using disease free seed and using strategies to minimize long periods of high humidity in the crop, such as choosing varieties with less lush growth habit and moderating seeding rate. Cereal crops used in the rotation can help reduce soil inoculum build-up. *Bacillus subtilis* QST713 is registered for control of the foliar stage of the disease.

Resistant Cultivars: None available.

Chemical Controls: Boscalid is registered for control of the foliar stage of the disease.

Issues for Botrytis Grey Mould

None identified.

Root rot (*Fusarium solani, Rhizoctonia solani* and *Pythium* sp.)

Pest information

Damage: Infected young seedlings usually die, while infected plants are yellow and stunted. Economic loss is rare, as the disease is usually scattered throughout the field. In some years, up to 2% of seedlings are lost to the disease.

Life Cycle: The pathogens responsible for this disease are soil borne and attack any part of the root system as well as the lower portions of the stem at the soil line. Rot is more severe when saturated soils are cool and when seedling emergence is delayed.

Pest Management

Cultural Controls: Encouraging rapid emergence by seeding at proper depths in warm, slightly moist, well-drained soil, will reduce disease. A rotation that includes cereals can help reduce the building of inoculum in the soil. If root rot has not been present in other host crops, cultural control practices should be sufficient to limit loss.

Resistant Cultivars: None available.

Chemical Controls: Seed treatments (captan, carbathiin, thiabendazole, fludioxonil and metalaxyl-m) will help control the disease.

Issues for Root Rot

None identified.

Stemphylium Blight (*Stemphylium botryosum*)

Pest information

Damage: Stemphylium blight is a disease that is emerging in western Canada and producers will need to watch for it in the future. It is common in other lentil growing areas, especially areas that have been producing lentils for a long time. The disease results in leaf spots and defoliation.

Life Cycle: Stemphylium blight is similar to anthracnose in that it is a seed, soil and residue borne fungus. Wet weather favours sporulation and infection.

Pest Management

Cultural Controls: Burying crop residue is used as a cultural control technique in other crops.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for Stemphylium blight

Since this is a new leaf spot disease, there is need for initial extension, awareness and assessment of potential losses.

Insects and Mites

Key Issues

- The possible loss of organophosphate insecticides is the greatest concern for the industry in terms of insect control. Although the two major insect pests can be dealt with to some degree using integrated pest management, severe outbreaks require rapid access to effective compounds that work well under the hot conditions that prevail when grasshoppers are prevalent. Aerial applications are essential, due to the rapid emergence and region wide nature of grasshopper outbreaks in particular.
- There is an opportunity to examine Metarhizium species for grasshopper control in this crop.
- There is concern over the low economic threshold for grasshoppers in lentil. This pest attacks the flowers, resulting in the need to control the pest quickly and at low population levels.

Table 8. Degree of occurrence of insect pests in Canadian lentil production

	Degree of occurrence
Pests	**SK**
Grasshopper	E
Cutworm	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) - "Canadian Expert Poll on Crop Protection" Focus Group for Saskatchewan (2007).	

Table 9. Availability and use of insect pest management approaches for Canadian lentil production

	Practice \ Pest	grasshopper	pale western cutworm	red backed cutworm
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			
	choice of planting site			
Prevention	tillage			
	residue removal / management			
	water management			
	equipment sanitation			
	row spacing			
	seeding depth			
	removal of alternative hosts (weeds/volunteers)			
	mowing / mulching / flaming			
Monitoring	scouting - trapping			
	records to track pests			
	field mapping of weeds			
	soil analysis			
	weather monitoring for degree day modelling			
	grading out infected produce			
Decision making tools	economic threshold			
	forecasting/ degree day modelling			
	recommendation from crop specialist			
	first appearance of pest or pest life stage			
	observed crop damage			
	crop stage			
	calendar spray			
Suppression	biological pesticides			
	pheromones			
	sterile mating technique			
	beneficial organisms & habitat management			
	pesticide rotation for resistance management			
	ground cover / physical barriers			
	trapping			

no information regarding the practice is available

available/used

available/not used

not available

Source: *Canadian Expert Poll on Crop Protection* focus group for Saskatchewan (2007).

Table 10. Insecticides registered on lentil in Canada.

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
chlorpyrifos (Lorsban 4E Insecticide, Pyrinex 480EC For Food Crops)	organophosphate	acetylcholine esterase inhibitors / 1B	RE	Pale western cutworm Grasshoppers
deltamethrin (Decis 5.0 EC Insecticide, Decis Flotable Insecticide)	pyrethroid	sodium channel modulators / 3	R	Cutworms Grasshoppers
lambda-cyhalothrin (Matador 120EC Insecticide, Warrior Insecticide)	pyrethroid	sodium channel modulators / 3	R	Cutworms Grasshoppers Lygus bugs Pea aphid Potato leafhopper
malathion (Fyfanon 50% Emusifiable Concentrate Insecticide, Malathion 500E Insecticide)	organophosphate	acetylcholine esterase inhibitors / 1B	RE	Grasshoppers
permethrin (Ambush 500EC Insecticide, Pounce 384 EC Insecticide)	pyrethroid	sodium channel modulators / 3	R	Cutworms (army, black, darksided, pale western, redbacked, white)

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

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

[5]Source: Pest Management Regulatory Agency

Table 11. Performance and use of insecticides for the control of insect pests of lentil in Canada

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Cutworms	deltamethrin	3		
	lambda-cyhalothrin	3		
	permethrin	3		
Cutworm (pale western)	chlorpyrifos	1B	A	Used to control patches of this insect.
Grasshoppers	chlorpyrifos	1B	A	Gives excellent control of grasshoppers. The threshold for grasshoppers is low and thus rapid deployment of spraying (combination of ground and aerial) is key when there is a problem. About 90% of growers use perimeter spraying to minimize chemical use. There are MRL issues with chlorpyrifos in some markets and thus careful use is important.
	deltamethrin	3		
	lambda-cyhalothrin	3	A	There is concern that this product may not be as effective as chlorpyrifos under hot weather conditions.
	malathion	1B		
Lygus bugs	lambda-cyhalothrin	3		
Pea aphid	lambda-cyhalothrin	3		
Potato leafhopper	lambda-cyhalothrin	3		

[1] List includes all active ingredients registered as of February 19, 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides:www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of active ingredient for recommended uses. A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control).

[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for Saskatchewan (2007).

Grasshopper* (Order: Orthoptera)

Pest information

Damage: Grasshoppers can cause extensive damage on a regional level, with large acreages of lentils, among other crops, being damaged in a very short period of time. The insects do not favour lentil foliage, but do eat flower buds, flowers and developing pods. Slight damage to pods may result in shattering and seed loss. Chewing on pods also increases the susceptibility of the plant to disease. Maturity can be delayed as the plant tries to compensate for lost pods by producing new ones. Lentil is one of the crops most susceptible to grasshopper damage.

Life Cycle: Grasshoppers can be a problem when summers are hot and dry. Warm and dry conditions in the spring and early summer increase hatchling survival, while heat in the late summer and fall encourage mating and laying of eggs. The previous season's population size can be used to help determine the extent of the current year's infestation.

Pest Management

Cultural Controls: Field margins, fence lines, roadsides and crops grown on stubble should be carefully monitored when hatching begins in the spring, as grasshoppers tend to lay eggs in areas with green growth and a potential food source. Early seeding, crop rotation and trap strips that collect grasshoppers into an area where they can be controlled by a minimum amount of insecticide, all help to control populations. Early spring weed control in the field and in proximity to the field eliminates feeding sites for hatching grasshoppers and can significantly reduce the numbers that survive. Tilling the soil can make sites less suitable for grasshopper egg laying, as undisturbed soil is preferred. Scouting and economic thresholds can be used to help coordinate different control methods.

Resistant Cultivars: None available.

Chemical Controls: Deltamethrin, lambda-cyhalothrin, malathion and chlorpyrifos are registered for control of grasshoppers in lentil. Control is best when grasshoppers are young. Perimeter applications reduce pesticide use and cost. A threshold of 2 grasshoppers per square meter has been established to indicate the point at which insecticide applications are warranted. Chlorpyrifos is most effective under higher temperatures, as experienced at the time of lentil flowering.

Issues for Grasshopper

1. There is concern of the registration status of chlorpyrifos and malathion for the control of insects in lentil. If registration is lost, the only alternative registered is deltamethrin or lambda-cyhalothrin. These do not work well when temperatures are in excess of 27°C, conditions under which the pest is most active.
2. There is concern over the low economic threshold for grasshoppers in lentil. The pest attacks the flowers, resulting in the need to control the pest quickly and at low population levels.

*Grasshoppers have been identified as a key priority and a risk reduction strategy has been developed for this pest under the Pesticide Risk Reduction Program.

Cutworms (pale western (*Agrotis orthogonia*), redbacked (*Euxoa ochrogaster*) and others)

Pest information

Damage: The insects eat lentil seedlings at or near the soil line.

Life Cycle: There are several species of cutworm that can cause damage in lentil. The insects occur in patches within the field. Several species hatch in the fall and overwinter as partly grown larvae, feeding on weeds and volunteer crops until freeze-up.

Pest Management

Cultural Controls: The timing of agronomic practices is important, as some species prefer to lay eggs in loose soil. When the insects are a problem, summer fallow fields are cultivated before mid-August and left to crust over or cultivated after mid-September. In the spring, a delay of 5 or more days between cultivation and seeding can help prevent infestations by starving newly hatched cutworms, but this can lead to a reduction in the ability of the crop to compete with early germinating weeds.

Resistant Cultivars: None available.

Chemical Controls: Deltamethrin and lambda-cyhalothrin are registered for the control of most species of cutworm in lentil, while permethrin is registered for the control of the redbacked cutworm and chlorpyrifos is registered for control of the pale western cutworm. Less than 1 percent of the crop is sprayed for this pest.

Issues for Cutworms

1. There is concern over the registration status of organophosphate insecticides that are used for the control of cutworms.

Weeds

Key Issues

- There is concern over the lack of alternatives for broadleaf weed control and the few products that are in the development pipeline. There is a need to investigate candidate chemistries being developed and biological controls.
- There is a need for more streamlined labelling.
- There is a need for a label expansion for imidazolinones.
- There is concern over the use of group 1 graminicides due to their frequency of use in other crops grown in rotation with lentil. Resistance is a possibility if the products are used too frequently. It is therefore important that this group of herbicides be used on crops that are poor competitors, such as lentil and for crops that have no other options for control.

Table 12. Degree of occurrence of weed pests in Canadian lentil production

	Degree of occurrence
Annual Weeds	
Kochia (*Kochia scoparia*)	E
Russian thistle (*Salsola pestifer*)	E
Foxtail *(Setaria* spp.)	E
Wild buckwheat (*Polygonum convolvulus*)	E
Wild tomato (*Lycopersicon* sp.).	E
Wild oats (*Avena fatua*)	E
Wild mustard (*Sinapis arvense*)	E
Perennial Weeds	**SK**
Canada thistle (*Cirsium arvensis)*	E
Perennial sow thistle (*Sonchus arvensis*)	E
Volunteer Crops	
Volunteer cereals (wheat)	E
Volunteer canola; volunteer tame mustard; volunteer flax.	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) - "Canadian Expert Poll on Crop Protection" Focus Group for Saskatchewan (2007).	

Table 13. Availability and use of weed pest management approaches for Canadian lentil production

	Practice \ Pest	Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	trap crops - perimeter spraying				
	use of weed-free seed				
	optimizing fertilization				
	reducing mechanical damage / insect damage				
	thinning / pruning				
	choice of planting site				
Prevention	tillage				
	residue removal / proper harvesting of cereal crops				
	water management				
	equipment sanitation				
	row or plant spacing				
	seeding depth				
	removal of alternative hosts (weeds/volunteers)				
	mowing / mulching / flaming				
	weed management in non-crop lands				
	weed management in non-crop years				
Monitoring	scouting - trapping				
	records to track pests				
	field mapping of weeds				
	soil analysis				
	Patch treatments				
	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 pest or pest life stage				
	observed crop damage				
	crop stage				
	calendar spray				
Suppression	mechanical weed control				
	biological pesticides				
	beneficial organisms & habitat management				
	pesticide rotation for resistance management				
	ground cover / physical barriers				

no information regarding the practice is available

available/used

available/not used

not available

Source: *Canadian Expert Poll on Crop Protection* focus group for Saskatchewan (2007).

Table 14. Herbicides registered on lentil in Canada

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
carfentrazone-ethyl (Aim EC)	triazolinone	inhibition of protoporphyrinogen oxidase / 14	R	broadleaf weeds and defoliate/desiccate crop as a harvest aid
clethodim (Select EC Post-emergence Herbicide, Centurion EC Post-emergence Herbicide)	cyclohexanedione	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	grassy weeds
diclofop-methyl (Hoe-grass 284 Emulsifiable Liquid Herbicide)	aryloxyphenoxy propionate	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual grasses
diquat (Reglone Desiccant)	bipyridylium	photosystem-l-electron diversion / 22	RE	desiccate crop and weeds
ethalfluralin (Edge Granular Herbicide)	dinitroanaline	microtubule assembly inhibition / 3	R	volunteer cereals, annual grasses and broadleaf weeds
fenoxaprop-p-ethyl (Excel Super Post-emergent Herbicide, Component #1 Post emergent Herbicide (Fusion Tank Mix))	aryloxyphenoxy propionate	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual grasses and volunteer cereals
fluazifop p-butyl (Venture L Herbicide, Component #2 Post-emergent Herbicide)	aryloxyphenoxy propionate	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual and perennial grasses

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
glufosinate ammonium (Harvest 15 SN Herbicide & Crop Desiccant, Liberty 150 SN Herbicide & Crop Dessicant)	phosphinic acid	inhibition of glutamine synthetase / 10	R	desiccate crop and weeds
glyphosate (Roundup Original Liquid herbicide, Vantage Plus Max Herbicide)	glyphosate	inhibition of EPSP synthesis / 9	RR	annual and perennial weeds prior to planting, post harvest or pre-harvest
imazamox/ imazethapyr (Odyssey WDG Herbicide)	imidazolinone	Inhibition of acetolacate synthases ALS (acetohydroxyacid synthase AHAS) / 2	R	grassy and broadleaf weeds
metribuzin (Sencor 480F Flowable Herbicide, Lexone DF Toss-N-Go Herbicide Dispersible Granule)	triazinone	Inhibition of photosynthesis at photosystem II site A / 5	R	annual broadleaf weeds
paraquat (Gramoxone Liquid Herbicide with Wetting Agent)	bipyridylium	photosystem-l-electron diversion / 22	R	annual grass and broadleaf weeds, top-growth control of perennial grass and broadleaf weeds.
quizalofop p-ethyl (Assure II Herbicide)	aryloxyphenoxypropionate	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual and perennial grasses

Regulatory Status as of February 19, 2008[5]				
Control product (active ingredient / organism)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
sethoxydim (Poast Ultra Liquid Emulsifiable Herbicide)	cyclohexanedione	inhibition of acetyl CoA carboxylase (ACCase) / 1	RE	annual grasses, wild oats, volunteer cereals and quackgrass
tepraloxydim (Equinox EC Herbicide)	cyclohexanedione	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual grasses and quackgrass
trifluralin (Treflan QR5 Granular Herbicide, Triflurex 40 EC Herbicide)	dinitroaniline	microtubule assembly inhibition / 3	RE	annual grasses and annual broadleaved weeds

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

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

[5]Source: Pest Management Regulatory Agency

Table 15. Performance and use of herbicides for the control of weeds in lentil in Canada

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
annual grasses	clethodim	1	**A**	Controls a wide range of grassy weeds. There are group 1 resistant grasses in the prairies.
	ethalfluralin	3	**A[P]**	Suppression only for wild oats; setaria species resistant to dinitroanilines have been noted in some parts of the prairies.
	fenoxaprop-p-ethyl	1	**A**	Controls a range of grassy weeds.
	fluazifop-p-butyl	1	**A**	Controls a wide range of grass weeds.
	glyphosate	9	**A**	Must be used as a pre-seeding burn-off.
	imazamox / imazethapyr	2	**A**	Allows for rotation from group 1 grass herbicides.
	quizalopfop-p-ethyl	1	**A**	Controls wild oats, volunteer cereals and foxtail.
	sethoxydim	1	**A**	Controls a broad spectrum of grasses.
perennial grasses	glyphosate	9	**A**	Used as a pre-seeding burn-off.
annual broadleaf weeds	ethalfluralin	3	**A**	Must be applied in the fall to minimize injury.
	glyphosate	9	**A**	Must be used as a pre-seeding burn-off.
	imazamox / imazethapyr	2	**A**	Controls a broad range of broadleaf weeds in lentil. Can be used only on IMI tolerant lentil. IMI resistant weeds are present in the prairies.
	metribuzin	5	**A[P]**	Controls only a limited number of weeds and can cause burn on the crop under hot conditions.
perennial broadleaf weeds	glyphosate	9	**A[P]**	When applied in spring, will control seedlings of thistle that have emerged at the time of application

[1] List includes all active ingredients registered as of Feb. 19 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance 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. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of active ingredient for recommended uses. A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control).
[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for Saskatchewan (2007).

Annual Grasses

Pest information

Damage: If left unmanaged, annual grasses can cause yield losses of 25 to 40%, depending on the density of weed populations and the time of emergence of the weed relative to the crop.

Life Cycle: Wild oats *(Avena fatua),* green foxtail (*Setaria viridis*), yellow foxtail (*Setaria glauca*) and volunteer wheat all occur in lentil fields throughout the growing region. Wild oats occur in most years, foxtails worsen in years where hot dry conditions prevail and volunteer cereals can be more serious if harvesting problems the previous season led to shattering/spreading of harvested grain.

Pest Management

Cultural Controls: Minimizing tillage leads to reduced populations of wild millet (foxtail) and wild oats by leaving seed on the soil surface where it is exposed to weather and birds. Delayed seeding allows for early flushes of wild oats and volunteer cereals, but this technique favours competition from foxtail and leads to reduced yields. Early seeding allows the crop to better compete with weeds. The use of clean, certified seed reduces the addition of new weeds to the field. Using harvesting techniques that minimize seed loss in cereal crops in prior years reduces volunteer cereals. Fall tillage prior to freeze-up can reduce volunteers in the subsequent year, but leaves the soil prone to erosion. Post-emergent harrowing can control weed seedlings when the lentil crop is very short, provided the foliage is dry and the operation is done on a warm, sunny day.

Chemical Controls: With the shift to reduced tillage and the use of soil conservation techniques for lentil production, there has been a reduction in the use of pre-plant incorporated herbicides such as trifluralin and triallate for the control of grassy weeds. This has lead to an increased reliance on group 1 graminicides such as quizalofop, fluazifop/ fenoxaprop, clethodim and sethoxydim. The new registration of imidazolinone resistant lentil varieties has provided the option of using imazamox for grass control.

Issues for Annual Grasses

1. There is concern over the use of group 1 graminicides due to their frequency of use in other crops grown in rotation with lentil. Resistance is a possibility if the products are used too frequently. It is therefore important that this group of herbicides be used on crops that are poor competitors, such as lentil and for crops that have no other options for control.

Annual Broadleaf Weeds

Pest information

Damage: Volunteer canola (*Brassica napus*), mustard (*Sinapsis arvensis*) and volunteer flax (*Linum usitatissimum*) are difficult to control in lentil. Weeds that germinate late in the season (Russian thistle (*Salsola pestifer*), kochia (*Kochia scoparia*) and wild tomato (*Lycopersicon lycopersicum*), are strong competitors with the crop, interfere with harvesting and increase dockage and moisture levels in harvested seed.

Life Cycle: Annual weeds complete their life cycle, from seed germination through vegetative gowth and flowering, to seed production in one growing season.

Pest Management

Cultural Controls: Mowing of field edges and areas surrounding saline spots will reduce the seed set of kochia and Russian thistle. Early seeding is important to allow the crop to better compete with weeds. Post-emergent harrowing can be used to control weed seedlings when the crop is very short, provided that the foliage is dry and the operation is done on a warm, sunny day. Clean, weed free seed should be used and fields should be scouted frequently. Patch treatments for weeds, such as kochia and Russian thistle, may be practical if the weeds are located in patches in saline areas, so that they do not spread through the field.

Chemical Controls: Metribuzin can be applied at early post-emergence, with best performance being achieved when lentil plants are at the two to five node stage and weeds are small. A split application of metribuzin is registered that includes a two-thirds rate followed in seven to ten days with an additional application of one-half rate if another flush of weeds has emerged. Ethalfluralin and trifluralin are registered for fall application only. A late-fall application of phenoxy herbicides can be used to control winter annual broadleaf weeds in fields planned for lentil production. The new registration of imidazolinone resistant lentil varieties provides the option of using imazamox/ imazethapyr for broadleaf weed control.

Issues for Annual Broadleaf Weeds

1. There is a need for tools for broadleaf weed control in lentils, particularly for post-emergence weed control. Post-emergent strategies that rely on metribuzin must cope with the fact that the product can cause crop injury, further reducing the crop's ability to compete with weeds.
2. There is a need to broaden imidazolinone tolerant technology to more varieties.

Perennial Broadleaf Weeds

Pest information

Damage: Canada thistle (*Cirsium arvensis*) and sow thistle (*Sonchus arvensis*) have become increasingly problematic in recent years due to the adoption of minimum tillage practices and continuous cropping.

Life Cycle: Thistle patches along the field margins are often a major source of invasion. Both thistle species have a deep, penetrating root system that generate shoots, allowing them to spread. Both also spread by seed, with sow thistle seeds travelling somewhat further by wind than Canada thistle.

Pest Management

Cultural Controls: Monitoring uncultivated field edges and roadsides and mowing when thistles are ready to flower will minimize spread. Tillage is generally more effective against perennial sow thistle than Canada thistle, but because perennial sow thistle has a deep, penetrating root system, frequent deep tillage is required. The high cost and risk of soil erosion make such tillage practices undesirable. Field-scale infestations require a combination of control measures, used during all periods of application and over several years, along with good fertility, to improve crop competition. Determining the extent of the infestation allows for proper action, with the possibility of using spot sprays on marked patches. There are many options for controlling perennial weeds, but these options

must be carried out in years of the rotation other than during lentil production. Therefore, there is a need to plan herbicide treatments so that the field to be seeded can be as clean as possible in the year of seeding lentil.

Chemical Controls: Careful record keeping of herbicide treatments is essential for decision making to minimize potential weed resistance problems and to prevent crop injury from herbicide carryover. In crop herbicide performance can be improved by delaying application to near the end of the period specified on the label, allowing the maximum number of perennial shoots to emerge. A pre-harvest application of glyphosate can control perennial sow thistle, but is less effective for Canada thistle.

Issues for Perennial Broadleaf Weeds

None identified.

Resources

Provincial Pulse Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialists	Minor Use Coordinators
Alberta	Alberta Agriculture, Food and Rural Development	Mark Olson (mark.olson@gov.ab.ca)	Dan Cole (dan.cole@gov.ab.ca)
Saskatchewan	Saskatchewan Agriculture	Ray McVicar (ray.mcvicar@gov.sk.ca); Penny Pearse (penny.pearse@gov.sk.ca)	Ray McVicar (ray.mcvicar@gov.sk.ca)
Manitoba	Manitoba Agriculture, Food and Rural Initiatives	John Gavloski (jgavloski@gov.mb.ca)	David Kaminski (david.kaminski@gov.mb.ca)

National and provincial pulse crop grower organizations

Pulse Canada
1212-220 Portage Ave.
Winnipeg, MB R3C 0A5
www.pulsecanada.com

Alberta Pulse Growers
www.pulse.ab.ca

Saskatchewan Pulse Growers
104-411 Downey Road
Saskatoon, SK S7N 4L8
www.saskpulse.com

Manitoba Pulse Growers Association
P. O. Box 1760
Carman, MB R0G 0J0
www.manitobapulse.ca

Research contacts for pulse crops in Canada

Name	Organization	Pest type	Specific pests	Type of research
S. Banniza	Crop Development Centre, U. of Saskatchewan, Saskatoon, SK	diseases	all	integrated pest management
B. Gossen	AAFC Research Station, Saskatoon, SK	diseases	all	integrated pest management; breeding
R. Holm	University of Saskatchewan	weeds, diseases	agronomy	integrated pest management; general agronomy
D. Johnson	U. of Lethbridge, Lethbridge, AB.	insects	grasshoppers	forecasting, monitoring, modelling, biological control
R. McVicar	Saskatchewan Agriculture	weeds, diseases and insects	extension	integrated pest management
P. Pearse	Saskatchewan Agriculture	diseases	extension	integrated pest management
Y. Gan	AAFC Research Station, Swift Current, SK	weeds, diseases and insects	all	integrated pest management systems

References

Alberta Pulse Growers www.pulse.ab.ca

Government of Alberta www.agric.gov.ab.ca/app21/infopage?cat1=Crops&cat2=Peas+%26+Pulses

Government of Manitoba www.gov.mb.ca/agriculture/crops/pulsecrops/bhf01s01.html

Government of Saskatchewan www.agr.gov.sk.ca
Lentil in Saskatchewan (Factsheet,2003)
Special Crop Report (2003)
Guide to Crop Protection 2003

Pulse Canada www.pulsecanada.com

Saskatchewan Pulse Growers www.saskpulse.com

Statistics Canada (purchased data) www.statcan.ca/english/Pgdb/prim11a.htm

United Nations - FAOSTAT http://faostat.fao.org/site/291/default.aspx