CROP PROFILE FOR LENTIL IN CANADA, 2015

PREPARED BY:
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Pest Management Centre
Agriculture and Agri-Food Canada

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Canada

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Preface

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

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

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

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

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

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The lentil (*Lens culinaris* L.) is a member of the Leguminosae family and is an important pulse crop in Western Canada. Lentil, the fourth most important pulse crop in the world in terms of production, was first grown in Asia in 7,000 B.C. Canada is the largest producer of lentil in the world – with Australia, Bangladesh, China, Ethiopia, India, Nepal, Turkey and the United States representing the balance of the top lentil producing nations (FAO, 2014, http://www.fao.org/statistics/en/). The crop is best adapted for production in cooler temperate zones. Canada is an important exporting nation for lentil. The largest importers of Canadian lentil include Australia, India, Myanmar, Thailand, Turkey, the United Arab Emirates and the United States.

Commercial production of lentil in Canada began in Saskatchewan in 1970, spreading to Manitoba and Alberta for a short period in the 1980s and early 1990s. 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. For the 2015-2016 cropping season, Saskatchewan accounted for 93 percent of the lentil seeded in Canada, with the balance seeded in Alberta (Table 2).

Lentil is classified based on seed size, with 1,000 seed weight for Chilean or large-seeded lentil at greater than 50 grams and Persian or small-seeded lentil at 45 grams or less. Lentils are also classified by colour. The two main market classes are green and red. Green lentil is usually marketed as whole seed, whereas red lentil is marketed as whole seed or in a de-hulled and split form. Most global lentil production and trade is in red lentil. In addition, there are also specialty lentils including French green lentils, black lentils and Spanish brown lentils.

A major limitation to lentil production was overcome with the introduction of imidazolinone herbicide-tolerant lentil which allowed for effective and broad spectrum control of grassy and broadleaved weeds. With new cultivar introductions in 2009, imidazolinone-tolerant lentil became available in every market class.

Most lentil production is consumed by humans as a protein source in a diverse range of products from soups to desserts. The lentil is 25 percent protein, and is 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 in a balanced diet.

Crop Production

Industry Overview

Table 1. General Production Information

Canadian Production (2015)[1]	2,540,500 metric tonnes 1,632,900 hectares seeded
Farm cash receipts (2015)[2]	$ 2.25 billion
Exports (2015-2016)[3,4]	2,146,000 metric tonnes
Imports (2015-2016)[3,4]	16,000 metric tonnes

[1]Statistics Canada. Table 001-0010 - Estimated areas, yield, production and average farm price of principal field crops, in metric units, annual, CANSIM (database) (accessed 2017-01-25).

[2]Statistics Canada. Table 002-0001 - Farm cash receipts, annual (dollars), CANSIM (database) (accessed: 2017-02-10).

[3]Agriculture and Agri-Food Canada. Canada: outlook for principal field crops, 2017-03-17. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops-industry/outlook-for-principal-field-crops-in-canada/canada-outlook-for-principal-field-crops-2017-03-17/?id=1490123889739

[4]Crop year is August 2015 to July 2016.

Production Regions

Table 2. Lentil Production in Canada

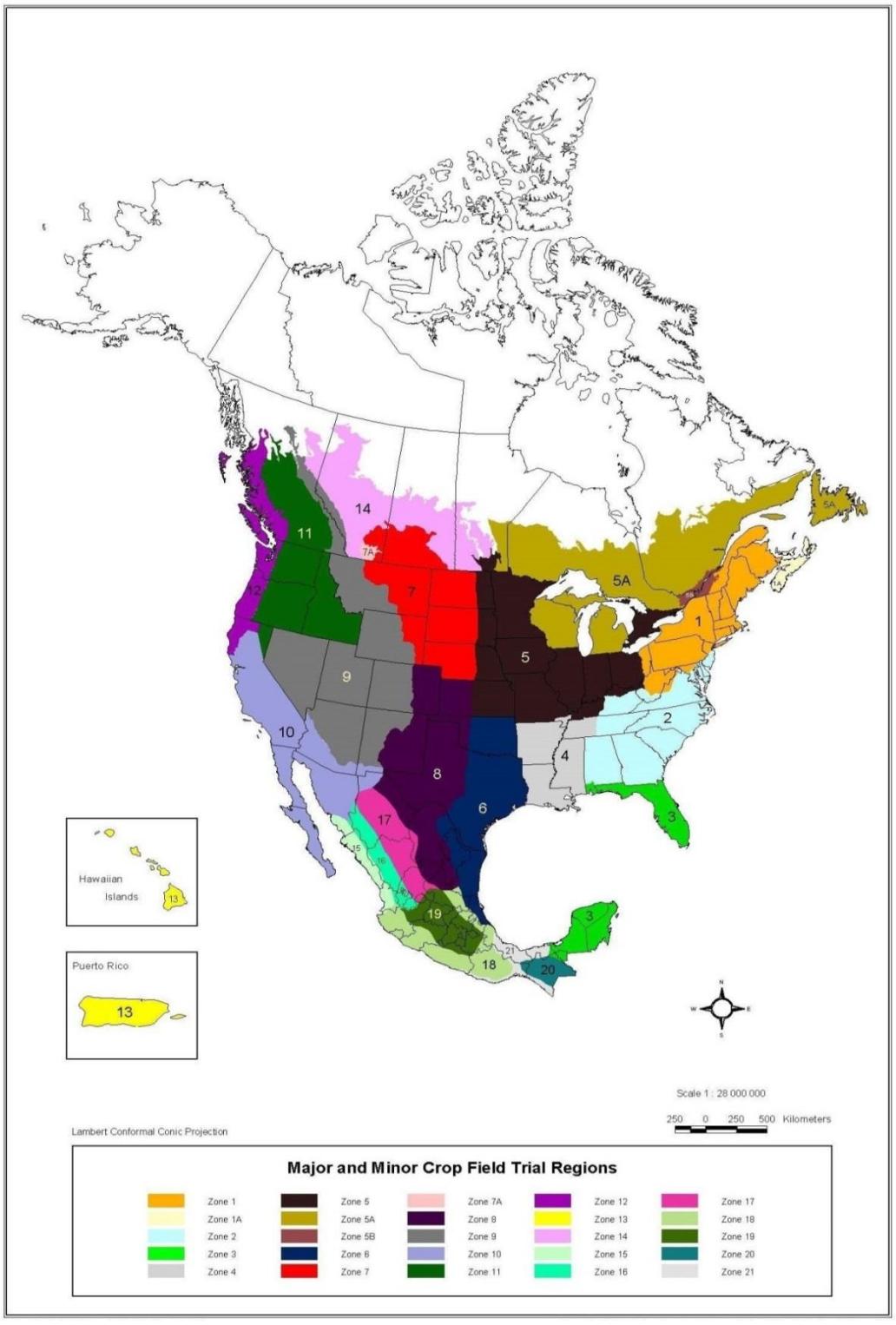
Production Regions[1]	Cultivated Area 2015 Seeded (hectares)	Percent National Production
Alberta	115,400	7
Saskatchewan	1,517,500	93
Canada	1,632,900	100

[1] Statistics Canada. Table 001-0010 - Estimated areas, yield, production and average farm price of principal field crops, in metric units, annual, CANSIM (database) (accessed 2017-01-25).

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (see Figure1) are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (EPA), to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate but they do not correspond to plant hardiness zones. For additional information on field trial regions and requirements, consult the PMRA Regulatory Directive 2010-05 "*Revisions to the Residue Chemistry Crop Field Trial Requirements"* (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir2010-05/index-eng.php).

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



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

Cultural Practices

Lentil is seeded three to eight cm deep, preferably into a firm, moist, weed-free seedbed, to allow proper germination and assure inoculant survival. The desired plant population for lentil is 130 per square metre, so seeding rates will vary based on seed size and percent germination. 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. Seeding rates typically range from 40 kg/ha for extra small sized lentil to around 90 kg/ha for large seed sized varieties. Lentil is seeded as early as possible after the minimum average soil temperature reaches 5ºC. Larger green varieties are typically seeded slightly earlier because they are relatively late maturing.

Rhizobial inoculants are used to increase the nitrogen fixing capacity of the plant. A well inoculated root system can fix 60 to 80 percent of the nitrogen the plant 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 carried out before the plants reach the five to seven node stage.

Table 3. Lentil production and pest management schedule in Canada

Time of year	Activity	Action
April	Soil care	Soil test for nutrients
	Plant care	No activities
	Weed management	Check field for overwintering weeds and treat or cultivate; apply early pre-plant and pre-emergence herbicides as early as late April
May	Plant care	Seeding
	Soil care	Fertilize to recommended soil test
	Disease management	Seed the crop using seed treatments applied for control of seed and/or soil-borne pathogens
	Insect & mite management	Monitor for cutworms
	Weed management	Early pre-plant and pre-emergence herbicides may be applied in early May; identify and scout for weeds to be controlled with post-emergence applications
June	Insect & mite management	Check for cutworms and apply insecticides if required
		Monitor grasshopper forecasts and apply insecticides if required
	Weed management	Spray if necessary for grassy and broadleaved weeds and spot treat perennial weeds if practical
July	Disease management	Scout for ascochyta and anthracnose, monitor provincial forecasts for these diseases and apply fungicides if required
	Insect & mite management	Monitor for grasshoppers and apply insecticides if required
	Weed management	Follow up on weed problems, observe results from control efforts and perform late herbicide applications if necessary
August	Plant care	Prepare for harvest, monitor timing of desiccant application and apply desiccant as required before harvest
September	Plant care	Harvest
	Weed management	Check for winter annual germination and treat or till if necessary; apply fall pre-plant incorporated herbicides, if required for time management the season before seeding the lentil crop
October - March	No activities	

Abiotic Factors Limiting Production

Storage and Handling

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 colour change. Discoloration decreases the grade and price received for the crop. Although market demand and price are key factors in making marketing decisions, lentils are sold as soon as possible after harvest to offset this potential problem. Lentils stored in cold, dark conditions with moisture content at or below 14 percent, have little to no color change. In addition, lentil seed is fragile, particularly so in cold temperatures, and care is taken in handling not to crack or damage the seeds as this can result in reduced germination. 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 can be adjusted to minimize damage with augers run at full capacity under lower speeds.

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.

Growth Habit

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 occur in the fall, the proportion 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.

Heat Canker

Heat canker can occur in lentil, and may be a particular problem on black soils, 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, which can be confused with seedling blight, is more predominant in years of extremely low moisture. Standing stubble from the previous crop can partially protect the lentil seedlings from the hot sun.

Diseases

Key Issues

- There is a need to enhance anthracnose control strategies and the range of disease management products available for control of the pathogen.
- There is a need for continued research into modeling and forecasting for disease for improved management decisions.
- The use of fungicide rotations needs to be further investigated. The development of ascochyta resistance to strobilurin chemistry in chickpea has caused great concern in the lentil industry. While strobilurin fungicides are available in products formulated with other modes-of-action, over 40 percent of the products registered for lentil contain a single strobilurin – and the risk of resistance is high.
- Producers also tend to rely on demethylation inhibitor fungicides, and over 65 percent of the products registered for lentil contain a single demethylation inhibitor; there is a risk of resistance development to this group of fungicides.
- Grower education is required on disease management, resistance management, disease identification and how to conduct field scouting for diseases of lentil in general.
- Since stemphylium blight is a relatively new leafspot disease, there is need for initial extension of information to growers and assessment of potential losses.

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

Disease	Alberta	Saskatchewan
Seed rot, seedling blight		
Anthracnose		
Ascochyta blight		
Stemphylium blight		
Botrytis grey mould		
Sclerotinia stem and pod rot (white mould)		
Root rots		
Fusarium root rot		
Aphanomyces root rot		

Widespread yearly occurrence with high pest pressure.

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

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

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Lentil stakeholders in reporting provinces.

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

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

Practice / Pest		Anthracnose	Ascochyta blight	Botrytis grey mould	White mould (sclerotinia)	Seed rot, seedling blight
Avoidance	Resistant varieties					
	Planting/ harvest date adjustment					
	Crop rotation					
	Choice of planting site					
	Optimizing fertilization					
	Reducing mechanical damage or insect damage					
	Thinning/ pruning					
	Use of disease-free seed, transplants					
Prevention	Equipment sanitation					
	Mowing/ mulching/ flaming					
	Modification of plant density (row or plant spacing; seeding rate)					
	Seeding/ planting depth					
	Water/ irrigation management					
	End of season crop residue removal/ management					
	Pruning out/ removal of infected material throughout the growing season					
	Tillage / cultivation					
	Removal of other hosts (weeds/ volunteers/ wild plants)					

…continued

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

Practice / Pest		Anthracnose	Ascochyta blight	Botrytis grey mould	White mould (sclerotinia)	Seed rot, seedling blight
Monitoring	Scouting/ trapping					
	Records to track diseases					
	Soil analysis					
	Weather monitoring for disease forecasting					
	Use of portable electronic devices in the field to access pest identification /management information					
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					
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					
Suppression	Pesticide rotation for resistance management					
	Soil amendments					
	Biopesticides					
	Controlled atmosphere storage					
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					

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

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

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

Information regarding the use of this practice for this pest is unknown.

[1]**Source: Lentil stakeholders in Saskatchewan.**

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed Treatments						
Bacillus subtilis strain GB03	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	seedling blight and root rot (suppression)
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	seed rot, seedling blight, root rot
captan	phthalimide	multi-site contact activity	multi-site contact activity	M 04	RE	seed decay, root rot, damping-off, seedling blights
carbathiin + thiram	succinate dehydrogenase inhibitor + dithiocarbamates and relatives	C2: respiration + multi-site contact activity	complexe II : succinate dehydrogenase + multi-site contact activity	7 + M 03	R + RE	seed rot, early season root rot, seedling blight
fludioxonil	phenylpyrrole	E2: signal transduction	MAP/histidine-kinase in osmotic signal transduction (os-2, HOG1)	12	RE	seed-borne and soil-borne diseases
fludioxonil + metalaxyl-M and S-isomer	phenylpyrrole + aclalanine	E2: signal transduction + A1:nucleic acids synthsis	MAP/histidine-kinase in osmotic signal transduction (os-2, HOG1) + RNA polymerase I	12 + 4	RE + R	seed-borne ascochyta blight, seed rot/ pre-emergence damping-off and post-emergence damping -off, seed rot and seedling blight caused by seed-borne *Botrytis* spp.

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed Treatments (continued)						
fluxapyroxad + pyraclostrobin + metalaxyl	pyrazole-4-carboxamide + methoxy-carbamate + acylalanine	C2: respiration + C3: respiration + A1:nucleic acids synthesis	complex II: succinate-dehydrogenase + complex III:cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + RNA polymerase I	7 + 11 + 4	R + R +R	seed rot, seedling blight; root rot, seed-borne *Botrytis cinerea*, *Asc**ochyta* spp., and *Colletotrichum lindemuthianum*
mandestrobin	methoxy-acetamide	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	seed rots, seedling blight, seedling root rot
metalaxyl-M and S-isomer	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	seedling blights and seed rots caused by *Pythium* spp.
penflufen	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	seed rot, pre-emergence damping-off, post-emergence damping-off, early season root rot, seed-borne *Botrytis cinerea*
penflufen + prothioconazole + metalaxyl	pyrazole-4-carboxamide + triazolinthione + acylalanine	C: respiration + G1: sterol biosynthesis in membranes + A1: nucleic acids synthesis	complex II: succinate-dehydrogenase + C14-demethylase in sterol biosynthesis (erg11/cyp51) + RNA polymerase I	7 + 3 +4	R + R + R	seed rot, pre-emergence damping-off, post-emergence damping-off, early season root rot, seedling blight, seed-borne *Botrytis cinerea*, seed-borne *Ascochyta rabiei* (suppression)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed Treatments (continued)						
penflufen + trifloxystrobin	pyrazole-4-carboxamide + oximino-acetate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complexe III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	seed decay, damping-off, seed-borne *Botrytis cinerea*, seed-borne *Ascochyta* spp. (suppression)
prothioconazole	triazolinthione	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	seed rot, pre-emergence damping-off
pyraclostrobin + fluxapyroxad + metalaxyl	methoxy-carbamate + pyrazole-4-carboxamide + acylalanine	C3: respiration + C2: respiration + A1: nucleic acid synthesis	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + complex II: succinate-dehydrogenase + RNA polymerase I	11 + 7 + 4	R + R + R	seed rot, seedling blight, root rot, seed-borne *Ascochyta* spp., seed-borne *Botrytis cinerea*, seed-borne *Colletotrichum lindemuthianum*
sedaxane	pyrazole-4-carboxamide	C: respiration	complex II: succinate-dehydrogenase	7	R	seed decay, seedling blight, damping-off

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed Treatments (continued)						
sedaxane + metalaxyl-M and S-isomer + fludioxonil	pyrazole-4-carboxamide + acylalanine + phenylpyrrole	C: respiration + A1: nucleic acid synthesis + E2: signal transduction	complex II: succinate-dehydrogenase + RNA polymerase I + MAP/histidine-kinase in osmotic signal transduction (os-2, HOG1)	7 + 4 + 12	R + R + RE	seed-borne ascochyta blight, seed rot, damping-off, seedling blight, seed-borne *Botrytis* spp.
thiabendazole + fludioxonil + metalaxyl-M and S-isomer	benzimidazole + phenylpyrrole + aclalanine	B1: cytoskeleton and motor proteins + E2: signal transduction + A1:nucleic acids synthsis	ß-tubuline assembly in mitosis + MAP/histidine- kinase in osmotic signal transduction (os-2, HOG1) + RNA polymerase I	1 + 12 + 4	R + RE + R	seed-borne ascochyta blight, seed rot, damping-off, seedling root rot, seed-borne *Botrytis* spp.
Trichoderma harzianum strain KRL-AG2	biological	unknown	unknown	N/A	R	root rot (suppression)
trifloxystrobin + metalaxyl-M and S-isomer	oximino-acetate + acylalanine	C3: respiration + A1:nucleic acids synthesis	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + RNA polymerase I	11 + 4	R + R	seed decay, damping-off, seed-borne *Botrytis cinerea*, seed-borne ascochyta blight (suppression)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatments						
Bacillus subtilis strain QST 713	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	white mould, botrytis blight, root rots
azoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Asian soybean rust, ascochyta blight, mycosphaerella blight, anthracnose (*Colletotrichum* spp.), sclerotinia (suppression)
azoxystrobin + benzovindiflupyr	methoxy-acrylate + pyrazole-4-carboxamide	C3: respiration + C2:respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + complex II: succinate dehydrogenase	11 + 7	R + R	ascochyta blight, Asian soybean rust, rust, anthracnose (*Colletotrichum* spp.), powdery mildew, mycosphaerella blight
azoxystrobin + difenoconazole	methoxy-acrylate + triazole	C3: respiration + G1: sterol biosynthesis in membranes	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + c14-demethylase in sterol biosynthesis (erg11/cyp51)	11 + 3	R + RE	ascochyta blight, anthracnose (*Colletotrichum* spp.)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatments (continued)						
azoxystrobin + propiconazole	methoxy-acrylate + triazole	C3: respiration + G1: sterol biosynthesis in membranes	complex III: cytochrome bc1 (ubiquinol oxisdase) at Qo site (cyt b gene) + C14- demethylase in sterol biosynthesis (erg11/cyp51)	11 + 3	R + R	powdery mildew, anthracnose (*Colletotrichum truncatum*), Asian soybean rust
benzovindiflupyr	pyrazole-4-carboxamide	C2: respiration	complex II: succinate dehydrogenase	7	R	ascochyta blight, Asian soybean rust, anthracnose (*Colletotrichim* spp.)
benzovindiflupyr + propiconazole	pyrazole-4-carboxamide + triazole	C2: respiration + G1:sterol biosynthesis in membranes	complex II: succinate dehydrogenase + C14-demethylase in sterol biosynthesis (erg11/cyp51)	7 + 3	R + R	ascochyta blight, Asian soybean rust, rust, powdery mildew, anthracnose (*Colletotrichum* sp.)
boscalid	pyridine-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	ascochyta blight, white mould, grey mould
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	ascochyta, white mould, grey mould, anthracnose (*Colletotrichum* spp.)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar treatments (continued)						
captan	phthalimide	multi-site contact activity	multi-site contact activity	M 04	RE	storage rots
chlorothalonil	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M 05	RE	ascochyta blight, anthracnose
copper octanoate	inorganic	multi-site contact activity	multi-site contact activity	M 01	R	ascochyta blight, bacterial blights of bean, brown spot, powdery mildew, rust
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	white mould, grey mould
ethaboxam	ethylamino-thiazole-carboxamide	B3: cytoskeleton and motor proteins	ß-tubulin assembly in mitosis	22	R	seed rot, pre-emergence damping-off, early season root rot
fluopyram	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	grey mould, white mould, ascochyta blight, mycosphaerella blight, powdery mildew

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatments (continued)						
fluopyram + prothioconazole	pyridinyl-ethyl-benzamide + triazolinthione	C2: respiration + G1: sterol biosynthses in membranes	complex II: succinate-dehydrogenase + C14-demethylase in sterol biosynthese (erg11/cyp51)	7 + 3	R + R	white mould, ascochyta blight, mycosphaerella blight, Asian soybean rust
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	suppression of ascochyta blight and white mould
fluxapyroxad + pyraclostrobin	pyrazole-4-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III:cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	ascochyta blight, anthracnose (*Colletotrichum truncatum*), suppression of white mould and grey mould
mancozeb	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M 03	RE	anthracnose, ascochyta blight
metconazole	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	suppression of ascochya blight and white mould
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	ascochyta blight, grey mould, Asian soybean rust (suppression)
picoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	mycosphaerella blight, Asian soybean rust, anthracnose, ascochyta blight, white mould (suppression)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatments (continued)						
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Asian soybean rust, powdery mildew
prothioconazole	triazolinthione	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	ascochyta blight
prothioconazole + trifloxystrobin	triazolinthione + oximino-acetate	G1: sterol biosynthesis in membranes + C3: respiration	C14- demethylase in sterol biosynthesis (erg11/cyp51) + complex III: ytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	3 + 11	R + R	white mould, ascochyta blight, grey mould, anthracnose (*Colletotrichum truncatum*)
pyraclostrobin	methoxy-carbamate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	anthracnose (*Colletotrichum* spp.), ascochyta blight
trifloxystrobin	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	seed decay, damping-off

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Soil Fumigants						
metam-potassium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	8F[4]	RE	weeds, germinating weed-seeds, soil-borne diseases, nematodes
metam-sodium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	8F[4]	RE	germinating weed seeds, symphylans (garden centipede), soil-borne fungal diseases and nematodes, suppression of perennial weeds
oriental mustard seed meal (oil) (*Brassica juncea*) (biofumigant)	not classified	unknown	unknown	NC	R	root knot nematode, soil-borne *Pythium* spp. and *Fusarium* spp.

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 3, 2017. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2017: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed March 7, 2017).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4]Source: Insecticide Resistance Action Committee. IRAC MoA Classification Scheme (Version 8.2; March 2017) (www.irac-online.org) (accessed March 7, 2017).

Seed Rots, Damping-Off, Seedling Blights and Root Rots (*Botrytis* spp., *Rhizoctonia* spp., *Pythium* spp. and *Fusarium* spp.)

Pest Information

Damage: Seeds affected by rot may fail to germinate or produce weak seedlings that fail to emerge from the soil. Young seedlings infected with root rot may become stunted or die, while mature plants which are infected may yellow, develop weakened and stunted growth, ultimately die, reducing crop stand and yield. Seedling damage or stress due to herbicide or environmental injury may increase the frequency of seedling blight resulting in the yellowing of the plant and ultimately its death.

Life Cycle: The pathogens survive in soil and crop debris and can attack any part of the root system of susceptible plants including the stem at the soil line. The disease is more severe when emergence is delayed and with cool, saturated soils.

Pest Management

Cultural Controls: Seeding at proper depths into warm, slightly moist, well-drained soil will promote emergence of the crop and reduce problems due to seed rots, seedling blights and root rot. Rotations that include cereals will help reduce the build-up of the pathogens in the soil with the exception of fusarium root rot because cereals are also host of this pathogen. Additional management practices for seed and seedling diseases are listed in *Table 5. Adoption of disease management practices in lentil production in Canada.*

Resistant Cultivars: None available. Some varieties are more prone to these diseases than others.

Control Products: Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada* for fungicides registered for seed rots and root rots.

Issues for Seed Rots, Damping-Off, Seedling blights and Root Rots

None identified.

Anthracnose (*Colletotrichum lentis*)

Pest Information

Damage: Usual symptoms of anthracnose are white to grey, oval lesions on lower leaflets which will then yellow, turn brown and drop. Stems show sunken tan lesions with a dark margin and brown areas below the lesions. In the field, anthracnose appears as rapidly expanding yellow or grey patches after the canopy has closed-in, the centers of which then die. Yield losses can be significant in affected fields.

Life Cycle: There are two races of the pathogen present in western Canada. The disease can be soil, residue and seed borne. Microsclerotia (i.e. hard compact mass of mycelia) can survive in the soil or in infected crop residue for some time, and several years in the case of buried infected crop residue. 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. The disease progress is favoured by high humidity and warm weather between 22 and 28°C.

Pest Management

Cultural Controls: 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 four years may help reduce pathogen loads in diseased fields. Monitoring which begins early in the season, well before flowering will enable timely management decisions. Control of volunteer plants or wild hosts such as fababean or wild vetch may help reduce disease pressure. A decision support checklist for control of anthracnose is available to help with management strategies at: http://proof.saskpulse.com/files/general/160615_Fungicide_Decision_Support_Checklist_for_Ascochyta_and_Anthracnose_in_Lentil.pdf. Additional management practices for anthracnose are listed in *Table 5. Adoption of disease management practices in lentil production in Canada.*

Resistant Cultivars: Some resistant varieties are available; however 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. Information on the susceptibility of various cultivars to anthracnose is available from http://www.agric.gov.ab.ca/app95/seedinginfo.

Control Products: Fungicides registered for the control of anthracnose in lentil are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada*.

Issues for Anthracnose

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

Ascochyta Blight (*Ascochyta lentis*)

Pest Information

Damage: Ascochyta blight causes grey spots that become tan with brown margins often with tiny black fruiting bodies, on leaves, stems and pods. Heavily infected leaves drop and flower and pods abort, resulting in yield loss and reduced seed quality.

Life Cycle: A. lentis is seed borne or stubble-borne and remains viable in lentil residue for several years. Spores produced in black fruiting bodies (pycnidia) are released from residue to nearby plants where they cause new infections. Pycnidia produced in new infections release spores that are spread from plant to plant mostly by rain splash. Disease progress is promoted when conditions are moist and cool.

Pest Management

Cultural Controls: The use of disease-free seed and planting new crops of lentil away from fields that were infected the year before will help to reduce disease development. A four year crop rotation with non-host crops will reduce crop debris in the field and the potential for disease carry-over. Regular monitoring, starting early in the season and continuing throughout the growing season is important for treatment decisions. A decision support checklist for the control of ascochyta blight is available to help with management strategies at: http://proof.saskpulse.com/files/general/160615_Fungicide_Decision_Support_Checklist_for_Ascochyta_and_Anthracnose_in_Lentil.pdf. Additional management practices for ascochyta blight are listed in *Table 5. Adoption of disease management practices in lentil production in Canada.*

Resistant Cultivars: Information on the susceptibility of various cultivars to ascochyta is available from http://www.agric.gov.ab.ca/app95/seedinginfo.

Control Products: Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada* for fungicides registered for the control of ascochyta blight.

Issues for Ascochyta Blight

1. There is concern that strobilurin fungicides will become ineffective over time if they are overused. This concern has been heightened with the development of strobilurin resistance of *Ascochyta rabiei* in chickpea. Rotations and integrated disease management are critical in the effort to avoid resistance development.

Grey Mould (*Botrytis cinerea*)

Pest Information

Damage: This disease causes pods and stems to rot during the flowering and seed filling stages. Infected stems are bleached or light brown and covered with a grey, moldy growth. The disease is more prevalent during periods of cool, wet weather. Under suitable conditions, there is a potential for yield reductions as well as a decrease in the quality of seed due to discoloration.

Life Cycle: The pathogen survives in seed, on crop residues and in the soil. Infection can occur at any stage of growth. Abundant spores are produced in infected tissues, become airborne and disperse rapidly. The dense foliage of established crops that results in high humidity within the crop canopy, produces ideal conditions for infection, sporulation and spread of the disease later in the season.

Pest Management

Cultural Controls: Thinner canopies are less conducive to disease development but may result in more problems due to weeds. Using proper rotations, disease-free seed, seed treatments and minimizing mechanical damage to the crop, may help minimize problems due to botrytis. Cereal crops used in the rotation are of particular help in reducing the build-up of soil-borne inoculum. Additional management practices for grey mould are listed in *Table 5. Adoption of disease management practices in lentil production in Canada.*

Resistant Cultivars: None identified.

Control Products: Dense canopies may interfere with fungicide penetration and control of this disease. Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada* for fungicides registered for the management of botrytis blight in lentils.

Issues for Botrytis Grey Mould

None identified.

Stemphylium Blight (*Stemphylium botryosum*)

Pest Information

Damage: Stemphylium blight is a foliar disease common in lentil, especially in areas that have been producing lentils for a long time. Cream coloured lesions develop on leaflets at all stages of lentil development resulting in defoliation. Yield losses may not be significant due to the disease appearance in the late summer, but may cause smaller seed size, seed staining, and reduced germination rates for the following season.

Life Cycle: Stemphylium blight spreads by airborne conidia (i.e., microscopic, asexual, fungal spores) that develop in successive generations on the leaf surface. This fungus survives in seed and residue as it is a saprophyte (i.e., utilizing dead or decaying organic matter as food). Although spores can germinate in cool (5ºC) wet weather, the pathogen thrives in warm (25 to 30ºC), wet weather which favours sporulation and infection throughout the summer.

Pest Management

Cultural Controls: Crop rotation may have little effect due to the saprophytic nature of the fungus.

Resistant Cultivars: None available. Plant breeders have conducted some research on stemphylium blight and have identified variation in response to the pathogen in breeding material.

Control Products: None available.

Issues for Stemphilium Blight

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

White Mould (Sclerotinia stem and pod rot) (*Sclerotinia sclerotiorum*)

Pest Information

Damage: Typical symptoms of this fungal disease is light brown, water-soaked discoloration of the stem, leaves or pods, followed by browning and rot of the root system and plant base. Under wet conditions fluffy white mycelium may develop. This disease rarely causes major losses in the brown and dark brown soil zones, where lentil is best adapted.

Life Cycle: S. sclerotiorum has a broad host range, attacking over 300 species of plants. The fungus overwinters as sclerotia in crop debris and in the soil. Warm, wet weather occurring one to two weeks before flowering, in combination with a thick canopy favours disease. The sclerotia germinate, producing mycelium or apothecia (fruiting bodies) that release ascospores that infect plants. Infections can spread to adjacent flowers, stems, leaves and pods within two to three days. New sclerotia are formed in rotting tissue and can persist in crop residue and soil for years. Other conditions favoring this disease include dense canopies and the use of canola, mustard, pea or sunflower in the rotation. Plants older than six weeks tend to be more susceptible. Frequent planting of susceptible crops may lead to inoculum build-up and severe infestations in wet years.

Pest Management

Cultural Controls: Reduced seeding rates and wide row-spacing improve canopy ventilation and may help reduce infection. Rotations with non-host crops such as cereals may help prevent the build-up of sclerotia in the soil. Deep plowing to bury crop debris may also facilitate the decay of sclerotia. Additional management practices for white mould are listed in *Table 5. Adoption of disease management practices in lentil production in Canada.*

Resistant Cultivars: None identified.

Control Products: Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in lentil in Canada* for fungicides registered for the management of white mould in lentil.

Issues for Sclerotinia stem and pod rot

None identified.

Insects and Mites

Key Issues

- Severe outbreaks of grasshoppers 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 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 7. Occurrence of insect pests in Canadian lentil production[1,2]

Insect and mite pests	Alberta	Saskatchewan
Pea aphid		
Leafhoppers		
Aster leafhopper		
Grasshoppers		
Pale western cutworm		
Redbacked cutworm		
Wireworms		

Widespread yearly occurrence with high pest pressure.

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

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

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Lentil stakeholders in reporting provinces.

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

Table 8. Adoption of insect pest management practices in lentil production in Canada[1]

Practice / Pest		Grass-hopper	Cutworm	Pea aphid	Potato leafhopper
Avoidance	Resistant varieties				
	Planting/ harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization				
	Reducing mechanical damage				
	Thinning/ pruning				
	Trap crops/ perimeter spraying				
	Physical barriers				
Prevention	Equipment sanitation				
	Mowing/ mulching/ flaming				
	Modification of plant density (row or plant spacing; seeding rate)				
	Seeding depth				
	Water/ irrigation management				
	End of season crop residue removal/ management				
	Pruning out/ removal of infested material throughout the growing season				
	Tillage/ cultivation				
	Removal of other hosts (weeds/ volunteers/ wild plants)				
Monitoring	Scouting/ trapping				
	Records to track pests				
	Soil analysis				
	Weather monitoring for degree day modelling				
	Use of portable electronic devices in the field to access pest identification /management information				
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests				

…continued

Table 8. Adoption of insect pest management practices in lentil production in Canada[1] (continued)

Practice / Pest		Grasshopper	Cutworm	Pea aphid	Potato leafhopper
Decision making tools	Economic threshold				
	Weather/ weather-based forecast/ predictive model (eg. degree day modelling)				
	Recommendation from crop specialist				
	First appearance of pest or pest life stage				
	Observed crop damage				
	Crop stage				
Suppression	Pesticide rotation for resistance management				
	Soil amendments				
	Biopesticides				
	Release of arthropod biological control agents				
	Habitat management to enhance natural controls				
	Ground cover/ physical barriers				
	Pheromones (eg. mating disruption)				
	Sterile mating technique				
	Trapping				
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)				

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

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

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

Information regarding the use of this practice for this pest is unknown.

[1]**Source: Lentil stakeholders in Saskatchewan.**

Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	grasshoppers, cabbage looper, cutworms, armyworm, fall armyworm, beet webworm, corn earworm, European corn borer,western bean cutworm
chlorpyrifos	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RE	pale western cutworm, grasshoppers
cyantraniliprole	diamide	ryanodine receptor modulator	28	R	cabbage looper, armyworm, beet armyworm, fall armyworm, cutworms, Europeam corn borer, soybean aphid, bean leaf beetle (suppression)
deltamethrin (for use in Prairie Provinces and Peace River region of British Columbia)	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	cutworm, grasshoppers
ferric phosphate	not classified	unknown	N/A	RE	slugs, snails
flupyradifurone	butenolide	nicotinic acetylcholine receptor (nAChR) competitive modulator	4D	R	aphids, leafhoppers, whiteflies

…continued

Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
imidacloprid (soil application)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids
imidacloprid (foliar application)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, leafhoppers (suppression)
imidacloprid (seed treatment)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	wireworm
lambda-cyhalothrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	soybean aphid, pea aphid, bean aphid, western bean cutworm, cutworms, grasshoppers, potato leafhopper, lygus bugs

…continued

Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
lambda-cyhalothrin + chlorantraniliprole	pyrethroid, pyrethrin + diamide	sodium channel modulator + ryanodine receptor	3A + 28	RE + R	grasshoppers, lygus bug, pea leaf weevil, potato leafhopper, soybean aphid, pea aphid, bean aphid, bean leaf beetle, western bean cutworm, cabbage looper, armyworm, fall armyworm, beet armyworm, corn earworm, European corn borer
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	grasshoppers
permethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	cutworms (army, black, dark-sided, pale western, red-backed and white)
spiromesifin	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	broad mite, two spotted spider mite, whiteflies (silverleaf, sweet potato, greenhouse)
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids, whiteflies
thiamethoxam (seed treatment)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES	wireworms

…continued

Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Soil fumigants					
metam-sodium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	8F	RE	germinating weed seeds, symphylans (garden centipede), soil-borne fungal diseases and nematodes, suppression of perennial weeds
Nosema locustae Canning	biological	unknown	N/A	R	may provide suppression of grasshopper and Mormon cricket populations
metam-potassium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	8F	RE	weeds, fungi, nematodes
Storage pests					
aluminum phosphide	phosphide	mitochondrial complex IV electron transport inhibitor	24A	RE	storage pests
magnesium phosphide	Not classified	unknown	N/A	R	storage pests

…continued

Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
phosphine	phosphide	mitochondrial complex IV electron transport inhibitor	24A	R	storage pests

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 3, 2017. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.2; March 2017)* (www.irac-online.org) (accessed March 7, 2017).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4]Source: Fungicide Resistance Action Committee. *FRAC Code List 2016: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed March 7, 2017).

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 prefer to lay their eggs in uncultivated soil, usually at field margins, on pasture land and on roadsides. These insects overwinter as eggs in soil which will hatch the following spring when temperatures reach 4.5ºC. The insect progresses through a number of nymphal stages, and has one generation per season. A late spring or a cool summer can delay the development of the pests, resulting in nymphs being present throughout the fall. Adult feeding can continue until the first heavy frost. 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 season's population size may be used to help predict the severity of infestation the following year.

Pest Management

Cultural Controls: Early seeding will result in the earlier development of larger plants that are more likely to survive grasshopper feeding. Tillage in the fall to eliminate weeds makes fields less attractive to grasshoppers for egg laying. Tillage in the spring will eliminate green plants on which young grasshoppers feed, decreasing the chances of their survival. Trap strips which are localized areas of crops that attract grasshoppers, may be treated with insecticide in an 'attract and kill' strategy to reduce the grasshopper population. Additional management practices for grasshoppers are listed in *Table 8. Adoption of insect pest management practices in lentil production in Canada*.

Resistant Cultivars: None available.

Control Products: Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada,* for insecticides and bio-insecticides for insect management in lentil.

Issues for Grasshopper

1. There is concern about the paucity of control options which are efficacious at the high temperatures typically present when 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.

Cutworms: Pale Western (*Agrotis orthogonia*), Redbacked (*Euxoa ochrogaster*) and others

Pest Information

Damage: Pale western and redbacked cutworms kill seedlings by feeding below ground and cutting off the stems near the soil surface. Cutworms may also damage the crop by feeding on foliage. Cutworm-damaged crops may recover if conditions are moist and cool. Cutworm injury may set back plant growth and reduce plant competitiveness to weeds.

Life Cycle: Cutworm moths lay eggs in the soil during the fall. This insect overwinters as eggs within the top few centimeters of the soil. Eggs hatch in the spring and larvae begin to feed on plants. The larvae develop through six instars (stages) while feeding, before pupating in the soil and emerging as adult moths.

Pest Management

Cultural Controls: Seeding early allows plants to reach larger sizes earlier in the season, enabling them to better withstand cutworm attack. Weekly monitoring during the seedling stage enables the early detection of cutworm problems and facilitates treatment decisions. Managing weeds will make a field less attractive to cutworms and may reduce pest pressure. Additional management practices for cutworms are listed in *Table 8. Adoption of insect pest management practices in lentil production in Canada*.

Resistant Cultivars: None available.

Control Products: Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada* for insecticides and bio-insecticides for insect management in lentil.

Issues for Cutworms

1. There is concern over the potential loss of registration of chlorpyrifos as a result of re-evaluation.

Pea Aphid (*Acyrthosiphon pisum*)

Pest Information

Damage: This serious pest of legume crops reduces yield by feeding on sap, which directly weakens plants and stunts overall plant growth. *A. pisum* can also be a vector of viral diseases of the plants.

Life Cycle: Pea aphids overwinter as eggs on aerial parts of perennial legumes such as alfalfa and clover. Aphids may also be carried into the field by wind. Following hatch, the aphids develop through a number of nymphal stages before becoming adults. Aphids bear live young and can reproduce without mating, characteristics that can result in rapid population build-up. There are many generations each year. Periodically, when aphid colonies become over-

crowded, winged individuals develop and disperse to other plants. Male aphids develop in the fall and following mating, adult females lay overwintering eggs.

Pest Management

Cultural Controls: Early spring seeding may help reduce yield loss due to this insect. Additional management practices for pea aphid are listed in *Table 8. Adoption of insect pest management practices in lentil production in Canada*.

Resistant Cultivars: None available.

Control Products: Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada,* for insecticides and bio-insecticides for insect management in lentil.

Issues for Pea Aphid

None identified.

Leafhoppers: Potato Leafhopper (*Empoasca fabae*) and Aster Leafhopper (*Macrosteles quadrilineatus*)

Pest Information

Damage: There are several leafhopper species which may cause damage in lentil crops. The main species causing damage in lentils are potato leafhopper and the aster leafhopper. Feeding damage caused by adults and nymphs of the potato leafhopper results when the insects pierce leaf tissue and suck sap, injecting saliva toxic to the plant. The aster leafhopper is a key vector of the aster yellows phytoplasma that causes yellowing and deformities of flowers and foliage. The severity of aster yellows is dependent on the numbers of aster leafhoppers and the proportion of phytoplasma-infected leafhoppers in the population.

Life Cycle: Although leafhoppers may be able to survive mild winters in Canada, most are blown northward on prevailing winds from the United States and arrive on the Prairies in May. The potato leafhopper settles on grasses and forages to mate before moving to lentils where it lays eggs in the stems and leaf veins of the plant. Tiny nymphs emerge from these eggs in seven toten day and reach adult stage about two weeks later. The entire life cycle takes about a month. There are two to three generations a year depending on seasonal weather conditions. The aster leafhopper develops from eggs, through five nymphal stages to adults and may have three generations per year. Both leafhopper populations die off in the fall.

Pest Management

Cultural Controls: While early seeding may minimize damage from leafhopper populations, there are no effective preventative measures for potato leafhopper since it has many host crops. Monitoring for aster leafhopper can be done using sticky traps and sweep nets. However no economic thresholds have been set for leafhoppers in lentil. Tests to determine the level of aster yellows infection in leafhopper populations are unavailable. Additional management practices for leafhoppers are listed in *Table 8. Adoption of insect pest management practices in lentil production in Canada*.

Resistant Cultivars: None identified.

Control Products: Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in lentil production in Canada* for insecticides and bio-insecticides for insect management in lentil.

Issues for Leafhoppers

None identified.

Wireworm (Family: Elateridae)

Pest Information

Damage: Wireworms feed on germinating seeds, roots and other underground parts of plants. Seedlings develop symptoms of poor vigour or may be killed, resulting in a thinning of the crop. Feeding damage occurs most commonly in early spring. Many species can cause economic damage to crops. A national wireworm species distribution map has been developed for Canada (http://www.agr.gc.ca/eng/?id=1300894028401).

Life Cycle: Wireworms are the larval stage of click beetles. Click beetles lay eggs in the soil in May and June. Following hatch, larvae feed on plant tissues in the soil. Depending on species, the larval stage requires one to five years to complete. Pupation takes place in the soil with adult emergence in the spring. Adult, larval and pupal stages can overwinter. Wireworms are more prevalent in fields previously planted to grasses and pasture. This insect tends to be more abundant when the soil is moist and in damp areas of a field.

Pest Management

Cultural Controls: It is important to scout fields for wireworm in the fall or early spring prior to planting lentil and to avoid planting in severely infested fields. Fields may be monitored by soil sampling or through the use of bait stations. Carrots, potatoes, whole wheat flour and oatmeal can be used to attract wireworms. Crop rotations with non-host crops and tillage to expose wireworms to predation by birds will help reduce wireworm populations.

Resistant Cultivars: None available.

Control Products: None available.

Issues for Wireworm

None identified

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 new chemistries under development for use in lentils as well as biological controls.
- There is a need for the development and communication of integrated management strategies for weeds in lentil.
- There is a need for grower education on crop rotations and cultural weed management strategies.
- The use of Group 1 graminicides is of concern due to their frequency of use in other crops grown in rotation with lentil. Resistance to Group 1 herbicides in wild oat is widespread throughout Western Canada due to these products being used frequently.

Table 10. Occurrence of weeds in Canadian lentil production

Weeds	Alberta	Saskatchewan
Annual broadleaf weeds		
Annual grass weeds		
Perennial broadleaf weeds		
Perennial grass weeds		
Widespread yearly occurrence with high pest pressure.		
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.		
Widespread yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.		
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.		
Pest not present.		
Data not reported.		

[1]Source: Lentil stakeholders in reporting provinces.

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

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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Avoidance	Planting/ harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization				
	Use of weed-free seed				
Prevention	Equipment sanitation				
	Mowing/ mulching/ flaming				
	Modification of plant density (row or plant spacing; seeding)				
	Seeding/ planting depth				
	Water/ irrigation management				
	Weed management in non-crop lands				
	Weed management in non-crop years				
	Tillage/ cultivation				
Monitoring	Scouting/ field inspection				
	Field mapping of weeds/ record of resistant weeds				
	Soil analysis				
	Use of portable electronic devices in the field to access pest identification/management information				
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests				
Decision making tools	Economic threshold				
	Weather/ weather-based forecast/ predictive model				
	Recommendation from crop specialist				
	First appearance of weed or weed growth stage				
	Observed crop damage				
	Crop stage				

…continued

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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Suppression	Pesticide rotation for resistance management				
	Soil amendments				
	Biopesticides				
	Release of arthropod biological control agents				
	Habitat/ environment management				
	Ground cover/ physical barriers				
	Mechanical weed control				
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)				

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

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

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

Information regarding the use of this practice for this pest is unknown.

[1]**Source: Lentil stakeholders in Saskatchewan.**

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
carfentrazone-ethyl (preplant burn-down, fallow systems and hooded sprayer applications)	triazolinone	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf weeds
clethodim	cyclohexanedione 'DIMs'	inhibition of acetyl CoA carboxylase (ACCase)	1	RE	annual grasses
ethalfluralin	dinitroaniline	microtubule assembly inhibition	3	R	grasses and broadleaf weeds
fluazifop-p-butyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	R[5]	annual grasses, seasonal control of quackgrass
flumioxazin	N-phenylphthalimide	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf and grass weeds, acetolactate synthase (ALS) resistant weeds

…continued

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
glufosinate ammonium + glyphosate	phosphinic acid + glycine	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	10 + 9	R + RE	many annual grasses and broadleaf weeds, quackgrass, Canada thistle
glufosinate ammonium + glyphosate	phosphinic acid + glycine	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	10 + 9	R + RE	quackgrass, Canada thistle, crop desiccant
glyphosate	glycine	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	RE	non-selective weed control in cropland systems many annual and perennial weeds, woody brush and trees
imazamox (Clearfield lentils) (Prairie provinces and Peace River area of British Columbia only)	imidazolinone	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R[6]	grass and broadleaf weeds

…continued

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
imazamox + imazethapyr (Clearfield lentils) (Prairie provinces and Peace River area of British Columbia only)	imidazolinone	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2 + 2	R[6]	grass and broadleaf weeds
metribuzin (western Canada)	triazinone	inhibition of photosynthesis at photosystem II site A	5	R	suppression of ball mustard, common chickweed, corn spurry, green smartweed, hempnettle, lamb's-quarters, stinkweed, tartary buckwheat, volunteer non-triazine tolerant canola and wild mustard
paraquat	bipyridylium	photosystem-I-electron diversion	22	R[7]	emerged annual grasses and broadleaf weeds, top-growth control of perennial grass and broadleaf weeds
pyraflufen-ethyl	phenylpyrazole	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	emerged broadleaf weeds

…continued

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
quizalofop-p-ethyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual and perennial grasses
salflufenacil (lentils including Clearfield® lentils) (Prairie Provinces and Peace River region of BC only)	pyrimidindione	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	kochia, Canada fleabane, cleavers, lamb's-quarters, narro-leaved hawk's beard, redroot pigweed, round-leaved mallow, stinkweed, volunteer canola, wild buckwheat, wild mustard
salflufenacil (red lentil varieties) (Prairie Provinces and Peace River region of BC only)	pyrimidindione	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	harvest aid
sethoxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual grasses, wild oats, volunteer cereals, quackgrass
tepraloxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	certain annual grasses, quackgrass

…continued

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
trifluralin (Prairie Provinces only, fall only)	dinitroaniline	microtubule assembly inhibition	3	R[8]	annual grasses and broadleaf weeds
Crop desiccant					
diquat	bipyridylium	photosystem-I-electron diversion	22	R	crop desiccant
glufosinate ammonium	phosphinic acid	inhibition of glutamine synthetase	10	R	harvest aid, crop dessicant
glufosinate ammonium + glyphosate	phosphinic acid + glycine	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	10 + 9	R + RE	crop desiccant

…continued

Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Soil fumigant					
metam-potassium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	8F[4]	RE	weeds, germinating weed-seeds, soil-borne diseases, nematodes
metam -sodium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor[4]	8F[4]	RE	germinating weed seeds, symphylans (garden centipede), soil-borne fungal diseases and nematodes, suppression of perennial weeds

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 7, 2017. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Weed Science Society of America (WSSA). Herbicide Mechanism of Action (MOA) Classification list (last modified 09/11/2016) http://wssa.net (accessed January 19, 2017)

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.2; March 2017)* (www.irac-online.org) (accessed March 7, 2017).

[5]Re-evaluation complete as published in PMRA *Re-evaluation Note REV2016-14, Special Review Decision: Fluazifop-P-butyl.*

[6]Re-evaluation complete as published in PMRA *Re-evaluation Decision RVD2016-04, Imazamox.*

[7]Re-evaluation complete as published in PMRA *Re-evaluation Note REV2015-14, Special Review Decision: Paraquat.*

[8]Re-evaluation complete as published in PMRA *Re-evaluation Note REV2016-11, Special Review Decision: Trifluralin.*

All Weeds

Pest Information

Damage: If left unmanaged, weeds can cause significant yield losses, depending on the density of weed populations and the time of emergence of the weed relative to the crop. Since lentil is a poor competitor, annual broadleaf weeds including volunteer canola (*Brassica napus*), mustard (*Sinapsis arvensis*) and volunteer flax (*Linum usitatissimum*) may crowd the crop. Those germinating late in the season including 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. Some perennial broadleaf weeds including Canada thistle (*Cirsium arvensis*), sow thistle (*Sonchus arvensis*), or perennial grasses such as quackgrass (*Elytrigia repens*) have become increasingly problematic due to the adoption of minimum tillage practices and continuous cropping.

Life cycle:

Annual weeds: Annual weeds complete their life cycle, from seed germination, through vegetative growth and flowering, to seed production, in one year producing large numbers of seeds. Some weed seeds remain viable in the soil for many years, germinating when conditions are suitable.

Perennial weeds: Perennials weeds live for many years. They spread through seeds, the expansion of various types of root systems and other vegetative means. Perennial grass weeds tend to have extensive creeping root systems, which frequently produce shoots that will then produce a new plant. They can also spread by seed or root fragments. Most perennial grass weed seeds will germinate within a year, but some may remain viable in the soil for twenty years or more.

Pest Management

Cultural Controls:

Annual weeds: Given lentil's sensitivity to herbicide drift, as well as herbicide intolerance caused by periods of stress from drought, frost, heat or land rolling, cultural weed control options may be considered. Therefore, growing lentil requires a long-term strategy for good weed control including crop rotation and proper assessment of weed occurrence in order to help determine the most appropriate control methods. It is important to know the history of the weed infestation in a field prior to planting so that heavily infested fields can be avoided. Minimizing tillage tends to lead to reduced populations of wild millet (foxtail) and wild oats because seed remains on the soil surface where it is exposed to weather and birds. The use of clean, certified seed reduces the introduction of new weed seeds. Deploying harvesting techniques that minimize seed loss in the cereal crop the year prior to growing lentils can lead to reduced populations of volunteer cereals. Fall tillage prior to freeze-up can do the same but this practice can leave the soil prone to erosion. For some annual broadleaf weeds, mowing of field edges will reduce the seed set. 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.

Perennial weeds: Where possible, fields with low weed infestations are selected for the growing of lentils. Minimizing tillage can reduce the spread of quackgrass, a common perennial grass weed, as tillage cuts up the rhizome which triggers the development of more shoots. Perennial weeds are controlled in non-lentil years of the rotation. Monitoring uncultivated field edges and roadsides and mowing weeds prior to flowering will help minimize spread into fields. The management of field-scale infestations requires a combination of control measures over several years, along with good fertility to improve crop competition. Careful record keeping on herbicide treatments is essential for the selection of herbicide groups, to minimize potential weed resistance problems and to prevent crop injury from herbicide carryover. Additional management practices for weeds are listed in *Table 11. Adoption of weed management practices in lentil production in Canada1*.

Resistant Cultivars: None available.

Control Products: Refer to *Table 12. Herbicides and bio-herbicides registered for weed management in lentil production in Canada* for herbicides and bio-herbicides for weed management in lentil.

Issues for weeds

Annual Weeds:

1. For annual grasses, there is concern with the overuse of Group 1 graminicides and Group 2 active ingredients that control grasses in the crop rotation. When a chemistry is used too often, resistance to the entire product group or to members of the group can occur. Resistance in wild oat is widespread throughout Western Canada.
2. There is a need for additional tools for annual broadleaf weed control in lentils, particularly for post-emergent weed control. Post-emergent strategies that rely on metribuzin must account for the fact that the product can cause crop injury, further reducing the crop's ability to compete with weeds. Furthermore, there is concern with the overuse of Group 2 broadleaf control products in the crop rotation. When a chemistry is used too often, resistance to the entire product group or to members of the group can occur. While the introduction of imidazolinone-tolerant lentil to a range of market classes provides an effective option for broadleaf weed control in this crop, it adds a layer of complexity to the management of Group 2 weed resistance.

Perennial Weeds:

None identified

Resources

IPM/ICM Resources for Production of Lentil in Canada

Alberta Agriculture and Forestry. Crop Information Portal
http://www.agric.gov.ab.ca/app95/seedinginfo

Alberta Agriculture and Forestry. Crops: Peas and Pulses.
http://www.agric.gov.ab.ca/app21/infopage?cat1=Crops&cat2=Peas%20%26%20Pulses

Alberta Agriculture and Forestry. *Varieties of Pulse Crops for Alberta*,
http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex3795/$FILE/142_32-1.pdf

Manitoba Agriculture. Guides and Publications.
https://www.gov.mb.ca/agriculture/crops/guides-and-publications/

Manitoba Agriculture. *Guide to Field Crop Protection, 2016.*
https://www.gov.mb.ca/agriculture/crops/guides-and-publications/

Manitoba Agriculture. *Field Crop Production Guide.*
https://www.gov.mb.ca/agriculture/crops/guides-and-publications/

Saskatchewan Ministry of Agriculture. *Seed-Borne Diseases of Pulse Crops*,
http://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/disease/seed-borne-diseases-of-pulse-crops

Saskatchewan Ministry of Agriculture. *Guide to Crop Protection 2017*
http://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/guide-to-crop-protection

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Manitoba	Manitoba Agriculture http://www.gov.mb.ca/agriculture/	Dennis Lange dennis.lange@gov.mb.ca	Pratisara Bajracharya pratisara.bajracharya@gov.mb.ca
Saskatchewan	Saskatchewan Ministry of Agriculture http://www.saskatchewan.ca/agriculture	Dale Risula, Provincial Specialist, Special Crops, dale.risula@gov.sk.ca	Danielle Stephens danielle.stephens@gov.sk.ca
Alberta	Alberta Agriculture and Forestry http://www.agriculture.alberta.ca/	Christy Hoy Research Agronomist christy.hoy@gov.ab.ca	John Paul Glaves johnpaul.glaves@gov.ab.ca Ron Pidskalny Prairie Minor Use Consortium pidskaln@gmail.com

National and Provincial Pulse Grower Organizations

Alberta Pulse Growers http://www.pulse.ab.ca

Canadian Special Crops Association http://www.specialcrops.mb.ca/

Manitoba Pulse and Soybean Growers http://www.manitobapulse.ca

Pulse Canada http://www.pulsecanada.com

Saskatchewan Pulse Growers http://www.saskpulse.com

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 11 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>Black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>Grey</td></tr>
</table>

References

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Alberta Agriculture and Forestry. Crop Information Portal http://www.agric.gov.ab.ca/app95/seedinginfo (accessed February 8, 2017)

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