CROP PROFILE FOR CHICKPEA IN CANADA, 2015

PREPARED BY:
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Agriculture and Agri-Food Canada

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Canada

First Edition –2005
Crop Profile for Chickpea in Canada
Catalogue No.: A118-10/5-2005E-PDF

Second Edition – 2009
Crop Profile for Chickpea in Canada
Catalogue No.: A118-10/5-2009E-PDF
ISBN: 978-0-662-48243-7
AAFC No.: 10870E

Third Edition - 2017
Crop Profile for Chickpea in Canada, 2015
Catalogue No.: A118-10/5-2015E-PDF
ISBN: 978-0-660-08821-1
AAFC No.: 12634E

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Electronic version available at www.agr.gc.ca/pmc-cropprofiles

Paru également en français sous le titre: « Profil de la culture du pois chiche au Canada, 2015 »

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Cover photograph courtesy of: Saskatchewan Pulse Growers

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 chickpea, 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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Crop Profile for Chickpea in Canada

Chickpea (*Cicer arietinum* L.) is an important food legume world-wide providing a source of high quality protein. The chickpea plant has an indeterminate growth habit, and therefore flowering and pod filling continue as long as temperature and moisture permit growth to occur. A member of the Leguminosae family, chickpea fixes nitrogen from the atmosphere through a symbiotic association with soil bacteria (generally called rhizobia). Chickpea is an ancient pulse crop that was first grown in Turkey about 7,000 B.C. Traditional production regions include the semi-arid zones of India and Middle Eastern countries.

Growers in Saskatchewan began commercially producing chickpea in the mid -1990's over a relatively small area that expanded substantially over the ensuing years. Canadian producers grow two market classes of chickpea, Desi and Kabuli. Desi types have smaller, angular seeds with yellow to brown seed coats. Kabuli types have a rounded seed with a cream-coloured coat. Kabuli chickpea is best adapted to the brown soil zone, while Desi chickpea is best adapted to the brown and dark brown soil zones of Saskatchewan. Almost all Canadian chickpea production is centered in these two soil zones in Saskatchewan, with small volumes also produced in Alberta in some years (refer to Table 2). Producers seed about 70 percent of the chickpea area to Kabuli types and 30 percent to Desi types.

Crop Production

Industry Overview

A summary of crop production and export and import data is provided in Table 1.

Table 1. General production information (2015)

Canadian Production (2015)[1]	83,500 metric tonnes 46,500 hectares (seeded)
Farm cash receipts (2015)[2]	$54 million
Total domestic use (2015-2016)[3,4,5]	63,000 metric tonnes
Exports (2015-2016)[3,5,6]	151, 000 metric tonnes
Imports (2015-2016)[3,5,6]	14,000 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: 2017-03-29).

[2]Statistics Canada. Table 002-0001 - Farm cash receipts, annual (dollars), CANSIM (database) (accessed: 2017-03-30).

[3]Agriculture and Agri-Food Canada. AAFC. 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]Total domestic use + food and industrial use + feed waste and dockage + seed use + loss in handling. Total domestic use is calculated residually.

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

[6]Imports and exports exclude products.

Production Regions

Chickpea is grown primarily in southern Saskatchewan, with a small amount grown in Alberta (Table 2) most years.

Table 2. Distribution of chickpea production in Canada (2015)

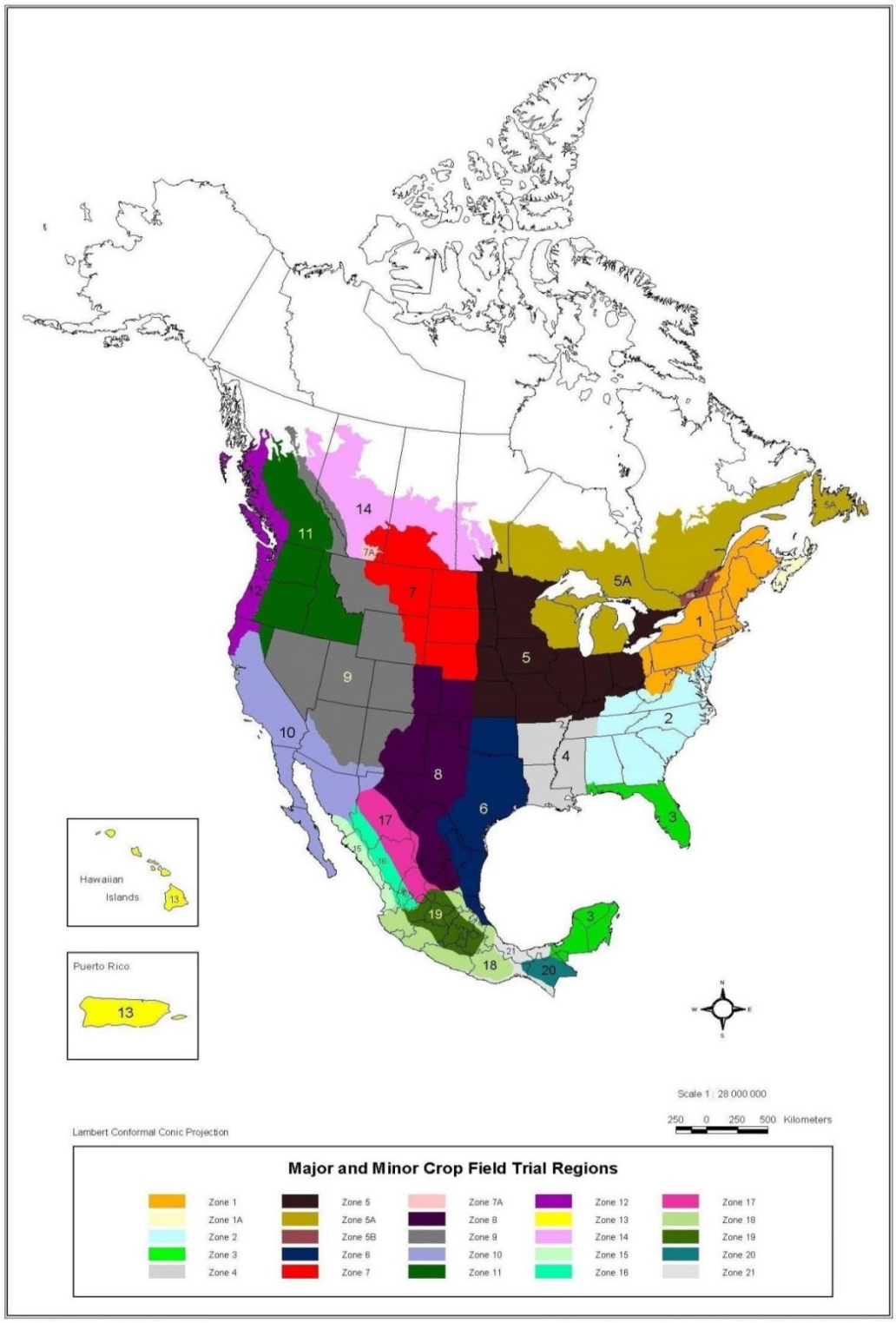
Production Regions	Seeded area (hectares)	Percent national production
Saskatchewan	46,500	100%
Alberta	N/A	N/A
Canada	46,500	100%

Source: Statistics Canada. Table 001-0010 - Estimated areas, yield, production and average farm price of principal field crops, in metric units, annual CANSIM (database) (accessed: 2017-03-27).

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

Cultural Practices

Chickpea must be handled carefully to avoid damage to the seed coat. Dry seed (less than 14% moisture) is brittle and can easily crack or split, leading to reduced germination and increased risk of disease. If a field has a past history of soil-borne diseases, the use of a fungicide seed treatment is recommended when planting chickpea.

Under ideal conditions, with a nitrogen-fixing inoculant (rhizobium), chickpea plants have the ability to fix 60 to 80 per cent of their nitrogen requirement from the atmosphere. The rhizobium may die if exposed to stresses such as high temperature, drying winds or direct sunlight. 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. Chickpea has a very specific relationship with rhizobium and it is essential that an inoculant specifically developed for chickpea be used.

Superior seed quality is needed for successful chickpea production. Chickpea is best seeded 3.5 to 6 cm deep, preferably into a firm, moist, weed-free seedbed to ensure proper germination and assure inoculant survival. The optimal temperature for germination is 15°C; however Desi chickpeas may begin germination at soil temperatures as low as 5°C. Seeding rates range from 90 to105 kg/ha for Desi types and 135 to 210 kg/ha for Kabuli types. The desired plant population is 33 to 44 seedlings per square meter. Crop stands of this density provide good competition against weeds and will result in more uniform maturity and higher yields. Newly emerged seedlings are relatively frost tolerant and spring frost is generally not an issue. Chickpea is not well adapted to saline soils, soils with high clay content, and soils that are slow to warm up in the spring. Areas with prolonged, high soil moisture and waterlogged conditions are also not suitable for chickpea production.

Site selection is critical for chickpea since pest control products are limited. It is important that chickpea not be planted adjacent to the previous year's chickpea stubble because of the potential for carry-over of inoculum of ascochyta blight, a major disease of chickpea. Planting a rotational crop such as a cereal, as a border strip adjacent to chickpea stubble will help prevent the rapid spread of ascochyta blight and crop loss. A crop rotation with chickpea planted one year in four is followed by the majority of producers because of the aggressive nature of ascochyta blight. A rotation such as this will allow for the breakdown of chickpea residue on which the pathogen survives. Chickpea does not leave a lot of crop residue, so cereal crops with tall stubble grown before and after chickpea also provide much needed residue to help protect the soil from erosion.

Chickpea can be planted on either summer fallow or stubble in the brown soil zone and on stubble in the dark brown soil zone. A soil test will provide a guideline for fertility needs. Fertility requirements for chickpea are not well defined. Based on limited data, the requirements for phosphorus, potassium and sulphur are similar to pea or lentil. While a well-inoculated crop should not require nitrogen fertilizer, low rates of supplemental nitrogen, applied before the onset of nitrogen fixation to soils with available nitrogen levels less than 11 kg per hectare, may be of benefit. Under these conditions, starter nitrogen may hasten early plant growth and prevent seedlings from yellowing due to nitrogen deficiency. While this nitrogen application may help alleviate early nitrogen deficiency and speed vegetative growth, it does not necessarily improve yield.

Table 3. Chickpea production and pest management schedule in Canada

Time of year	Activity	Action
October - March	None	
April	Soil care	Soil testing (nutrients)
	Weed management	Scouting for overwintering weeds; herbicide treatment or cultivation; application of burn-down herbicide treatments; early pre-plant and pre-emergence herbicides applied as early as late April
May	Plant care	Seeding
	Soil care	Fertilization according to soil test recommendations
	Disease management	Application of seed treatments for control of seed and/or soil-borne pathogens
	Insect and mite management	Monitoring
	Weed management	Application of early pre-plant and pre-emergence herbicides in early May; scouting and identifying weeds to be controlled with post-emergence applications
June	Plant care	Monitoring
	Disease management	Monitoring and application of foliar fungicides if necessary
	Insect and mite management	Monitoring
	Weed management	Spraying if necessary for grassy and broadleaved weeds and spot treatments for control of perennial weeds if practical
July	Disease management	Application of fungicides if necessary
	Insect and mite management	Monitoring
	Weed management	Follow up on weed problems, observe results of control and application of late herbicide treatments if necessary
August	Plant care	Preparation for harvest
	Disease management	Monitoring
	Insect and mite management	Monitoring
	Weed management	Monitoring
September	Plant care	Harvesting
	Weed management	Checking for winter annual germination and application of treatments or tillage if necessary; application of fall pre-plant incorporated herbicides (if required for time management the season before seeding the chickpea crop)

Abiotic Factors Limiting Production

Growth Habit

Due to the indeterminate growth habit of chickpea, a moisture or nitrogen stress is required to encourage seed set and maturity. Harvesting before the crop is mature can result in green seed and a loss in grade. Factors such as field topography, moisture availability, disease and uneven seeding can cause variations in maturation in a field and contribute to green seed.

Fall Frost

A hard killing frost in the fall on an immature chickpea crop will increase the amount of green seeds, thus decreasing the quality and price of the crop.

Storage

The moisture level of a chickpea crop must be monitored especially shortly after harvest. At harvest the outside seed coat of chickpea seed normally has a lower moisture level than the inside of the seed. During storage the differential moisture level evens out (sometimes referred to as the 'tempering' or 'sweating' of the seeds) and the overall moisture level of the seed may rise. A crop that was harvested at an acceptable moisture level may be measured at a moisture level higher than 14% (the maximum moisture level to safely store the crop) a week later, which can cause heat to build up and the crop to spoil. It is important that chickpea be stored in a hopper-bottomed bin that has aeration, which can bring down the moisture level of the chickpeas.

Handling

Care needs to be taken when handling chickpea seed in order not to damage the beak, the protruding seedling root tip, or crack the seed coat, both of which can downgrade the quality of the seed. This is especially important under extreme cold conditions, such as when hauling chickpea to the processor in the winter. The cold can cause the seed coat to become quite fragile and crack easily when handled.

Soil Moisture Depletion

Chickpea has a deep tap-root, which allows it to use water from greater depths than other pulse crops. Due to its indeterminate growth habit and the fact that it continues growing into the fall, it can deplete the subsoil moisture in the field, which can be of concern for the following rotational crop.

Diseases

Key Issues

- There is concern over the reliance on strobilurin fungicides for the control of a number of diseases, as resistance to this chemistry has been discovered. While strobilurin fungicides are available in products formulated with a second mode-of-action, over 40 percent of the products registered for chickpea contain a single strobilurin, and the risk of resistance in pathogen populations is high.
- There is also concern over the reliance on demethylation inhibitor fungicides, as over 60 percent of the products registered for chickpea contain a single demethylation inhibitor which is listed at a medium risk for the development of resistance in pathogen populations.
- There is a need to develop enhanced ascochyta-resistance germplasm.
- There is a need for improved management tools and practices for a number of diseases of chickpea.
- There is a need for modeling, forecasting and decision making tools.
- Grower education is required on disease identification and management, resistance management and field scouting in chickpea.

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

Disease	Alberta	Saskatchewan
Seed rot and seedling blight		
Ascochyta blight		
Botrytis stem and pod rot (grey mould)		
Sclerotinia stem rot (white mould)		
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 not present.

Data not reported.

[1]Source: Chickpea 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 chickpea production in Canada[1]

Practice / Pest		Ascochyta blight	Botrytis stem and pod rot (grey mould)	Root rot	Sclerotinia stem rot (white mould)
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)				
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				

…continued

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

Practice / Pest		Ascochyta blight	Botrytis stem and pod rot (grey mould)	Root rot	Sclerotinia stem rot (white mould)
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 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: Chickpea stakeholders in reporting provinces (Alberta and Saskatchewan).**

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment						
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	suppression of seedling blight and root rot caused by *Rhizoctonia solani* and *Fusarium* spp.
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, seedling blight (*Ascochyta* spp.), root rot (suppression)
captan	phthalimide	multi-site contact activity	multi-site contact activity	M 04	RE	seed decay, root rot, damping-off, seedling blights
ethaboxam	ethylamino-thiazole-carboxamide	B3: cytoskeleton and motor proteins	ß-tubulin assembly in mitosis	22	R	seed rot, pre-emergence damping-of, early season root rot (*Aphanomyces euteiches)* (suppression)
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, damping-off, seedling blight, seed rot and seedling blight caused by seed-borne *Botrytis* spp.

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (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, seedling blight caused by seed-borne *Ascochyt*a spp., suppression of seed rot and seedling blight caused by seed-borne *Botrytis cinerea*
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	pythium damping-off, early season phytophthora root rot
penflufen	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	seed rot, damping-off, early season root rot, seedling blight (*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, damping-off, early season root rot and seedling blight, seedling blight (*Botrytis cinerea),* seed rot and pre-emergence damping-off (*Ascochyta rabiei*) (suppression)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (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 decay, damping-off, and seedling blight (*Botrytis cinerea),* seed-borne ascochyta blight
prothioconazole	triazolinthione	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	seed rot, damping-off; seed rot and pre-emergence damping-off (*Ascochyta rabiei)*
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, seedling blight (*Ascochyta* spp.), seed rot and seedling blight (*Botrytis cinerea)*
sedaxane	pyrazole-4-carboxamide	C: respiration	complex II: succinate-dehydrogenase	7	R	seed decay, seedling blight, damping-off
sedaxane + metalaxyl-M and S-isomer + fludioxonil	pyrazole-4-carboxamide + acylalanine + phenylpyrrole	C: respiration + A1: nucleic acid synthesis + ES: 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 rot and seedling blight (*Botrytis* spp.)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (continued)						
thiabendazole + fludioxonil + metalaxyl-M and S-isomer +	benzimidazole + phenylpyrrole + aclalanine	B1: cytoskeleton and motor proteins + E2: signal transduction + A1:nucleic acids synthesis	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 blight, seed rot and seedling blight (*Botrytis* spp.)
trifloxystrobin	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	seed decay, damping-off
Trifloxystrobin + metalaxyl	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 ascochyta blight (suppression)
Soil / In-furrow Treatment						
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	root rots
Foliar Treatment						
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

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (continued)						
azoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	ascochyta blight, anthracnose, 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, anthracnose, powdery mildew
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
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
benzovindiflupyr	pyrazole-4-carboxamide	C2: respiration	complex II: succinate dehydrogenase	7	R	ascochyta blight, anthracnose (*Colletotrichum* spp.)

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (continued)						
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, powdery mildew , anthracnose (*Colletotrichum* spp.)
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 blight, white mould, grey mould
chlorothalonil	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M 05	RE	ascochyta blight
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
fluopyram	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	grey mould, white mould, ascochyta blight, powdery mildew

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (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
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	ascochyta blight, white mould (suppression)
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, white mould and grey mould (suppression)
metconazole	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	ascochya blight and white mould (suppression)
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	ascochyta blight, grey mould
picoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	white mould (suppression)
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment (continued)						
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
trifloxystrobin	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	seed decay, damping-off
Soil Fumigant						
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*)	diverse	not classified	unknown	N/A	R	root knot nematode, soil-borne *Pythium* spp. and *Fusarium* spp.

…continued

Table 6. Fungicides and bio-fungicides registered for disease management in chickpea 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 Treatment for Storage						
captan	phthalimide	multi-site contact activity	multi-site contact activity	M 04	RE	storage rots

[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 February 21, 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).

Ascochyta Blight (*Ascochyta rabiei*)

Pest Information

Damage: Ascochyta blight, causes brown lesions on leaves, stems and pods. Stems may be girdled by lesions. Heavy infections can result in yield loss and reduced seed quality.

Life Cycle: A. rabiei overwinters on crop residues and can be introduced into a field on infected seed. In the spring, new infections on young plants are caused by seed-borne inoculum and by conidia and ascospores (sexual spores) produced in infected crop debris. Pycnidia are formed within the new infections and produce spores (conidia) that are released when conditions are moist. The spores require a minimum of 24 hours of rainfall or humid conditions to germinate and penetrate the plant. There can be multiple infection cycles within one season. The pathogen can survive for several years on exposed crop residue.

Pest Management

Cultural Controls: The use of disease-free seed and planting new crops of chickpea away from other chickpea fields and at least 500 meters from fields where chickpeas were grown the preceding season will help to reduce disease development. A three to four year crop rotation with non-host crops will reduce crop debris in the field and disease carry-over. Tillage can facilitate the breakdown of crop residues and reduce overwintering of the pathogen. Regular monitoring, starting early in the season and continuing throughout the growing season is important for treatment decisions. A disease decision support checklist is available on which to base management strategies (http://publications.gov.sk.ca/documents/20/84063-58d8a4fa-054c-4227-b742-6d037090bf89.pdf). Additional management practices for ascochyta blight are listed in *Table 5. Adoption of disease management practices in chickpea production in Canada*.

Resistant Cultivars: There are no resistant varieties, but the disease is less severe on fern-leaf varieties. Information on the susceptibility of various cultivars to ascochyta blight 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 chickpea in Canada* for fungicides registered for the control of ascochyta blight.

Issues for Ascochyta Blight

1. There is concern that the over-use of the strobilurin fungicides will cause them to become ineffective over time. The first populations of resistant *Ascochyta rabiei* appeared in 2007. Fungicide rotations and integrated disease management will be critical if this is to be managed.
2. New, resistant cultivars need to be developed to help in an integrated approach to managing this disease.

Grey Mould (*Botrytis cinerea*)

Pest Information

Damage: Botrytis infection can cause seedling blight and blighting of flowers, foliage and pods. Seedlings may be killed. 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 result in high humidity within the crop canopy produce 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 damage to the crop, can 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 chickpea production in Canada*.

Resistant Cultivars: None available.

Control Products: Refer to *Table 6. Fungicides and bio-fungicides registered for disease management in chickpea in Canada* for fungicides registered for the management of botrytis blight in chickpeas.

Issues for Grey Mould

None identified.

Sclerotinia Stem Rot (*Sclerotinia sclerotiorum*)

Pest Information

Damage: Sclerotinia causes white lesions to develop on stems leaves and pods. Lesions may girdle stems. Under wet conditions fluffy white mycelium may develop. Hard, black fungal resting bodies called sclerotia develop in infected tissues.

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 including dead blossoms. 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.

Pest Management

Cultural Controls: Rotations with non-host crops such as cereals will help prevent the build-up of sclerotia in the soil. Deep plowing to bury crop debris will facilitate the decay of sclerotia. Additional management practices for sclerotinia stem rot are listed in *Table 5. Adoption of disease management practices in chickpea production in Canada*.

Resistant Cultivars: None available.

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

Issues for Sclerotinia Stem Rot

None identified.

Seed rots, Seedling Blights and Root Rots (*Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp. and *Botryis* sp.)

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 develop weakened and stunted growth.

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 favour 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. Additional management practices for root rot diseases are listed in *Table 5. Adoption of disease management practices in chickpea production in Canada*.

Resistant Cultivars: None available. Kabuli chickpeas are very susceptible.

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

Issues for seed rots and seedling blights

None identified.

Insects and Mites

Key Issues

- Reduced risk insecticides are needed which can be used in an integrated approach to insect control.

Table 7. Occurrence of insect pests in Canadian chickpea production[1,2]

Insect and mite pests	Alberta	Saskatchewan
Alfalfa Looper		
Cutworms		
Pale western cutworm		
Redbacked cutworm		
Grasshoppers		
Migratory grasshopper		
Wireworm		
Aster leafhopper		
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: Chickpea 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 chickpea production in Canada[1]

Practice / Pest		Alfalfa looper	Cutworm	Grasshopper	Wireworm
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 chickpea production in Canada[1] (continued)

Practice / Pest		Alfalfa looper	Cutworm	Grasshopper	Wireworm
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: Chickpea stakeholders in reporting provinces (Alberta and Saskatchewan).**

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed Treatment					
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	wireworm
thiamethoxam	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES	wireworm
Soil Treatment					
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids
Foliar Treatment					
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	grasshoppers, cabbage looper, cutworms, armyworm, fall armyworm, beet webworm, corn earworm, European corn borer, western bean cutworm
cyantraniliprole	diamide	ryanodine receptor modulator	28	R	cabbage looper, armyworm, beet armyworm, fall armyworm, cutworms, European corn borer, soybean aphid, bean leaf beetle (suppression)

…continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatment					
flupyradifurone	butenolide	nicotinic acetylcholine receptor (nAChR) competitive modulator	4D	R	aphids, leafhoppers, whiteflies
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, leafhoppers (suppression)
lambda-cyhalothrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	soybean aphid, pea aphid, bean aphid, western bean cutworm, cutworms, grasshoppers, bean leaf beetle, potato leafhopper
lambda-cyhalothrin + chlorantraniliprole	pyrethroid, pyrethrin + diamide	sodium channel modulator + ryanodine receptor	3A + 28	RE + R	grasshopper, 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
methoxyfenozide	diacylhydrazine	ecdysone receptor agonist	18	R	cabbage looper, European corn borer

…continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar Treatment					
Nosema locustae Canning	biological	unknown	N/A	R	may provide suppression of grasshopper and Mormon cricket populations
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 + lambda-cyhalothrin	neonicotinoid + pyrethroid, pyrethrin	nicotinic acetylcholine receptor (nAChR) competitive modulator + sodium channel modulator	4A + 3A	RES + RE	soybean aphid, bean leaf beetle
Soil Fumigant					
metam-potassium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor	8F	RE	weeds, germinating weed-seeds, soil-borne diseases, nematodes
metam-sodium	methyl isothiocyanate generator	miscellaneous non-specific (multi-site) inhibitor	8F	RE	germinating weed seeds, symphylans (garden centipede), soil-borne fungal diseases and nematodes, suppression of perennial weeds

…continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Storage Pests					
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 February 22, 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.

Alfalfa Looper (*Autographa californica*)

Pest Information

Damage: The alfalfa looper feeds on a number of plants but prefers alfalfa and can injure chickpea when it is planted in close proximity to alfalfa. Larval feeding results in large holes in leaves and flowers and seedpods may be clipped, affecting yield.

Life Cycle: The pest overwinters as pupae in the soil or in trash near the base of the host plant. Eggs are laid on plant tissues and hatch in early summer. Larvae are present throughout the summer. There are up to three generations per year. Moths may also be carried northward from the United States on air currents in early summer.

Pest Management

Cultural Controls: Avoiding the planting of chickpea near alfalfa will help prevent feeding damage due to the alfalfa looper. Seeding crops early will result in larger plants with vigorous growth earlier in the season, that are more tolerant of feeding by this insect. Additional management practices for alfalfa looper are listed in *Table 8. Adoption of insect pest management practices in chickpea production in Canada*.

Resistant Cultivars: None available.

Control Products: None available.

Issues for Alfalfa Looper

1. There is a need for a biopesticide or chemical pest management tool for alfalfa looper control.

Cutworms: Pale Western (*Agrostis orthogonia*) and Redbacked Cutworm (*Euxoa ochrogaster*)

Pest Information

Damage: Pale western and redbacked cutworms kill seedlings by feeding below ground and cutting off the stems near the soil surface.

Life Cycle: Eggs are laid in the soil by cutworm moths in the fall. Eggs hatch in the spring and larvae begin to feed on plants. The larvae develop through 6 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 that enables 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. Additional management practices for cutworms are listed in *Table 8. Adoption of insect pest management practices in chickpea production in Canada*.

Resistant Cultivars: None available.

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

Issues for Cutworms

None identified.

Grasshoppers: Migratory Grasshopper (*Melanoplus sanguinipes*)

Pest Information

Damage: Grasshoppers prefer other crops and tend to attack chickpea only when other food sources are not available. Grasshopper injury is more severe when the insect feeds on small seedlings.

Life Cycle: Grasshoppers prefer to lay their eggs in uncultivated soil, usually at field margins, on pasture land and on roadsides. Eggs, which are the overwintering stage, are laid in August and September and hatch the following May and June. 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.

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 to reduce the grasshopper population. Additional management practices for grasshoppers are listed in *Table 8. Adoption of insect pest management practices in chickpea production in Canada*.

Resistant Cultivars: None available.

Control Products: Pesticides and bio-pesticides registered for the control of grasshoppers are listed in *Table 9. Insecticides and bio-insecticides registered for insect management in chickpea production in Canada*.

Issues for Grasshoppers

1. There is a need for the development of a reduced risk approach, including the use of biological controls for the management of grasshoppers in chickpea.

Wireworms (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 1 to5 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.

Pest Management

Cultural Controls: It is important to scout fields for wireworm in the fall or early spring prior to planting chickpea 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. Additional management practices for wireworms are listed in *Table 8. Adoption of insect pest management practices in chickpea production in Canada*.

Resistant Cultivars: None available

Control Products: Pesticides and bio-pesticides registered for the control of wireworms are listed in *Table 9. Insecticides and bio-insecticides registered for insect management in chickpea production in Canada*.

Issues for Wireworm

1. There is a need for the registration of a control agent for wireworm in chickpea.

Aster Leafhopper (*Macrosteles quadrilineatus*)

Pest Information

Damage: The aster leafhopper is a key vector of the aster yellows phytoplasma that causes yellowing and deformities of flowers and foliage. The severity of disease is dependent on the numbers of leafhoppers and the proportion of 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. Leafhoppers develop from eggs, through five nymphal stages to adults. There may be three generations per year.

Pest Management

Cultural Controls: Monitoring for aster leafhopper can be done using sticky traps and sweep nets. However no economic thresholds have been set for leafhoppers in chickpea. Tests to determine the level of aster yellows infection in leafhopper populations are unavailable. -

Resistant Cultivars: None available.

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

Issues for aster leafhopper

None identified.

Weeds

Key Issues

- There is a need for the development and communication to growers of integrated pest management strategies that include crop rotations and cultural pest management strategies for weed control in chickpea.
- There is concern over the sensitivity of chickpea to residual herbicides in the soil. Education is required to inform growers of the hazards posed by certain herbicides to this crop.

Table 10. Occurrence of weeds in Canadian chickpea production[1,2]

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: Chickpea 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 chickpea 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 sanitization				
	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 chickpea 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: Chickpea stakeholders in reporting provinces (Alberta and Saskatchewan).**

Table 12. Herbicides and bio-herbicides registered for weed management in chickpea 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 burndown, 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
flumioxazin	N-phenylphthalimide	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf and grass weeds, acetolactate synthase (ALS) resistant weeds
glufosinate ammonium + glyphosate	phosphinic acid + glycine	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	10 + 9	R + RE	most herbaceous plants
glyphosate (various salts)	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
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

…continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
paraquat	bipyridylium	photosystem-I-electron diversion	22	R[5]	annual grasses and broadleaf weeds
pyraflufen-ethyl	phenylpyrazole	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf weeds
salflufenacil	pyrimidindione	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	kochia, Canada fleabane, cleavers, lamb's-quarters, narrow-leaved hawk's beard, redroot pigweed, round-leaved mallow, stinkweed, volunteer canola, wild buckwheat, wild mustard
sethoxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual grasses, wild oats, volunteer cereals, quackgrass
sulfentrazone	triazolinone	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	wild buckwheat, kochia, lamb's-quarters, redroot pigweed, cleavers, powell pigweed, eastern black nightshade, common waterhemp, smooth crabgrass, large crabgrass, yellow wood sorrel, common groundsel, common purslane
tepraloxydim (for use in the Prairie Provinces and Peace River region of British Columbia only)	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 chickpea production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Crop dessicant					
diquat	bipyridylium	photosystem-I-electron diversion	22	R	crop desiccant
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 February 22, 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 REV2015-14, Special Review Decision: Paraquat.*

Annual Grasses

Pest Information

Damage: Chickpeas are poor competitors with weeds. If left unmanaged, weeds can cause significant yield losses, depending on density of the weed and the time of emergence of the weed relative to the crop.

Life Cycle: Annual weeds complete their life cycle from seed germination, through vegetative growth and flowering to seed production, in one year. Wild oats occur in most years. Wild millet (foxtail) is worse in years where hot, dry conditions prevail. Volunteer cereals can be more serious if harvesting problems the previous season led to shattering/spreading of harvested grain.

Pest Management

Cultural Controls: It is important to know the history of 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 seed. Deploying harvesting techniques that minimize seed loss in the cereal crop the year prior to growing chickpeas can lead to reduced populations of volunteer cereals. A fall tillage prior to freeze-up can do the same but this practice can leave the soil prone to erosion. Additional management practices for annual grass weeds are listed in *Table 11. Adoption of weed management practices in chickpea production in Canada1.*

Resistant Cultivars: None available.

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

Issues for Annual Grasses

1. There is concern with the overuse of group 1 graminicides throughout the course of the crop rotation. When the 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 are a very limited number of chemicals available for weed control in chickpeas.

Annual Broadleaf Weeds

Pest Information

Damage: Chickpeas are poor competitors with weeds. If left unmanaged, weeds can cause significant yield losses, depending on density of the weed and the time of emergence of the weed relative to the crop.

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

Pest Management

Cultural Controls: It is important to know the history of weed infestations in a field prior to planting so that heavily infested fields can be avoided. Mowing of field edges and areas surrounding saline spots will reduce the seed set of weeds such as kochia and Russian thistle. Early seeding is important to allow the crop to better compete with weeds. As with annual grasses, it is important to use clean, weed-free seed and to scout fields frequently to minimize the ingress of broadleaf weed problems. Patch treatment of weeds like kochia or Russian thistle may be practical if the weeds are located in patches in saline areas. Additional management practices for annual broadleaf weeds are listed in *Table 11. Adoption of weed management practices in chickpea production in Canada1*.

Resistant Cultivars: None available.

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

Issues for Annual Broadleaf Weeds

1. While imidazolinone-tolerant chickpea (currently under development) will provide an additional option for broadleaf weed control in this crop, it may add a layer of complexity to the management of Group 2 weed resistance.

Perennial Grasses

Pest Information

Damage: Chickpeas are poor competitors with weeds. If left unmanaged, weeds can cause significant yield losses, depending on density of the weed and the time of emergence of the weed relative to the crop.

Life Cycle: Perennial 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 weed seeds will germinate within a year, but some may remain viable in the soil for twenty years or more.

Pest Management

Cultural Controls: Where possible, fields with low weed infestations are selected for the growing of chickpeas. 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. Additional management practices for perennial grass weeds are listed in *Table 11. Adoption of weed management practices in chickpea production in Canada1a*

Resistant Cultivars: None available.

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

Key Issues for Perennial Grasses

None identified.

Perennial Broadleaf Weeds

Pest Information

Damage: Weeds compete with chickpea for moisture, nutrients and light, reducing yields.

Life Cycle: Perennial broadleaf weeds can spread by seed and by root fragments. Many species have deep, penetrating root systems from which new shoots are generated.

Pest Management

Cultural Controls: Where possible, fields with low weed infestations are selected for the growing of chickpeas. Perennial weeds are controlled in non-chickpea 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 to base decisions selection of herbicide groups , to minimize potential weed resistance problems and to prevent crop injury from herbicide carryover. Additional management practices for perennial broadleaf weeds are listed in *Table 11. Adoption of weed management practices in chickpea production in Canada1*.

Resistant Cultivars: None available.

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

Issues for Perennial Broadleaf Weeds

None identified.

Resources

IPM/ICM Resources for Production of Chickpea 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

Health Canada: Pesticides and Pest Management
http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

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. *2016 Guide to Crop Protection – For the chemical management of weeds, plant diseases and insects*
http://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/guide-to-crop-protection

Saskatchewan Ministry of Agriculture. *2016 Guide to Crop Protection – For the chemical management of weeds, plant diseases and insects – Spring Update*
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
Alberta	Alberta Agriculture and Forestry http://www.agriculture.alberta.ca/	Dr. Manjula Bandara Research Scientist manjula.bandara@gov.ab.ca	John Paul Glaves johnpaul.glaves@gov.ab.ca Ron Pidskalny Prairie Minor Use Consortium pidskalny@gmail.com
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

National and Provincial Pulse Grower Organizations

Pulse Canada
www.pulsecanada.com

Alberta Pulse Growers
www.pulse.ab.ca

Saskatchewan Pulse Growers
www.saskpulse.com

Manitoba Pulse Growers Association

www.manitobapulse.ca

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

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 10 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 pressure 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

Agriculture and Agri-Food Canada – *An Integrated approach to Manage Ascochyta blight in Chickpea* (Date modified August 9, 2013). http://www.agr.gc.ca/eng/about-us/offices-and-locations/agricultural-pest-management/agricultural-pest-management-resources/sustainable-crop-protection-factsheet-series/archived-content-an-integrated-approach-to-manage-ascochyta-blight-in-chickpea/?id=1247678986193 (accessed December 7, 2016)

Agriculture and Agri-Food Canada. *National Wireworm Species Distribution Map (2013).* http://www.agr.gc.ca/eng/?id=1300894028401

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

Alberta Agriculture and Forestry. Crops: Peas and Pulses www.agric.gov.ab.ca/app21/infopage?cat1=Crops&cat2=Peas+%26+Pulses (accessed November 29, 2016)

Alberta Agriculture and Forestry. *Grasshopper Management*. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex6463 (accessed December 19, 2016)

Canadian Grain Commission publication, Official Grain Grading Guide. https://www.grainscanada.gc.ca/oggg-gocg/ggg-gcg-eng.htm (accessed November 29, 2016)

Food and Agricultural Organization of the United Nations (Statistics) http://www.fao.org/about/en/ (accessed November 29, 2016)

Grasshopper forecasting sites:

https://www.gov.mb.ca/agriculture/crops/insects/grasshopper-forecast.html (accessed November 29, 2016)

https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/crop-protection/insects/grasshoppers/grasshopper-map (accessed November 29, 2016)
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm15609 (accessed November 29, 2016)

Government of Saskatchewan. Chickpea Crop Protection. http://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/pulse-crop-bean-chickpea-faba-bean-lentils/chickpea/crop-protection (accessed November 29, 2016)

Health Canada: Pesticides and Pest Management http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

Saskatchewan Ministry of Agriculture. *Crops: Aster Yellows* http://publications.gov.sk.ca/documents/20/84064-138085f7-6d21-41d7-8a92-f43d7f901570.pdf (Accessed December 19, 2016)

Saskatchewan Ministry of Agriculture. *Scouting and Management of Ascochyta Blight in Chickpea*. 2nd edition. 2010. http://publications.gov.sk.ca/documents/20/84063-58d8a4fa-054c-4227-b742-6d037090bf89.pdf (accessed Jan 4, 2017)

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 (accessed 29 November 2016)

Saskatchewan Pulse Growers. Chickpeas. http://saskpulse.com/growing/chickpeas-beans/ (accessed December 7, 2017)

Statistics Canada. CANSIM. http://www5.statcan.gc.ca/cansim/a33?lang=eng&spMode=master&themeID=920&RT=TABLE