Crop Profile for Canola in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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Crop Profile for Canola in Canada

Canola (family *Cruciferae*) is a genetic variation of rapeseed developed through traditional breeding by Canadian plant breeders. It was developed specifically for its nutritional qualities, particularly its low level of erucic acid in the oil, low glucosinolates in the meal and its low saturated fat. The characteristics of canola defined under Codex Alimentarius are less than 2% erucic acid that has been shown to cause fatty deposits in the hearts of test animals and less than 30 micromoles of the non-nutritive components called glucosinolates in the meal. There are three species that fit the canola definition: *Brassica napus*, *B. rapa* and a canola quality mustard, *B. juncea.*

In 1956, the nutritional aspects of rapeseed oil were questioned, especially the high concentration of eicosenoic and erucic fatty acids. In the early 1960s, Canadian plant breeders isolated rapeseed plants with low eicosenoic and erucic acid content. The Health and Welfare Department recommended conversion to the production of low erucic acid varieties of rapeseed. Effective December 1, 1973, the industry responded with a voluntary agreement to limit erucic acid content up to 5% in food products. At this time, animal nutritionists also expressed concerns about the sharp tasting, anti-nutritive glucosinolates which were affecting the meal quality of rapeseed.

In 1974, Dr. Baldur Stefansson, a University of Manitoba plant breeder, developed the first 'double low' plant variety that contained low levels of erucic acid in the oil and glucosinolates in the meal. This *B. napus* variety (Tower) was the first variety to meet the specific quality requirements used to identify a greatly improved crop known as canola. Since then, many varieties have been registered with improved yield, disease resistance and quality characteristics. In addition, canola has been developed for specialty markets with specific fatty acid profiles that have high stability (high oleic and low linolenic), reducing the need for hydrogenation, which results in low trans fat. Production of varieties containing these specialty oils is expected to increase, as the nutritional guidelines in both Canada and the U.S. require trans fat labelling of foods.

Canola produces seeds in small pods. The seeds are crushed to obtain canola oil, with seeds containing approximately 40% oil. The remainder of the seed is processed into canola meal, which is used as a high protein livestock feed. Canola is used mainly as an oil for salad dressings, food processing and frying, with the meal being marketed for livestock consumption. Lately, niche and specialty applications for the developing, high stability (non-hydrogenated) market (through production of high oleic and low linolenic varieties) and a revival of the industrial use canola market (high erucic acid) mean more markets for the crop.

Crop acreage has increased due to the success of international marketing. In the 1980's, crops averaged below 4 million tonnes. Today, there is a recognized need for 7 million tonnes of canola annually to meet market demand.

General Production Information

Canadian Production (2003)	6.669 million metric tonnes 4.689 million hectares
Farm gate value (2002)	$2,645 million
Domestic consumption (2002)	$1,709 million (oil) $70 million (meal)
Exports (2002)	$1,135 million (seed), $420 million (oil) $238 million (meal)
Imports (2002)	$80 million (seed), $21 million (oil) $690,000 (meal)

Source(s): Statistics Canada, Canola Council of Canada historical prices

Production Regions

Canola is grown primarily in western Canada, with some acreage in British Columbia, Ontario and Quebec. Saskatchewan accounts for 44% of the Canadian production, Alberta 30% and Manitoba 25%.

Cultural Practices

Selection of cropping site

Canola/rapeseed is a cool-season crop and yields highest when grown in areas where extreme heat and moisture limitations are not the norm. Fields selected for canola must be relatively free of disease, insects and hard-to-control weeds. Other factors to be considered include competition from volunteer growth from previous crops, seed separation problems and chemical residues from herbicides used on other crops in the rotation. The choice of which crops to grow and in what kind of rotation depends to a large extent on the soil and climatic conditions of a particular farm and on the grower's management skills. Crops susceptible to *Sclerotinia* should not be included too frequently in the rotation.

Land preparation process

Canola should be planted into a seedbed that is reasonably level, uniform, well packed, free from weed growth, warm, slightly lumpy on the surface and moist throughout its depth. The soil surface should have a good granular structure with 30 to 45 % fine material and the rest ranging up to 5 mm in size with only enough larger lumps to prevent wind erosion. It is also desirable to have a moderate amount of semi-rotted crop residue uniformly scattered over the surface and throughout its depth to provide protection from erosion and to reduce crusting. A firm, well-packed seedbed provides excellent soil moisture and oxygen contact with the seed.

Seeding techniques

A seeding date should allow for rapid germination and a high percent emergence. Under cold soil conditions, young canola plants are poor competitors with weeds because of their slow growth. Seeding into warmer soils later in the spring promotes rapid germination, emergence and vegetative growth. Soil temperatures greater than 10°C provide optimum germination and emergence. The variety sown should mature within the frost-free period of the area. Early seeding of canola is desirable, especially in short season areas where a killing frost in the fall could drastically affect seed development prior to maturity, or where high summer temperatures adversely affect flowering and pod development.

Production Issues

Weather drives the potential for profitability of canola crops from year to year. Adequate soil moisture is the most important factor controlling canola yield. Low temperature during the growing season, high temperatures at flowering and frost in the spring and/or early fall are also limiting factors that can reduce yields.

Table 1. Canadian canola production and pest management schedule

Time of Year	Activity	Action
October - March		Planning rotations, fall soil test and fertilizer applications if weather permits
April	Plant Care	Check field for overwintering weeds, calibrate seeder
	Soil care	Soil test
	Disease management	Arrange to have treated seed available
	Insect & mite management	Arrange to have treated seed available
	Weed management	Check field for overwintering weeds. Use preemergence herbicide if required
May	Plant care	Seed crop
	Soil care	Fertilize to recommended soil test
	Disease management	Seed the crop with seed treatments for seedling diseases
	Insect & mite management	Check for cutworms, flea beetles
	Weed management	Identify and scout weeds
June	Plant care	Walk fields and monitor for problems
	Insect & mite management	Check for cutworms, set up bertha armyworm traps
	Weed management	Spray if necessary for broadleaf weeds and patch treat for perennials if practical
July	Disease management	Scout for sclerotinia, blackleg. Monitor provincial forecasts for these diseases.
	Insect & mite management	Monitor and spray for Bertha armyworm, diamondback, moth, grasshoppers and cabbage seed pod weevil if necessary
	Weed management	Follow up on weed problems and observe results from control efforts
August	Plant care	Prepare for harvest
	Insect & mite management	Monitor flea beetle numbers for predicting next year's risk
September	Weed management	Check for winter annual germination and treat or till if necessary

Table adapted from BC Ministry of Agriculture, Food and Fisheries strawberry crop profile
Source(s): Canola Council of Canada Growers Manual

Abiotic Factors Limiting Production

Key Issues

- A better understanding of the benefits from specific fertilizers under various weather scenarios and with new varieties is needed.
- More information on the impact of frost on canola seedlings and their ability to recover under different conditions is required.
- There is a need for research on factors that optimize plant stand establishment.

Soil Moisture and In-season Rainfall

Stored soil moisture and in-season rainfall are the most important weather factors affecting canola growth. For maximum yields, crops in black and gray-wooded soils require 325 to 350 mm (13 to 14 in.) of water. In most of the thin black and gray-wooded soil zones, the rainfall during the growing season normally exceeds 250 mm. Additional moisture stored in the soil may result in higher yields. In these areas, canola can be grown successfully as a stubble-in crop. Canola crops grown in cooler, more humid areas require less moisture than those grown in warmer, drier areas.

Low Temperatures

Canola is sensitive to cold soil temperatures that greatly reduce the speed of germination. Germination and emergence in the field is slower by at least 1 to 2 days at 9°C and 4 to 5 days at 3°C. Field trials with cold soil temperatures (3.7°C and lower) showed seedlings required up to 18 days to emerge. Cooler spring soils can result in a higher disease incidence on seeds and seedlings. However, early seeding may also result in the crop maturing in early fall before fall frosts. Frost causes the plants to stop metabolizing and can result in immature or green seeds, reducing the grade and quality of the crop.

High Temperatures

Although canola is reasonably adapted and performs well in many areas under variable temperatures, it is sensitive to high temperatures during flowering. Seeding early can reduce the chances of the crop flowering during the hottest part of the summer. There are differences between *B. napus, B. rapa* and *B. juncea* in terms of their yield under both good and adverse conditions.

Crop establishment

Crop establishment continues to be a challenge for growers, as farm size increases and the crop is seeded earlier to optimize yield. Although canola has a great ability to compensate for low plant stands and injury resulting from low temperatures in early spring, a uniform, adequate plant stand is important for pest management later in the season and to optimize yield and quality. Any management practice or pest problem that delays the crop, increases the risk of problems due to delayed maturity.

Diseases

Key Issues

- There is a need for research on the epidemiology of *Fusarium* wilt and the development of a varietal screening test for resistance to this disease.
- The development of a fungicide or a biofungicide for the control of *Fusarium* wilt is required. Currently, there are no registered products.
- There is a need to develop a biological control for *Sclerotinia* stem rot and blackleg.
- Blackleg resistance in canola lines needs to be monitored to ensure that resistance does not break down; canola breeders need to stay ahead of the changes in strain types.
- An improved system for forecasting *Sclerotinia* stem rot is necessary. Disease development is weather dependent and current forecasting systems are not accurate.
- There is a need to monitor new and emerging diseases, such as clubroot and *Fusarium* wilt, to ensure that severe problems do not develop.
- The development of a comprehensive, integrated approach to *Alternaria* black spot is needed, including the development of varieties with resistance to the disease.

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

	Degree of occurrence					
Major Diseases	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Blackleg (Races PG1 and PG2)	E	E	E	E	E	E
Blackleg (Race PG3)	D	D	D	D	D	D
Sclerotinia stem Rot	E	E	E	E	E	E
Seedling Disease Complex	E	E	E	E	E	E
Fusarium Wilt	D	E	E	E		
Lesser Diseases	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Brown girdling root rot	E	E				
Alternaria black spot	E	E	E	E	E	E
Downey mildew	E	E	E	E	E	E
White rust	E	E	E	E	E	E
Aster yellows	E	E	E	E	E	E
Clubroot		D			E	E

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): The diseases of canola and their status in Canada

Major diseases

Blackleg (*Leptosphaeria maculans*)

Pest Information

Damage: The fungus attacks the cotyledons, leaves, stems and pods. The weakly virulent form (PG1) usually infects plants near maturity, resulting in shallow stem lesions and rarely extended, girdling cankers. The highly virulent form of the fungus (PG2) attacks the crop earlier in the season. If basal infection begins early, stem cankers appear from flowering onwards. As the season progresses, cankers penetrate, deepen and may girdle stem bases, often completely severing the plant. By mid-July, plants may start falling over. Less severely affected plants remain standing but ripen prematurely and have shriveled seeds and pods due to the restricted moisture and nutrient flow. Two new groups of blackleg, virulent PG3 and PGT of blackleg have been detected in western Canada.

Life Cycle: Airborne spores produced on residue are the main source of infection in subsequent crops. Pin-head sized, black fruiting bodies called pycnidia develop in lesions that are produced on cotyledons, leaves, stems and pods. Under moist weather conditions, pycnidia release conidia (spores) that may infect and cause new lesions or cankers on all the above-ground parts of the plant. Infected seed is the cause of spread over long distances.

Pest Management

Chemical Controls: Propiconazole, a foliar systemic fungicide is available for use against blackleg. Propiconazole however, will not control blackleg for the entire season because the disease continuously reinfects canola plants throughout all stages of growth. The fungicide is not commonly used as most growers have had success with the use of resistant varieties.

Cultural Controls: Burying canola residues in the fall reduces the amount of overwintering inoculum. Fall burial of crop residues and direct seeding of a cereal crop the following spring avoids re-exposing the residue, but should be done only in situations where soil erosion is not a problem. Cruciferous weeds should be controlled in cereal crops. A minimum of three years of non-susceptible crops should be grown before canola is planted again.

Alternative Controls: For growers in areas with no blackleg, the introduction of the disease should be avoided by the use of disease free seed. Seed should be treated with a fungicide treatment.

Resistant Cultivars: There are many varieties available that are moderately resistant or resistant.

Issues for Blackleg

1. The development of *L. maculans* needs to be monitored so that immediate action can be taken if new or resistant strains develop.
2. The new PG3 and PGT groups of *L. maculans* need to be studied to identify the impact these races will have on the crop and control methods currently available.
3. To keep the disease in check, sound disease management practices, such as crop rotation, must continue to be practiced by all growers.
4. The development of resistant varieties is essential.

Sclerotinia Stem Rot (*Sclerotinia sclerotiorum*)

Pest Information

Damage: The severity of stem rot varies from year to year and from field to field within a region. The severity of stem rot symptoms and the resulting effect on yield varies according to temperature, rainfall, crop density and the stage of crop growth at the time of infection. Extreme cases are rare. Severe disease may occur however when conditions are favourable to infection throughout the flowering period, when they have the potential to cut yields in half.

Life Cycle: Infection occurs during bloom. The amount of disease that develops will vary depending on the quantity of infectious spores, plant population, crop height and vigor, rainfall, soil moisture and temperature.

Pest Management

Chemical Controls: Spraying foliar fungicides during flowering can control the disease. Protection of the crop is necessary only during flowering, because of the critical role petals play in infection. Registered fungicides include iprodione, vinclozolin, azoxystrobin and boscalid.

Cultural Controls: A rotation of at least 4 years out of susceptible crops (bean, sunflower, mustard, lentil, field pea, faba bean, alfalfa, clover, carrot and potato) should be used. Planting non-susceptible crops, such as cereals and grasses, will bring about a reduction of viable sclerotia in the soil through decay or germination in the absence of susceptible hosts. Sowing canola adjacent to fields in which a heavily infected crop was present the previous year should be avoided. A seed source free of sclerotia should be used in areas where the disease has not been a problem. Burying infected plant residues may reduce the production of apothecia in the subsequent crop. To keep sclerotia buried, minimum and shallow tillage should be used for cereals sown in fields where infected canola stubble has been worked in and buried.

Alternative Controls: Spray/no spray decisions can be made on the basis of prediction checklists and forecasting maps that are distributed by the Canola Council of Canada and by provincial extension services. A petal test kit is available to determine if the disease is present, but it can be ineffective at forecasting disease since by the time the test results are available, the time for taking action is often past.

Resistant Cultivars: There are no varieties with resistance to *Sclerotinia*. Apetalous canola, (canola with no petals) will develop less disease because they have no locus of infection (petals), a key point in the development of the white mold.

Issues for Sclerotinia Stem Rot

1. Techniques for predicting *Sclerotinia* infection need to be improved. Current models depend on weather and provide only a crude indication of the potential for disease.
2. Educational tools are needed so that growers can better recognize and deal with the disease. In some areas, growers are less familiar with the disease.

Seedling Disease Complex (*Rhizoctonia solani, Fusarium* spp., *Pythium* spp. and others)

Pest Information

Damage: Poor stand establishment may be caused by a seedling disease complex. Seedling disease results in seed decay, pre- and post-emergence damping-off, seedling blight and seedling root rot. The problem is greatest under cold conditions or when the seedbed is not firmly packed and conditions are dry and cool. The disease complex is most often a problem in the north-western prairies, where soil temperatures remain low for prolonged periods of time. The greatest losses come from seeding early into cold soils and from deep seeding. Fertilizer placed with the seed may delay or reduce germination and emergence, prolong the period of susceptibility and increase infection. Inadequate or unbalanced nutrients also favour the disease complex fungi.

Life Cycle: The fungi causing seedling disease are soil borne.

Pest Management

Chemical Controls: Several fungicidal seed treatments are available and offer some protection against disease. The fungicide package Prosper© contains metalaxyl, carbathiin and thiram. Metalaxyl is a systemic control for *Pythium*. Carbathiin (systemic fungicide) and thiram (contact fungicide) control the rest of the seedling disease causing fungi. Thiram also has activity on *Pythium* in addition to other diseases. The fungicide packages of Helix and Helix Xtra contain 3 active ingredients: (1) difenoconazole (triazole chemistry), which is systemic and is active against *Fusarium*, *Rhizoctonia* and seed-borne blackleg, (2) fludioxonil (phenylpyrolle chemistry), which is a contact fungicide active against *Fusarium*, *Rhizoctonia* and seed-borne *Alternaria* and (3) metalaxyl-M (phenylamide chemistry) which is systemic and active against *Pythium*.

Cultural Controls: Seeding should be done when conditions are favourable for quick emergence and growth (warm soils, adequate moisture). Soil temperatures below 10°C delay germination and emergence, reduce growth rates and vigour of seedlings and prolong the period of seedling susceptibility. Placing harmful quantities of fertilizer with seed should be avoided. Deep seeding, poor seed quality, seeding into a cold, wet, dry, crusty seedbed, toxic herbicide residues, flea beetle injury and placement of excessive fertilizer with the seed should all be avoided.

Alternative Controls: None identified.

Resistant Cultivars: There are no available, resistant varieties.

Issues for Seedling Blight

1. As growers seed earlier to maximize yield, there have been more reports of crop establishment issues that are sometimes caused by seedling diseases. More research is needed to evaluate the balance between seeding early and avoiding seedling diseases.
2. A canola seedling diagnostic tool is under development to assist agronomists and growers in diagnosing seedling problems. There is a need for the continued support of the development of this important tool.
3. Greater understanding is required of the impact of residual herbicides on the incidence of seedling disease complex.

Fusarium Wilt (*Fusarium avenaceum* and *Fusariun oxysporum*)

Pest Information

Damage: The disease was first observed in the north-east agricultural regions of Alberta and has since been found in the Peace River Region, Saskatchewan and Manitoba. The disease can cause up to 30% yield loss. Symptoms include chlorosis and necrosis of stems, vascular discoloration, poor seed set and premature ripening. Stems and/or branches turn reddish-brown, but plants remain upright with roots intact. Infected plants are often stunted and have small pods with no seeds. Plants with minor infections may ripen prematurely and tend to shatter.

Life Cycle: Information on the life cycle and spread of this new disease is being developed.

Pest Management

Chemical Controls: None

Cultural Controls: Encouraging rapid emergence helps to manage the disease. Good disease prevention measures, such as rotations, *Brassica* weed control in cereal crops and the control of annual weeds in crop borders and headlands, helps to minimize *Fusarium* wilt. Placing harmful quantities of fertilizer with seed should be avoided. Inadequate or unbalanced nutrients also favour the disease complex.

Alternative Controls: None identified.

Resistant Cultivars: While data is limited, many varieties appear to have resistance. Resistant varieties include DKL 3235, Hyola 454, Nexera 710, Q2, Quantum and 46A76. Varieties including 45A55, DS Roughrider, Nexera 705 and DKL33-45 are considered to be susceptible.

Issues for Fusarium Wilt

1. An integrated pest management approach needs to be developed to control the disease.
2. Although there are some resistant varieties, screening tests need to be developed to predict resistance in the field.

Minor diseases

Brown Girdling Root Rot (*Rhizoctonia solani* and *Fusarium spp.*)

Pest Information

Damage:. This soil-borne disease is believed to be caused primarily by the fungus *Rhizoctonia solani*, with secondary infections by *Fusarium* spp. Infection levels may reach 80-100% in some fields, with losses approaching 50%. Taproots are affected, being shortened by girdling caused by the growth and coalescence of sunken lesions well below the soil line. Affected plants may ripen prematurely, often before seed is set. Girdled plants often die due to uprooting by wind or from desiccation. The disease is found on all soil types in the Peace River Region of Alberta and B.C.

Life Cycle: The root rot pathogens are soil borne. Losses are highest when wet soil conditions occur at early flowering, followed by dry weather later in the season.

Pest Management

Chemical Controls: None

Cultural Controls: Seeding shallowly into a firm, moist seed bed helps reduce the disease. Optimal soil fertility, including balanced levels of phosphorus, potassium and nitrogen, will help to minimize yield losses. A three to four year crop rotation, that includes cereals should be used. Weeds of the mustard family and volunteer plants should be controlled to help prevent a build-up of the root pathogens in the soil.

Alternative Controls: None identified.

Cultivar Resistance: B. rapa varieties are generally more susceptible than *B. napus* varieties. should be used in suitable regions.

Issues for Brown Girdling Root Rot

1. Improved breeding technology is needed to enable the development of resistant varieties.

Alternaria Black Spot (*Alternaria brassicae* and *A. raphani*)

Pest Information

Damage: Black spot (*Alternaria brassicae* and *A. raphani*) is common in canola in western Canada. With heavy infection, pod shattering and seed shrinkage may occur, resulting in severe damage. Yield losses can be greater than 20%. For each 1% of pod and stem surface affected by black spot, a 1% yield loss can be expected.

Life Cycle: These fungi survive and can overwinter on infected crop residue, seed and cruciferous weeds. Spring infections on plants begin directly from infested seed or from spores produced on crop residue or diseased cruciferous weeds. The disease is favoured by warm and humid conditions. Spores, produced in lesions are spread by wind and they cause further infection. Seeds may become infected following development of lesions on the pods. It is not uncommon for 20% or more of the seeds to be infested in seed lots from northern growing areas.

Pest Management

Chemical Controls: The fungicide fludioxonil (phenylpyrolle chemistry) has contact activity against seed-borne *Alternaria*. Iprodione and azoxystrobin can be used as foliar fungicides near flowering to control the disease.

Cultural Controls: Diseased stubble should be incorporated into the soil if canola is to be grown on an adjacent field the following year. A crop rotation with at least three years of non-cruciferous crops between canola crops will reduce air-borne spores from crop residue. Cruciferous weeds and volunteer canola should be controlled during the rotation. Planting well-cleaned seed that is free of small, shrunken and infected seed will reduce seed-borne transmission. Early swathing of badly infected crops may prevent serious losses from shattering.

Alternative Controls: None identified.

Resistant Cultivars: B. rapa varieties of canola are more susceptible than *B. napus* cultivars.

Issues for Alternaria Black Spot

1. There is a need for a systemic seed treatment.

2. The development of management tools for the disease on pods before harvest is needed for years with high levels of disease.

Staghead or White rust (*Albugo candida*), Downy mildew (*Peronospora parasitica*)

Pest Information

Damage: These two diseases are found in almost constant association with each other. Downy mildew also appears alone on infected seedlings and leaves of the rosette stage of *B. rapa* during periods of cool, wet weather in the spring. The disease appears as a white growth on the lower surface of leaves and on green stagheads, which are caused by the white rust fungus. The most obvious symptom of white rust is the swollen, twisted and distorted inflorescences named "stagheads" that become brown, hard and dry as they mature.

Life Cycle: The staghead fungus overwinters as resting spores in decaying, infected plant tissues (mainly stagheads) or as a seed contaminant. Spores may remain dormant in soil or on seed for a number of years. In the spring spores germinate and infect the cotyledons and leaves of young susceptible plants. These infections develop and white pustules are formed on the underside of leaves or on stems. The pustules release chalk-like, air-borne spores that can spread the disease to other parts of the plant or to nearby plants and cause secondary infections on leaves, stems or flower buds. Stagheads develop from infected flower buds. At harvest, stagheads may be broken during threshing resulting in contamination of the seed with resting spores. The disease cycle of downy mildew is similar to that of staghead, however it does not cause growth distortions.

Pest Management

Chemical Controls: None

Cultural Controls: Only certified, disease free seed should be planted. A crop rotation with at least three years between canola crops should be used. The rotation should include non-cruciferous crops. All volunteer canola, stinkweed, wild mustard and other cruciferous weeds should be controlled throughout the rotation.

Alternative Controls:

Resistant Cultivars: These diseases affect primarily the *B. rapa* variety. Some varieties of *B rapa* have resistance to staghead, but there are two strains of the disease and not all varieties are resistant to both strains.

Issues for Staghead and Downy Mildew

1. There is a need to develop varieties resistant to both diseases.

Aster yellows (aster yellows phytoplasma)

Pest Information

Damage: Generally less than 2% of canola plants are infected. Infected plants produce blue-green, sterile, hollow bladders in place of normal pods or fail to produce pods altogether.

Life Cycle: Aster yellows overwinters in perennial host plants and is spread primarily by the six-spotted leafhopper. Once infected, the leafhopper can spread the disease continuously as long as it lives. The six-spotted leafhopper overwinters in the United States and migrates north each spring. The prevalence of aster yellows varies with the abundance of this leafhopper.

Pest Management

Chemical Controls: There are no pesticides registered for the control of aster yellows. However, the insecticide dimethoate can be used to control the leafhopper.

Cultural Controls: There are few management options available for field crop protection from aster yellows. Seeding crops in the fall or as early in the spring as possible, may help to avoid or delay infection as the crop has a chance to mature earlier, making it less attractive to migrating leafhoppers. The control of perennial weeds in the immediate area can help reduce the sources of the aster yellows phytoplasma in close proximity to the crop.

Alternative Controls: Monitoring for leafhoppers and early detection by scouting in the field are important.

Resistant Cultivars: There are no varieties with resistance to aster yellows.

Issues for Aster Yellows

None identified

Clubroot (*Plasmodiophora brassicae*)

Pest Information

Damage: The disease was first identified in Alberta in 2003. Galls appear on the roots of infected plants, ranging in size from tiny nodules to large club-shaped outgrowths that may involve most of the root system. The galls are at first firm and white, but become soft and grayish-brown as they mature and decay. With severe infection, most of the taproot is destroyed, causing plants to become stunted and wilt under moisture stress.

Life Cycle: The pathogen survives in the soil for many years in the form of spores. The roots of susceptible crops stimulate the spores to germinate and release motile zoospores which infect rootlets. The infection induces abnormal plant cell growth and the formation of root swellings.

Pest Management

Chemical Controls: None

Cultural Controls: Due to the longevity of spores in soil, fields that have been infected must be kept free of susceptible crops for many years. Cultivation equipment from infested fields should not be used in non-infested areas without first being thoroughly cleaned. The application of lime may help reduce the severity of disease on acidic soils. Canola growers should be alert for symptoms in areas where the disease is a problem in other crucifers. Crop rotation is very important in managing this disease.

Alternative Controls: None identified.

Resistant Cultivars: None identified.

Issues for Clubroot

None identified

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
azoxystrobin	Strobilurine fungicide	11	RR	Sclerotinia stem Rot	A	
				Alternaria blackspot		
				Blackleg		
boscalid	Anilidefungicide	7	RR	Sclerotinia stem Rot	A	
carbathiin	Anilide fungicide	7	R	Seedling diseases	A	
difenoconazole	Conazole fungicide (Triazole)	3	R	Seedling diseases	A	
fludioxonil	Pyrrole fungicide	12	RR	Seedling diseases	A	
iprodione	Dichlorophenyl dicarboximide fungicide	2	R	Sclerotinia stem		
				Seedling diseases	A	
metalaxyl	Acylamino acid fungicide	4	R	Seedling diseases	A	
propiconazole	Conazole fungicide (Triazole)	3	R	Blackleg	I	Only provides partial control of the disease.

(continued)

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
thiram	Dithiocarbamate fungicide	M2	RE	Seedling diseases	A	
vinclozolin	Dichlorophenyl dicarboximide fungicide	2	R	Sclerotinia stem Rot	A	

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

Sources(s): Canola Council

Table 4. Availability and use of disease pest management practices for Canadian canola production

	Practice \ Pest	Black leg	Sclerotinia	Seedling disease complex	Fusarium Wilt	Club root
Prevention	tillage					
	residue removal / management	available/used	available/used			
	water management					
	equipment sanitation					available/used
	row spacing / seeding depth					
	removal of alternative hosts (weeds/volunteers)	available/used			available/used	
	mowing / mulching / flaming					
Avoidance	resistant varieties	available/used	not available	not available	available/used	not available
	planting / harvest date adjustment			available/used		
	crop rotation	available/used	available/used		available/used	available/used
	trap crops - perimeter spraying					
	use of disease-free seed	available/used	available/used			
	optimizing fertilization			available/used	available/used	
	reducing mechanical damage / insect damage					
	thinning / pruning					
	choice of planting site		available/used			
Monitoring	scouting - trapping		available/used			
	records to track pests					
	field mapping of weeds					
	soil analysis					
	weather monitoring for disease forecasting		available/used			
	grading out infected produce					
Suppression	use of thresholds for application decisions		available/used			
	biological pesticides					
	pheromones					
	sterile mating technique					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management					
	ground cover / physical barriers					
	controlled atmosphere storage					
	forecasting for applications					
	innovative techniques					
	pest specific pesticides / consideration of beneficials					

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Information in the crop profile for individual pests

Insects and Mites

Key Issues

- Reduced risk alternatives to synthetic pyrethroids, organophosphates and carbamates are needed.
- Effective biological control options are needed for key pests, such as grasshoppers, diamondback moths, bertha armyworms, lygus bugs and flea beetles.
- There is a need for a flea beetle prediction system and biological options for management.
- Decision making tools for managing alfalfa looper and root maggot are needed.
- There is a need for more information on the biology and impact of newer insect pests (such as lygus bugs, cabbage seedpod weevil and root maggot) so that a better understanding of economic thresholds and best control techniques can be developed.
- There is a concern that although there are economic thresholds for most pests, thresholds for multiple pests in the same field are not available.

Table 5. Degree of occurrence of insect pests in Canadian canola production

	Degree of occurrence					
Major pests	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Flea beetle	E	E	E	E	E	E
Bertha armyworm	E	E	E	E	E	E
Diamondback Moth	E	E	E	E	E	E
Grasshopper	E	E	E	E	E	E
Cutworm	E	E	E	E	E	E
Root Maggot	E	E	E	E	E	E
Seed pod weevil	E	E	E	E	E	E
Lygus bug	E	E	E	E	E	E
Minor pests	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Alfalfa Looper	E	E	E	E	E	E
Beet Webworm	E	E	E	E	E	E
Aphid	E	E	E	E	E	E
Red Turnip Beetle	E	E	E	E	E	E

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): Canola Council

Major Insects and Mites

Flea Beetle (*Phyllotreta* spp.)

Pest Information

Damage: Damaged plants typically have a "shot-holed" appearance. Canola seedlings can withstand up to 50% leaf area removal in the cotyledon stage under good growing conditions without a significant reduction in yield. With heavy attacks, seedlings may wilt and die, particularly when feeding is combined with poor plant growth during hot, dry weather. If growing conditions are good and there is adequate soil moisture, canola can often outgrow a moderate attack from the flea beetle with no reduction in yield. When the crop passes the seedling stage, damage does not usually occur.

Life Cycle: Flea beetles have a single generation each year. They overwinter in areas such as windbreaks, leaf litter, under hedges and in wooded areas, leaving their winter hibernation sometime between April and early May. In the spring, flea beetles feed on volunteer canola, mustard or on weeds such as wild mustard, flixweed and peppergrass, then move to newly emerged canola seedlings. Feeding is heaviest from May to late June. Larvae are present from mid June to early July and feed on the roots of the developing canola crop. Adults emerge in early August and begin to feed on green tissue of canola, mustard or cruciferous weeds. Adults can continue to feed until mid October, but by mid September, most adults have entered a dormant, overwintering stage. Sunny, warm and dry weather increases feeding activity, while cool, damp weather slows flea beetle activity and promotes plant growth.

Pest Management

Chemical Controls: thiamethoxam, acetamiprid, clothanidin, imidacloprid.

Cultural Controls: Early seeded crops are less affected by the beetles. When flea beetle populations are high, there are no cultural controls that will effectively reduce their attack. Delaying cultivation on adjacent summerfallow fields with cruciferous weeds and volunteer canola will delay the movement of the beetles into canola. The crop should reach the four-leaf stage before major tillage operations are done on adjacent fields.

Alternative Controls: None identified

Resistant Cultivars: None

Issues for Flea Beetle

1. There is a need for a reduced risk insecticide or an insecticide with a different mode of action than the organophosphates, carbamates and synthetic pyrethroids currently available, for flea beetle control.
2. An improved forecasting system for flea beetles is needed.
3. The education of growers on the selection of seed treatments and the forecasting of flea beetles is required.
4. There is a need to develop a biological control strategy for flea beetles.
5. The development of the resistant varieties is needed.

Grasshopper -predominantly the Two Striped Grasshopper (*Melanoplus bivittatusand*) and Clearwinged Grasshopper (*Camnula pellucida*)

Pest Information

Damage: Drier areas, such as southern Alberta, are more prone to recurring grasshopper problems, but infestations can occur throughout all canola growing regions. Grasshoppers are a serious problem as they can eat 30 to 100 mg (dry weight) of plant material each day and under the right conditions can grow quickly. Temperature, rainfall and snowfall impact the severity of an outbreak. A smaller grasshopper population present under hot and dry conditions may do as much damage as a large population under cool and wet conditions.

Life Cycle: Grasshoppers overwinter as eggs, in the ground usually in headlands and uncultivated areas. The eggs hatch in the spring and nymphs begin to feed on emerging plants. Adults develop later in the season and also feed on crop plants. Following mating, eggs are laid in the soil for the next generation. Drought can delay egg hatching and even destroy eggs, especially at certain critical stages just before hatching. Cool, wet weather is preferable for the control of the pest as it hinders development and increases the possibility of disease in the grasshopper population, which will have a significant impact on the following year's population.

Pest Management

Chemical Controls: Malathion, chlorpyrifos, cypermethrin, methamidofos, dimethoate and lambda cyhalothrin are registered.

Cultural Controls: Early seeding, crop rotation, tillage and the use of trap strips, can all help in the control of grasshopper populations. Cultivation of fields in the fall may help control grasshoppers by exposing some of their eggs to predation, sun, wind and frost. Deep tilling will bury the eggs so deep that nymphs cannot reach the surface when the eggs hatch.

Alternative Controls: In recent years in the U.S., the use of protozoans such as *Nosema locustae and Malameba locustae* is being investigated. However, to date, none of these methods have been advanced for use in canola.

Resistant Cultivars: None.

Issues for Grasshopper

None identified

Bertha armyworm (*Mamestra configurata*)

Pest Information

Damage: The Bertha armyworm is one of the most significant insect pests of canola in Canada. Severe infestations can occur throughout most of it's range, but epidemics are usually limited to the parkland area of the Prairies and the Peace River region of British Columbia and Alberta. Outbreaks usually occur every 5-7 years depending on the region and weather conditions. Populations can increase dramatically if the natural controls fail, potentially damaging a wide variety of crops. In extreme situations, infestations of more than 1,000 larvae per m^2 have been reported, while densities of 50 to 200 larvae per m^2 may be common. Infestations may be localized or spread over millions of acres.

Life Cycle: Bertha armyworms develop through four distinct stages: adult, egg, larva and pupa. Adult moths emerge from early June to early August and lay eggs on the lower surface of leaves. The larvae feed and develop for six weeks and then burrow into the soil in the late summer or early fall to pupate. In Canada, there is one complete generation per year.

Pest Management

*Chemical Controls: D*eltamethrin, cypermethrin, methomyl, chlorpyrifos and methamidofos.

Cultural Controls: The trend toward reduced tillage and stubble conservation has resulted in more snow accumulation on infested fields and may favour Bertha armyworm survival, especially in years with early snowfall. Fall cultivation can kill many pupae mechanically. Tillage can decrease the survival of armyworms by reducing the amount of snow trapped on a field and exposing pupae to sub-zero temperatures over the winter. To be effective , this practice must be adopted by all producers in a region as adult moths are strong flyers and can easily move to adjacent fields. The presence of Bertha armyworm larvae in a crop one year is not a reliable indicator of what to expect the following year, as populations fluctuate widely from year to year.

Alternative Controls: The nuclear polyhedrosis virus, ichneumonid wasp (*Banchus flavescens*) and the tachinid fly (*Athrycia cinerea*) are used as biocontrol agents. The use of cultural practices and monitoring techniques minimize the need to spray. Larval monitoring in each field should begin about two weeks after peak trap catches and continue until the number of larvae exceed economic thresholds and the crop is sprayed, or until it is swathed.

Resistant Cultivars:

Issues for Bertha Armyworm

1. Early detection of Bertha armyworm infestations is necessary to prevent widespread losses and problems due to temporary insecticide shortages.
2. Although biological control agents have been identified, they are not effective enough during an outbreak. Commercial biocontrol agents need to be developed.

Diamondback Moth (*Plutella xylostella L.*)

Pest Information

Damage: Infestation levels vary greatly from year to year. Damage caused by young larvae is characterized by irregular holes and surface stripping on the undersides of leaves, as well as small white mines on leaves. Yield reduction due to leaf area lost is probably minimal except in the most extreme cases. Older larvae may feed on flowers, young pods and on the surface tissue of stems and mature pods, usually from mid July until early August. Damage is due to feeding on the surface of filling and maturing pods, causing pods to be filled improperly. In severe cases, damage can be seen from a distance as an abnormal whitening.

Life Cycle: The moth is carried into Canada from the United States on northerly winds in early May and June. The number of spring migrants and their establishment is weather dependent. The moth feeds on wild flowers at dusk and mates and lays eggs after dark. In the main canola growing areas, most of the canola crops will not have emerged early enough to be affected by the initial arrival of the moths. Older larvae, present from mid-July until early August, have a greater potential to cause damage. After an infestation has been controlled in a podded crop, a new infestation is not likely to become established because of the rapid advance of the crop toward maturity.

Pest Management

*Chemical Controls: D*eltamethrin, chlorpyrifos, malathion and trichlorfon.

Cultural Controls: Tillage and/or herbicides can reduce the availability of cruciferous weeds and volunteer canola host plants, preventing the successful establishment of the first generation of the larvae where moths arrive before canola emergence.

Alternative Controls: The use of economic thresholds is important, as only severe infestations of small caterpillars will cause economic damage. An economic threshold has been set at 200-300 larvae per square metre (19-28 per square foot). Control at the lower end of the threshold should be considered if leaves are beginning to turn yellow and dry up, as larvae will tend to feed more heavily on the pods.

Resistant Cultivars: None.

Issues for Diamondback Moth

1. It is important to detect infestations early enough to allow sufficient time to apply chemicals before severe damage occurs.
2. There is concern over temporary insecticide shortages that can occur when suppliers are not aware of potential outbreaks.
3. The development of biological control agents is needed.
4. There is a need to monitor resistance of diamondback to insecticides as the pets is exposed to multiple applications in the U.S. where it originates.

Cutworm - red-backed (*Euxoa ochrogaster*) and pale western (*Agrotis orthogonia*)

Pest Information

Damage: The pale western cutworm is of greatest concern in the southern, more open prairie areas, while the red-backed cutworm is of concern in the park belt and northern agricultural areas of the Prairie provinces. Young, red-backed cutworms chew holes and notches in leaves, whereas older larvae and the larvae of the pale western cutworm, eat into the stems and usually sever them at or just above, the soil surface. Cut plants can be found drying up and lying on the soil surface. Areas of bare soil where patches of crop have started to disappear characterize infestations. These patches gradually enlarge until anywhere from an acre to entire fields are destroyed. The first signs of damage usually appear on hilltops, south-facing slopes or in areas of light soil which normally warm faster.

Life Cycle: Cutworms overwinter as tiny eggs that are laid in the fall. In April and early May, the eggs hatch and the young larvae feed, mainly at night, on weeds and volunteer plants. The young larvae of both species pass through six development stages. Late May and the first three weeks of June are the most likely times for cutworm activity (seedling to rosette stage). After the cutworms finish their growth, usually in late June, they burrow deeper into the soil to pupate. Adult moths emerge from the soil in August to early September. After mating, the pale western moths lay eggs on, or just below, the surface of loose, dry soil. Red-backed cutworm moths lay eggs in weedy stubble or fallow fields. There is one generation per year.

Pest Management

*Chemical Controls: P*ermethrin and chlorpyrifos are used to control cutworms.

Cultural Controls: Summerfallow fields that have a protective crust through August and the first half of September are much less attractive for egg laying by pale western cutworms.

Therefore, summerfallow fields should be worked in late July and allowed to harden by summer rains. In the spring, a delay of 10 to 14 days between cultivation and seeding can help reduce populations, as larvae that have already fed will die if deprived of food for several days.

Alternative Controls: Cutworm control may only be necessary in small areas of the field, when bare patches appear and large numbers of cutworms are still actively feeding.

Resistant Cultivars: None.

Issues for Cutworm

1. Since 2001, cutworms seem to be on the increase. It is not clear at this time if this is due to normal population fluctuations, management practices or the loss of lindane as a seed treatment. The situation needs to be monitored and addressed if needed.

Root Maggot (*Delia* spp.)

Pest Information

Damage: Maggots inhabit roots of canola plants that are bolting, in flower or in the early pod ripening stages. Plants severely infested with maggots can turn pale green and appear stunted and wilted, especially on hot days. Root rot fungi invade roots damaged by larval tunneling. Infestations have been most severe in central and northwestern Alberta, where 95-100 % of plants in a field are frequently infested to some degree by root maggots. Yield losses can be as high as 52 % for crops of *B. rapa* and 20 % for crops of *B. napus*.

Life Cycle: Root maggots overwinter as pupae about 5-20 cm beneath the soil surface. Adult flies emerge from early May through July. Eggs are laid in June, most commonly beneath the soil surface near the base of the plant. Occasionally eggs are also laid on the lower stems and leaves of canola plants. During their 5-6 week life span, females lay 50-200 oval white eggs, either singly or in small masses. Small, white, legless larvae (maggots) hatch in 3-5 days and then eat their way through canola roots, creating feeding tunnels. The maggots mature in about 3 weeks and measure 6-10 mm in length. Mature maggots pupate in the soil from late July to mid-August. Root maggots have one generation per year.

Pest Management

Chemical Controls: None

Cultural Controls: Tillage prior to seeding reduces the survival of overwintering root maggot pupae by up to 60 %. For areas with longer growing seasons or if seeding can be done early in spring, then *B. napus* is a better choice than *B. rapa*. In areas with a shorter growing season, seeding *B. rapa* at higher rates (approximately 10 kg/ha rather than 5.6 kg/ha) also reduces root maggot damage. Increasing row spacing when seeding to about 25-30 cm reduces damage to canola.

Alternative Controls: Female root maggots select plants with large basal stems (those planted at lower densities) for oviposition. Hence, seeding at higher densities will help to reduce damage.

Resistant Cultivars: Varieties of *B. rapa* are more susceptible than *B. napus* varieties.

Issues for Root Maggots

1. Data on the economic impact of this pest is not complete. A better understanding is needed as to whether canola production techniques on their own are sufficient for the crop to survive and yield well even if infestations are present.
2. Reduced risk chemistries and varietal resistance are needed to supplement agronomic control techniques.

Lygus Bug (*Lygus lineolaris*, *L. borealis*, *L. elisus* and *L. keltoni*)

Pest Information

Damage: Lygus bugs have piercing-sucking mouthparts and physically damage plants by puncturing the tissue and sucking plant juices. Adults feed actively on the bases of canola buds and flowers causing blasting. Feeding lesions may occur on the surfaces of stems, buds, flowers and pods. Lesions on stems and pods are characterized by brown raised areas. Canola buds and flowers attacked by Lygus turn white within 24 hours and are shed soon afterwards. When pods develop in late July and early August, older nymphs and adults can puncture the pods and suck out the contents of the developing seeds. Seeds affected by Lygus may have small ruptures in the seed coat or in cases of severe damage, may be completely or partially collapsed.

Life Cycle: Adults overwinter under debris or within plant cover along fence lines, ditch banks, and in wooded areas. Lygus adults enter canola fields in the bud stage to feed and lay eggs. Eggs are laid individually into the stems and leaves of host plants. Hot, dry weather favors build-up of lygus populations and increases the possibility of damage to early growth. There are two generations per year in the southern prairies, but only one in more northern areas. Adults remain in fields until late summer when they migrate to overwintering sites.

Pest Management

Chemical Controls: Trichlorfon, lambda-cyhalothrin and chlorpyrifos are registered for lygus control. Imidacloprid, as a seed treatment, is also registered for suppression.

Cultural Controls: None identified.

Alternative Controls: Populations of lygus bug should be monitored when the plants bolt until seeds within the pods are firm and when nearby alfalfa crops are cut. Before petal fall is complete, thresholds are set at 15 bugs per 10 sweeps. The threshold is 20 bugs per 10 sweeps within 4 or 5 days after petal fall is complete. Once the seeds have ripened to yellow or brown, the cost of controlling lygus bugs may exceed the damage they will cause prior to harvest. Fairy wasp, in the family Mymaridae, parasitizes the eggs of the lygus bug. In western Canada, a parasitic wasp, *Peristenus pallipes*, attacks lygus nymphs in alfalfa, but is less effective in canola. Nabid plant bugs, big-eyed bugs and spiders occasionally prey on young lygus bug nymphs. An European wasp, *P. digoneutis*, has been introduced into alfalfa fields in eastern North America where it parasitizes about 40 % of the tarnished plant bugs. One of the few parasitoids of lygus adults is a tachinid fly, *Alophorella* sp.

Resistant Cultivars: None.

Issues for Lygus Bugs

1. Recent work has shown that given adequate growing conditions, canola can compensate for lygus bug damage during the bud through flowering stages. Further work is needed so that the impact of this pest is better understood.

Cabbage seed pod weevil (*Ceutorhynchus litura*)

Pest Information

Damage: The cabbage seedpod weevil is native to Europe and was first discovered in Alberta in 1995. Since that time, weevil numbers have increased dramatically and the insect is now found throughout southern Alberta from the U.S. border north to Innisfail. In 2000 it was found in the southwest corner of Saskatchewan. Weevil populations are highest in canola crops at the bud and flowering stages. Crop losses from attack can occur in several ways. When adults invade crops in the bud to early-flowering stages, they feed on flower buds causing them to die off (bud-blasting). In addition to feeding injury by larvae within pods, infested pods are more likely to shatter than non-infested pods even after the crop has been swathed. If environmental conditions are humid, fungal invasion of larval exit holes can destroy many more seeds. When new generation adults emerge late in the season, they feed on seeds within green pods to build up fat stores for overwintering.

Life Cycle: In winter, they remain dormant beneath leaf litter in areas such as shelterbelts. When spring air temperatures reach 10 °C adults take flight in search of cruciferous plants such as wild mustard, volunteer canola, flixweed and stinkweed. Adults are attracted to canola fields when the crop reaches the bud to early flowering stage. Each female weevil lays eggs individually into recently formed pods. The pest has a single generation per year.

Pest Management

Chemical Controls: The use of imidacloprid seed treatments will suppress the larval stage of the pest. Cyhalothrin lambda is registered as a foliar insecticide for control of the pest.

Cultural Controls: Currently there is research being conducted on the time of seeding and the impact on cabbage seed pod weevil.

Alternative Controls: Crops should be monitored regularly from the time the crop enters the bud stage until the end of flowering. The best monitoring tool is a standard insect sweep net. Economic threshold research is underway, but a "rule of thumb" a threshold of 3 to 4 weevils per sweep has been adopted.

Resistant Cultivars: Both *B. rapa* and *B. napus* are susceptible to weevil damage. Crops of brown mustard (*Brassica juncea*) are also at risk. Crops of white mustard (*Sinapis alba*, or mustard with hairy pods) and non-cruciferous crops (wheat, barley, corn, potatoes, sugar beet) are resistant to cabbage seedpod weevil.

Issues for Cabbage Seed Pod Weevil

1. As this is a relatively new pest, work on the impact and biology of the cabbage seed pod weevil is required for the development of an integrated approach to control.

Minor Insect and Mite Pests

Alfalfa Looper (*Autographica californicus*)

Pest Information

Damage:. Infestations are not common but have occurred in northern and southern Alberta. Damage is characterized by defoliation and clipping of flowers and small seedpods.

Life Cycle: The alfalfa looper adult, like the diamondback moth, is blown in from the U.S., although some may overwinter as pupae in the soil. Moths appear all summer long due to overlapping generations. They feed on flower nectar at dusk and fly during daylight hours. Adults lay between 150 and 200 yellow, hemispherical eggs, singly or in small groups on host plants prior to bloom, often near floral parts if present. The larvae hatch in about a week and climb to the flowers where they cut them off. As a result, patches of fields that bloomed suddenly do not have any flowers. The larvae mature after four weeks of feeding and spin cocoons attached to plants, in which to pupate. The are usually 2 generations a year, depending on weather conditions.

Pest Management

Chemical Controls: Methomyl and chlorpyrifos.
Cultural Controls: Canola should not be grown near alfalfa.
Alternative Controls: Virus diseases are potential biocontrol agents.
Resistant Cultivars: None.

Issues for Alfalfa Looper

1. There has been no economic threshold established. Generally, a count of more than 15 larvae per m^2, combined with heavy defoliation or flower and pod clipping, warrants control.
2. There is a need for continued monitoring to assess the potential for spread.

Beet Webworm (*Loxostege sticticalis*)

Pest Information

Damage: Damage is characterized by defoliation and clipping of flowers and small seedpods. The most serious damage to canola is normally caused by larvae of the first generation. Initially, the larvae feed on the leaves and then on the stems and pods, stripping surface tissue and giving the crop a whitish appearance, usually in localized areas within the field. Damage often results from invasion by a marching army of beet webworms that has developed elsewhere in an adjacent weedy field. Such an invasion can almost completely destroy the invaded portion of a crop. Canola fields containing infestations not heavy enough to completely destroy plants may suffer reduced yields from pod peeling, which leads to incomplete formation and filling of pods.

Life Cycle: There are two generations per year. Beet webworms overwinter either as pupae or larvae within cocoons. The first generation moths emerge in late May or early June. The hard-to-find, tiny white eggs are laid in rows on the undersides of leaves of preferred plants. Lamb's-quarters are favorite egg-laying sites and food plants. The larvae first appear in late June and July. The larvae spin silk, which appears as webbing at the tops of plants. The caterpillars will often migrate in "armies" to nearby crops when weed hosts are destroyed by defoliation, drought or herbicides. When the larvae of the first generation mature in mid August, they burrow into the soil and spin long tubular silken cocoons. The second-generation moths appear in August and September and lay eggs. The larvae feed and enter the soil where they form silken cocoons to overwinter.

Pest Management

Chemical Controls: Deltamethrin, methomyl and trichlorfon are registered as foliar insecticides for the control of this pest.

Cultural Controls: Good weed control practices, especially for lamb's quarters, can prevent high larval populations from developing.

Alternative Controls: The control of alternate hosts, such as lamb’s quarters, is the key to integrated pest management of this insect.

Resistant Cultivars: None.

Issues for Beet Webworm

None identified

Aphid (*Brevicoryne brassicae* L.)

Pest Information

Damage: Occasionally aphids can become abundant in canola crops. The damage is rarely significant since the bulk of pod formation is usually complete by the time aphid populations are high.

Life Cycle: Noticeable numbers appear at the tops of plants between late July and early August. The aphids frequently cover the entire top 10-15 cm of the plant. In most cases, individual or small groups of plants are infested.

Pest Management

Chemical Controls: Dimethoate is registered for use on aphids. Imidacloprid is registered as a seed treatment.

Cultural Controls: None identified.

Alternative Controls: Several beneficial insects, including the ladybird beetle and lacewing, feed primarily on aphids. Their populations increase as the aphid population increases, usually in numbers sufficient to control the aphids.

Resistant Cultivars: None.

Issues for Aphids

None identified

Red Turnip Beetle (*Entomoscelis americana*)

Pest Information

Damage: The red turnip beetle is native to North America and is occasionally a pest of canola. Damage is normally found along the field margins where beetles move in from adjacent fields of cruciferous crops. Crop damage may occur in patches where volunteer canola, rapeseed, mustard or other cruciferous weeds were abundant in the previous crop.

Life Cycle: The beetle overwinters in the soil as reddish brown, oval eggs. The eggs hatch in early May and the larvae feed on the foliage of cruciferous plants such as flixweed, shepherd's-purse, volunteer canola and the seedling crop. After feeding, the larvae enter the soil to form bright orange pupae and transform into the adult beetles. The adult beetles appear from early June until early July. After feeding into mid July, the adults burrow into the soil, rest for the summer and then leave the soil in late July or early August to mate and lay eggs. The beetles are often found in groups scattered throughout canola fields, mating near the tops of maturing plants. After mating, the adults lay eggs randomly throughout the field. There is only one generation per year.

Pest Management

Chemical Controls: Spraying with a recommended insecticide as the insects enter a canola crop can control the adult or larval stages of this insect.

Cultural Controls: Fields with red turnip beetles should be cultivated in late fall or early spring to bury eggs and reduce larval survival. This practice can cause 75-100 % mortality of newly hatched larvae. Cultivation also kills larvae by destroying host plants and starving them to death. Cultivation from mid-May to mid-June subjects the pupae to mechanical injury, predation and desiccation. Infestations generally originate in stubble fields previously seeded to canola, rapeseed or mustard or in fields that had previous heavy stands of weeds of the mustard family. For this reason, under seeding canola, rapeseed and mustard with forages that are not cultivated should be avoided. The practices of direct seeding and no-till may contribute to increasing the importance of this insect as a pest in canola.

Alternative Controls: None identified.

Resistant Cultivars: None.

Issues for Red Turnip Beetle

None identified

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Carbaryl	Carbamate insecticide	1A	RE	Flea beetles	A	Foliar applications on flea beetles are often difficult when warm conditions persist because of the rapidity with which the insect can destroy the crop (Hours)
Carbofuran	Benzofuranyl methylcarbamate insecticide	1A	RE	Flea beetles Red turnip beetle	A	Foliar applications on flea beetles are often difficult when warm conditions persist because of the rapidity with which the insect can destroy the crop (Hours)
Chlorpyrifos	Organothiophosphate insecticide / acaricide	1B	RE	Grasshoppers Alfalfa looper Cutworms Diamondback moth larvae Bertha armyworm Lygus	A	
Clothanidin				Flea beetles	A	
Cypermethrin	Pyrethroid ester insecticide	3	R	Not being Used	A	

(continued)

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Deltamethrin	Pyrethroid ester insecticide	3	R	Flea beetles	A	Foliar applications on flea beetles are often difficult when warm conditions persist because of the rapidity with which the insect can destroy the crop (Hours)
				Grasshoppers		Poor results on grasshoppers can result when warm temperatures persist.
				Bertha armyworm		
				Cabbage seed pod weevil		
				Diamondback moth larvae		
				Lygus		
Dimethoate	Organothiophosphate insecticide / acaricide	1B	RE	Grasshoppers	A	
Imidacloprid	Nitroquanidine insecticide	4	R	Flea beetles	A	
cyhalothrin lambda	Pyrethroid ester insecticide	3	R	Grasshoppers	A[P]	Poor results on grasshoppers can result when warm temperatures persist.
				Lygus		
				Cabbage seed pod weevil		
Malathion	Aliphatic organothiophosphate insecticide	1B	RE	Not being used in significant acreages		
Methamidophos	Phosphoramidothioate acaricide / insecticide	1B	RE	Not being used in significant acreages		

(continued)

Control product (active ingredient / organism)[1]	**Classification**[2]	**Mode of action – resistance group**[3]	**PMRA status of active ingredient**[4]	**Pests or group of pests targeted**	**Performance of product according to recommended use**[5]	**Notes**
Methomyl	Oxide carbamate insecticide	1A	RE	Not being used in significant acreages		
Terbufos	Aliphatic organothiophosphate insecticide	1B	DI	Flea beetles	A	
Thiamethoxam	Nitroguanidine insecticide	4	R (organophosphate replacement)	Flea beetles	A	
Trichlorfon	Phosphonate insecticide / acaricide	1B	RE	Not being used in significant acreages		

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

Table 7. Availability and use of insect pest management practices for Canadian canola production.

	Practice \ Pest	Flea beetle	Grasshopper	Diamondback Moth	Bertha armyworm	Cutworm	Root Maggot	Lygus bug	Cabbage seed pod weevil
Prevention	tillage		available/used	available/used	available/used	available/used	available/used		
	residue removal / management								
	water management								
	equipment sanitation								
	row spacing / seeding depth						available/used		
	removal of alternative hosts (weeds/volunteers)								
	mowing / mulching / flaming								
Avoidance	resistant varieties	not available					available/used		not available
	planting / harvest date adjustment	available/used	available/used			available/used	available/used		available/not used
	crop rotation		available/used						
	trap crops - perimeter spraying		available/used						
	use of disease-free seed								
	optimizing fertilization								
	reducing mechanical damage / insect damage								
	thinning / pruning								
	choice of planting site								
Monitoring	scouting - trapping	available/used	available/used	available/used	available/used	available/used		available/used	available/used
	records to track pests								
	field mapping of weeds								
	soil analysis								
	weather monitoring for disease forecasting								
	grading out infected produce								
Suppression	use of thresholds for application decisions		available/not used	available/used	available/used	available/used		available/used	available/not used
	biological pesticides		available/not used						
	pheromones				available/used				
	sterile mating technique								
	beneficial organisms & habitat management		available/used		available/used			available/used	
	pesticide rotation for resistance management								
	ground cover / physical barriers								
	controlled atmosphere storage								
	forecasting for applications								
	innovative techniques								
	pest specific pesticides / consideration of beneficials				available/used				

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Information in the crop profile for individual pests

Key issues

- There is a need to support continued weed surveys as weed species are in flux due to the changes in tillage and production practices that have occurred in canola in the last decade.
- Growers need to be vigilant about rotating herbicide groups to delay the onset of herbicide resistant weeds.
- The development of economic thresholds for multiple weeds is required.
- The greater adoption of several practices, such as early or fall seeding, use of certified seed and improved sanitation practices (cleaning of equipment between fields, cleanliness of fields in proximity to canola crops) is necessary.

Table 8. Degree of occurrence of weed pests in Canadian canola production

	Degree of occurrence					
Major weeds	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Grassy weeds (Wild oats, green foxtail, volunteer cereals	E	E	E	E	E	E
Wild mustard	E	E	E	E	E	E
Wild buckwheat	E	E	E	E	E	E
Stinkweed, flixweed, shepherds purse	E	E	E	E	E	E
Perennials (Canada and sow thistle, quackgrass)	E	E	E	E	E	E
Cleavers, hemp nettle, chickweed	E	E	E	E	E	E
Minor weeds	**BC**	**AB**	**SK**	**MN**	**ON**	**QC**
Lambs quarters	E	E	E	E	E	E
Ragweed	E	E	E	E	E	E

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): Canola Council

Major Weeds

Canola is not a strong weed competitor in the early growth stages because it is slow growing and slow to cover the ground. If weeds emerge before the crop, there are greater yield losses than if the crop emerges first. After canola becomes established, there are few weeds that can survive the intense competition. Weeds emerging 7 to 10 days after the crop may cause little or no yield loss.

Damage: Wild oat, green foxtail, volunteer wheat and volunteer barley are strong competitors at early growth stages and can cause yield losses in canola. Wild oat can reduce canola yields by 18% at high densities. Green foxtail can result in significant yield losses if it emerges ahead of or with the canola crop. Green foxtail is a poor competitor in cooler regions unless it is growing in dense stands. Volunteer wheat and barley, at 7 to 8 plants/m^2 can reduce canola yield by 10 to 13%.

Life Cycle:

Pest Management

Chemical Controls: With the shift of canola production to reduced tillage/soil conservation techniques, there has been a corresponding reduction in the use of preplant incorporated herbicides such as trifluralin and triallate for the control of grassy weeds. This initially led to increasing reliance on Group 1 graminicides such as quizalofop, fluazifop, clethodim and sethoxydim. These products are effective in a wide range of application stages on all of the grassy weeds mentioned above. Fortunately, the advent of herbicide tolerant canola has led to a broadening of grassy weed control products through the use of glyphosate, glufosinate and imidazolinone chemistry. The use of herbicide rotations may help to avoid weed resistance to certain chemicals.

Cultural Controls: Minimizing tillage tends to lead to reduced populations of green foxtail and wild oat because seed remains on the soil surface where it is exposed to weather and birds. Delayed seeding allows for early flushes of wild oat and volunteer cereals, but this technique favours competition from green foxtail and it also leads to reduced yields. Early seeding is important to allow the crop to better compete with weeds. Green foxtail problems tend to lessen as minimum tillage practices are employed. Wild oat problems lessen as well, but not to the degree seen with green foxtail. Use of clean, certified seed reduces the addition of new weed seeds. Deploying harvesting techniques that minimize seed loss in the cereal crop the year prior to growing canola can lead to reduced populations of volunteer cereals. Fall tillage can lead to reduced populations of volunteer cereals.

Alternative Controls: There are economic thresholds developed for wild oat, green foxtail, volunteer barley and volunteer wheat. These are available for interpretation and use through provincial government crop protection publications and through the Canola Council's 'Canola Growers Manual'. Shallow tillage done just before or during planting is commonly practiced.

Issues for Annual Grass

1. There is concern of the reliance on Group 1 graminicides in other crops through the rotation and the potential for resistance development. It is essential that producers limit the use of these products for less competitive crops or for crops where there are no other options. This has become less of an issue with the widespread use of herbicide tolerant canola.

Annual Broadleaf

Pest Information

Damage: Seeds of wild mustard (*Sinapsis arvensis*), are similar in size and shape to canola seed seeds can result in a loss in grade. The weed is distributed throughout the northern prairies in the Parklands (black soil zone). Chickweed (*Stellaria media*) and hemp nettle (*Galeopsis tetrahit*) are also an issue, as these weeds germinate in flushes and can cause yield loss and harvesting issues in the crop.

Life Cycle: Both wild mustard and stinkweed are winter annuals, but can also germinate in the spring.

Pest Management

Chemical Controls: Herbicides are available for all annual weeds.

Cultural Controls: Tillage and the use of competitive crops in rotation are used to manage weeds.

Alternative Controls:

Issues for Annual Broadleaf

None identified

Perennial Weeds

Pest Information

Damage: The only perennial grass of any significance in canola is quackgrass (*Agropyron repens*). In the broadleaf group, Canada thistle (*Cirsium arvense*) is 3-4 times more competitive than wild oats.

Life Cycle:

Pest Management

Chemical Controls: The development of effective Group 1 graminicides as well as the refinement of glyphosate as a preharvest tool has reduced quackgrass populations.

Cultural Controls:

Alternative Controls: The Lacombe Agriculture and Agri-Food Canada station has developed an equation to predict yield losses through competition from Canada thistle.

Issues for Perennial Weeds

None identified

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
clethodim	Cyclohexene oxime herbicide	1	FR	Grassy weeds	A	
clopyralid	Picolinic acid/ pyridine herbicide	4	FR	Perennial thistles	A	
ethafluralin	Dinitroaniline herbicide	3	FR	Grass/broadleaf weeds	A	
ethametsulfuron	Triazinylsulfonylurea herbicide	2	FR	Mustard spp	A	
fenoxaprop	Aryloxyphenoxypropionic herbicide	1	FR	Grassy weeds	A	
fluazifop	Aryloxyphenoxypropionic herbicide	1	FR	Grassy weeds	A	
glufosinate	Organophosphorus herbicide	10	FR	Grass/broadleaf weeds	A	
glyphosate	Organophosphorus herbicide	9	RR	Grass/broadleaf weeds	A	
imazamox	Imidazolinone herbicide	2	RR	Grassy weeds	A	
imazethapyr	Imidazolinone herbicide	2	FR	Broadleaf weeds	A	

(Continued)

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
quizalofop	Aryloxyphenoxypropionic herbicide	1	FR	Grassy weeds	A	
sethoxydim	Cyclohexene oxime herbicide	1	FR	Grassy weeds	A	
triallate	Thiocarbamate herbicide	8	RE	Grassy weeds	A	
trifluralin	Dinitroaniline herbicide	3	FR	Grass/broadleaf weeds	A	

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

Source(s): Canola Council

Table 10. Availability and use of insect pest management practices for Canadian canola production.

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

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

References used in this document

Canola Growers Manual, published by the Canola Council of Canada

Guide to Crop Protection 2003, published by Saskatchewan Agriculture and Food

Guide to Crop Protection 2003, published by Alberta Agriculture and Food

Guide to Crop Protection 2003, published by Manitoba Agriculture, Food and Rural Initiatives

CANSIM Statistics Canada database and Canola Council of Canada Historical Pricing of Canola

http://www.canola-council.org/production

http://www.canola.ab.ca/research/9621.shtml

http://www.scdc.sk.ca/pdf/fact3alternaria.pdf

http://www.agric.gov.ab.ca/pests/insects/62010010.html (Alfalfa looper in Alberta)

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex741 Lygus Bugs in Canola

http://.www.gov.mb.ca/agriculture/crops/oilseeds/bga01s01.htm Field selection

IPM/ICM resources for production of canola in Canada

Canola Growers manual, published and updated annually by the Canola Council of Canada

Pests in Canola, published by the Canola Council of Canada, 2001.

Integrated Pest Management in Your Canola, published by the Canola Council of Canada, 2001.

Scouting & Sweep Net Insect Identification Card, published by the Canola Council of Canada 2003.

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

Name	Organization	Pest type	Specific pests	Type of research
Carcamo	Agriculture & Agri-Food Canada - Lethbridge	Insects	Lygus	Management of Lygus Bugs and Cabbage Seedpod Weevils in Canola
Derksen	Agriculture & Agri-Food Canada - Brandon	Weeds	Volunteer canola	Volunteer Canola Dynamics & Management Under Current & Emerging Management Systems
Dosdall	Alberta Agriculture Food & Rural Development - Edmonton	Insects	Seed pod weevil	Integrated Management of the Cabbage Seedpod Weevil & Over wintering Biology of Canola Pests
Falk	Ag. & Agri-Food Canada - Saskatoon	Disease	Brown girdling root rot	Marker Assisted Breeding for Resistance to Brown Girdling Root Rot in B. rapa
Farenhorst	University of Manitoba	Weeds	Various	Effect of Hog Manure Applications on Weed Control Management
Fernando	University of Manitoba	Diseases	Sclerotinia	Development of a Biological Pesticide Against Sclerotinia in Canola
Foottit/Mason	Agriculture & Agri-Food Canada - Ottawa	Insects	Lygus	Assessing Genetic Diversity of Lygus Pest Species in Crop & Non-crop Habitats
Holliday	University of Manitoba	Insects	Root maggots	Classical Biological Control of Root Maggots in Canola: Assessment of Control Agents
Holliday	University of Manitoba	Insects	Root maggots	Management of Root Maggots, Delia spp., on Oilseed Rape in Manitoba
Irvine	AAFC Brandon	Diseases	Numerous	Improving Disease Management in Canola Using "Planned-limited Tillage"
Irvine	Agriculture & Agri-Food Canada - Brandon	Weeds	Various	Interaction of Temperature & Moisture with Soil Moisture Disturbance on Weed Emergence
Jones	Alberta Agriculture Food & Rural Development	Insects	Lygus	Does Canola Compensate for Lygus Bug Damage
Khadhair	Alberta Research Council	Diseases	Aster yellows	Aster Yellows: Impact of Infection on Yield and Quality Aspects in Canola

Name	Organization	Pest type	Specific pests	Type of research
Lange	Alberta Research Council	Diseases	Fusarium wilt	Fusarium Wilt of Canola: Development of Effective Control Measures
McClay	Alberta Research Council	Weeds	F.cleavers	Field Evaluation of a Gall Mite for Biological Control of False Cleavers
McLaren	AAFC Brandon	Weeds diseases insects	All	Impact of Agronomic Practises on Canola Diseases, Including Fusarium Wilt of Canola, Insects & Weeds
Mohr	AAFC Brandon	Diseases	All	Disease Incidence in Canola as Affected By Preceding Crop
Rakow	Ag. & Agri-Food Canada - Saskatoon	Disease	Blackleg	Development of Early Maturing, Blackleg Resistant B. napus
Rimmer	AAFC - Saskatoon	Disease	Blackleg	Effect of Herbicides & Disease Resistance on Survival & Inoculum Production of Leptosphaeria Maculans, the cause of Blackleg
Rimmer	Ag. & Agri-Food Canada - Saskatoon	Disease	Sclerotinia	A Genomes Approach to Sclerotinia Resistance in B. napus
Scarth	University of Manitoba	Disease	Blackleg	Development of Blackleg Resistant B. rapa Germplasm
Soroka	Agriculture & Agri-Food Canada - Saskatoon	Insects	Flea beetles	Strategies for Managing Flea Beetle and Other Pest Insect Populations in Canola