Flax on the Farm

Insect Monitoring and Control

Even though flax is susceptible to attack by a number of insects, economic losses tend to be minimal except in a few cases. The only insect pest of flax that is unique to the crop is the flax bollworm. All other pests are generalists, meaning they feed on multiple host species, and prefer other crops over flax.

Methods of insect control

- Chemical
    - Scouting for insects and their accurate identification is critical before making chemical application decisions.
    - A pest population must be above a certain level to cause economic losses for chemical control to be worth the time and cost.
    - An economic threshold is the pest population or level of crop damage at which the cost of controlling the pest is equal to the value of the crop that would be destroyed without any control measures. Economic thresholds provide a guide to indicate when chemical control of a pest is economical (see Table 1)
        - To maximize control and prevent the development of resistance, follow best practices for chemical control of insect pests; use the right product at the recommended rate at the proper stage when conditions are optimal.
        - Only three groups of insecticides are available for use on flax, so chemical rotation is important to reduce the risk of the development of resistance.
        - Always follow the most restrictive label directions and use precautions when tank mixing.
        - Consult product labels and provincial crop protection guides for application rates and restrictions related to environmental conditions, personal protective equipment (PPE), water volume, number of applications, application intervals, chemical rotation, tank mixes, crop and pest staging, pest specificity, beneficial insects, re-entry periods, buffer zones, re-cropping and pre-harvest intervals.
        - The use of pest control products that are not registered for use on flax or are applied outside of the recommended pre-harvest interval can result in marketing and trade issues related to maximum residue limits (MRLs).
- Host Tolerance/Resistance
    - Refers to the ability of a plant to suppress, prevent or tolerate the feeding of an insect.
    - Insect tolerance traits are not available in any commercial flax varieties.
- Cultural
    - Includes mechanical, environmental or other non-chemical or non-biological methods of controlling a pest (e.g., seed early to avoid *Lygus* bugs).
- Biological
    - Refers to natural enemies of the pest that can include parasitoids, predators and diseases.
    - These organisms play a largely behind the scenes role in controlling the populations of many pest species on the Prairies and are often collectively referred to as ‘beneficials’.

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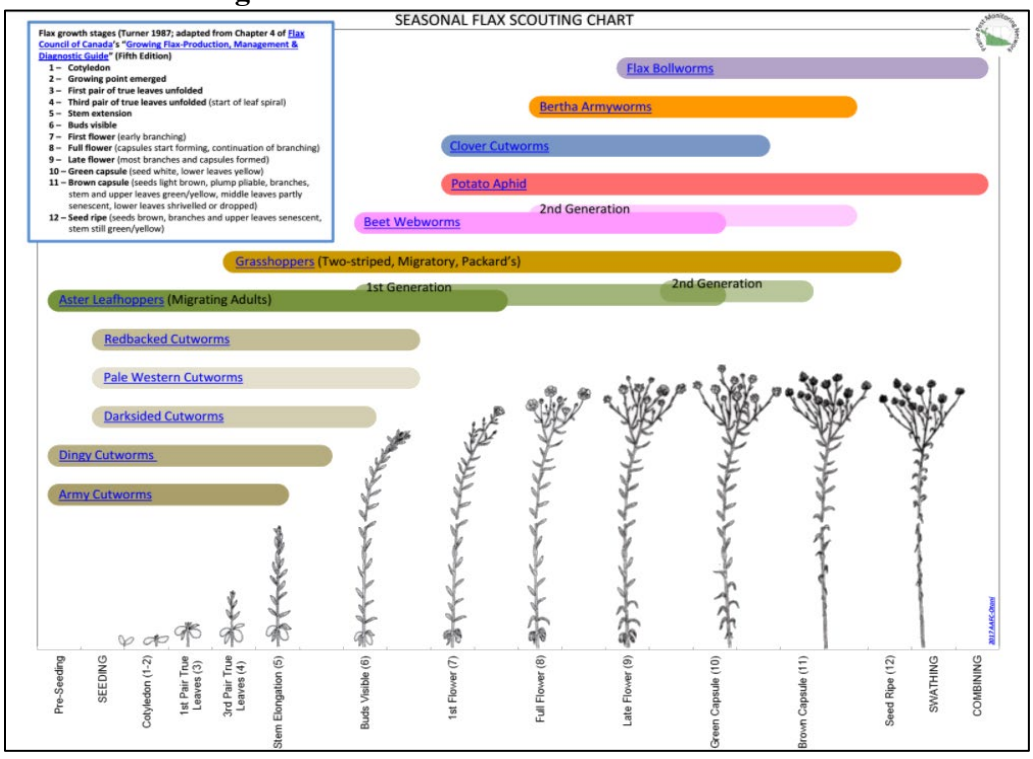
Integrated Pest Management (IPM)

- Integrated Pest Management is the practice of evaluating all available methods of pest control (chemical, cultural and biological) and making decisions on which single or combination of methods to use based on economics, environmental safety and efficacy.
- This crop management practice has gained prominence in recent years because of public concern over the safety of pesticides and their effect on beneficial insects.
- Six elements of IPM:
    - Prevention of pest problems
    - Accurate identification and knowledge of pests, their damage and natural enemies
    - Surveillance of pests, pest damage, natural enemies and weather conditions
    - Application of economic thresholds
    - Suppression of pest populations
    - Evaluation of results

Scouting

- Continuous monitoring of insects throughout the growing season is important for implementing effective control measures.
- Scouting should be done on a weekly basis and more frequently when conditions are favourable for an outbreak or when pest levels are getting close to the economic threshold.
- Sampling methods for insects are dependent on the behavioural and feeding characteristics of the pest. Refer to the links on page 10 for specifics.

Figure 1. Flax insect scouting chart



Courtesy of the Prairie Pest Monitoring Network.
Version with hyperlinks: https://prairiepest.ca/wp-content/uploads/2019/11/2017_PPMN_FlaxScoutingChart_Otani.pdf

The accurate identification of insects, knowledge about their lifecycles and methods of control are key to making good crop management decisions. For example, a grasshopper is typically not a pest if it is flying before June, its hind wings are highly visible (i.e. colourful) in flight or if it makes noise in flight or on the ground. Additionally, anticipating what insects to keep an eye out for this season can help to prioritize scouting activities. Below are descriptions of the insects that you may come across in your flax crop and the methods that can be used to monitor and control them if necessary.

Table 1. Insect pests of flax

Insect	Characteristics	Crop damage	Natural enemies	Cultural control	Chemical control	Concern?	Economic threshold	Comments
Aphid, potato (*Macrosiphum euphorbiae*)	sucking insect, overwinters as eggs on the stems of perennials, many generations per year, highest populations typically occur in late July/early August, winged forms appear when populations get too high or a new host plant is required, many generations per year	not typically noticeable because feeds on sap of leaves, stems and bolls, premature desiccation if drought stressed plants infested with high numbers, decreased test weight and fewer seeds per boll	prone to attack by a fungus especially if moist and humid in late June and July, predatory mites, beetles (ladybird, rove), green lacewings, spiders (harvestman, wolf), syrphid/hover flies, bugs (assassin, big-eyed, damsel, minute pirate), wasps (aphid, braconid, chalcid, ichneumonid, trichogrammid), aphid midge, snakeflies	reduce populations of nearby summer hosts weeds (nightshade, ragweed, lamb's quarters, jimsonweed, pigweed, shepherd's purse) and avoid growing near summer host crops (potato, tomato)	dimethoate	yes	3 healthy aphids per main stem at full flower, 8 healthy aphids per main stem at the green boll stage	if aphids appear unhealthy when scouted during full bloom, count again at the green boll stage as this may mean that a natural enemy is effectively controlling the population, can reduce yield by 20% or more when population reaches 50 aphids per plant, yield losses: 0.021T/ha/aphid/plant at full bloom and 0.008T/ha/aphid/plant at the green boll stage, populations highest when warm and dry in July
Armyworm, bertha (*Mamestra configurata*)	climbing cutworm, larva of a noctuid moth, overwinters as pupae, larvae appear in early June, 1 generation per year	feeds on leaves, flowers, developing bolls, the bract-like calyx below late stage bolls and occasionally the stems of bolls, can cause boll drop	susceptible to a viral disease and a fungus, beetles (ground, rove), flies (bee, robber, snipe, tachinid), bugs (assassin, damsel, minute pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), green lacewings, snakeflies, harvestman spiders, birds	crop rotation with non-susceptible crops (cereals, legumes except for peas), good control of weedy hosts (lamb's quarters, kochia, pigweed, Russian thistle, wild mustard), early swathing to reduce larval feeding, fall cultivation to expose pupae to the environment	chlorpyrifos^, Coragen, deltamethrin, Matador 120EC, Labamba, Voliam Xpress	rarely	4-5/m^2 (nominal), 25-30% stand reduction (nominal)	was a significant pest of flax before canola and mustard were widely grown, tends to only become a problem if nearby canola, mustard or alfalfa fields have been swathed or harvested and the flax field is still green, the most damage occurs when late-instar larvae feed on flowers and newly formed bolls, large infestations typically limited to the Parkland and Peace River regions, populations usually well controlled by adverse weather and/or natural enemies, apply insecticide in late evening or early morning when larvae most active
Bollworm, flax (*Heliothis ononis*)	climbing cutworm, larva of a noctuid moth, overwinters as pupae, larvae appear in early May, 1 generation per year	feeds on the inside of developing bolls and then emerges to feed on other bolls, may feed on foliage if bolls become too ripe	beetles (ground and rove), flies (bee, robber, snipe, stiletto, tachinid), bugs (damsel, minute pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), green lacewings, snakeflies, harvestman spiders, birds	fall cultivation to expose pupae to the environment	Coragen, deltamethrin, Labamba, Matador 120EC	very rarely	3% or more of bolls damaged (nominal)	eggs laid in open flowers, population effectively regulated by diseases, predators and parasitoids in most years, the most damage to flax crops traditionally occurred in western Saskatchewan
Bug, lygus (*Lygus spp.*)	sucking insect, overwinters as adults, 1 or 2 generations/year, sometimes concentrated at field edges	feeds on the sap of stems, leaves, growing points, buds and flowers, may cause leaf curling and wilting, causes bud abortion, growing point deformation, stunting and dieback	tachinid flies, bugs (assassin, big-eyed, damsel), wasps (braconid, chalcid, ichneumonid, trichogrammid), lacewings, spiders (jumping, crab)	seed early, good control of weedy hosts (asters, chickweed, dandelion, goldenrod, plantain, redroot pigweed, lamb's quarters, stinkweed, wild mustard)	Decis 5 EC, Voliam Xpress	no	not established	eggs laid in stems and leaves, typically completes one generation on an alternative host before moving to flax, often moves into a flax crop when buds begin to develop, symptoms similar to thrip damage, flax is very tolerant to feeding damage under good growing conditions even when populations are high, late-seeded crops more susceptible to damage, feeding can cause bitter tasting seeds, most common species found on flax is the tarnished plant bug
Caterpillar, zebra (*Melanchra picta*)	larva of a noctuid moth, overwinters as larvae, 1 to 2 generations/year	feeds on leaves	beetles (ground and rove), flies (robber, bee, stiletto, tachinid), bugs (assassin, damsel, minute pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), green lacewings, snakeflies, harvestman spiders, birds	none	none registered	very rarely	not established	incidence often corresponds with that of bertha armyworms and variegated cutworms, damage usually isolated to patches along the edges of the field
Cutworm, army (*Euxoa auxiliaris*)	above-ground cutworm, larva of a noctuid moth, overwinters as larvae, 1 generation/year	feeds on leaves	susceptible to a viral disease, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	seed crops later (after mid-May) to avoid and/or starve larvae, good weed control in fallow and after harvest will reduce egg laying, spring and fall cultivation expose larvae to natural enemies	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC, permethrin	occasionally	4-5/m2 (nominal), 25-30% stand reduction (nominal)	early seeded crops at high risk because overwinters as larvae, higher populations often present the year after an abnormally dry July followed by a wet fall, 10 or more larvae/m2 can cause significant damage, apply insecticide in late evening or early morning when larvae most active
Cutworm, armyworm (*Mythimna unipuncta*)	climbing cutworm, larva of a noctuid moth, migratory, adults arrive in mid-April and larvae appear in early June, 2 generations/year	feeds on leaf margins, growing points and flowers	susceptible to a viral disease, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	good control of grassy weeds before adults arrive and prior to seeding	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC	no	4-5/m2 (nominal), 25-30% stand reduction (nominal)	first generation causes the greatest damage, apply insecticide in late evening or early morning when larvae most active

Table 1. Continued

Insect	Characteristics	Crop damage	Natural enemies	Cultural control	Chemical control	Concern?	Economic threshold	Comments
Cutworm, clover *(Discestra trifolii)*	climbing cutworm, larva of a noctuid moth, overwinters as pupae, larvae appear in mid to late June, 2 generations/year	feeds on leaves	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	crop rotation with non-susceptible crops (cereals, legumes), good control of weedy hosts (flixweed, mustards, shepherd's purse, stinkweed, wild radish), early swathing to reduce larval feeding, fall cultivation to expose pupae to the environment	Coragen, deltamethrin, Labamba, Matador 120EC	rarely	20-30/m2	also known as the nutmeg moth, flax is a major host, first generation most critical to control, apply insecticide in late evening or early morning when larvae most active
Cutworm, darksided *(Euxoa messoria)*	climbing cutworm, larva of a noctuid moth, overwinters as eggs, larvae appear in late April, 1 generation/year	feeds on leaves and stems, older larvae may sever stems	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds, small rodents	none	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC, permethrin	rarely	5-6/m2	look very similar to the redbacked cutworm, apply insecticide in late evening or early morning when larvae most active
Cutworm, dingy *(Feltia jaculifera)*	climbing cutworm, larva of a noctuid moth, overwinters as larvae, 1 generation/year	feeds on leaves and occasionally stems	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	good weed control in fallow and after harvest will reduce egg laying, spring and fall cultivation to expose larvae to natural enemies	Coragen, deltamethrin, Labamba, Matador 120EC	rarely	25-30% stand reduction (nominal)	can't be avoided by early seeding because larvae present until mid-July, prefers drier conditions, apply insecticide in late evening or early morning when larvae most active
Cutworm, early *(Euxoa tristicula)**	subterranean cutworm, larva of a noctuid moth, overwinters as eggs, larvae appear in late April, 1 generation/year	feeds on leaves of seedlings before they emerge, feeds on leaves and severs the stems of newly emerged seedlings	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	none	Coragen, deltamethrin, Labamba, Matador 120EC	rarely	4-5/m2 (nominal), 25-30% stand reduction (nominal)	
Cutworm, pale western *(Agrotis orthogonia)**	subterranean cutworm, larva of a noctuid moth, overwinters as eggs, larvae appear in late April, 1 generation/year,	feeds on roots and leaves of seedlings before they emerge, feeds on leaves and severs the stems of newly emerged seedlings	susceptible to a viral disease, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	weed free fallow fields from July to mid-September and good in-crop weed control significantly reduces egg laying, cultivation of soil and keeping free of plant growth for a period of 10 days after cutworms have hatched can reduce larval populations	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC, permethrin	yes	4-5/m2	preferred host is cereals so monitor volunteer cereals for presence early in the season, a population of 12 larvae/m2 can cause 10% yield loss, larval parasitism very common and effective at controlling many outbreaks, apply insecticide in late evening or early morning when larvae most active
Cutworm, redbacked *(Euxoa ochrogaster)**	above-ground cutworm, larva of a noctuid moth, overwinters as eggs, larvae appear in late April, 1 generation/year	feeds on leaves of seedlings before they emerge, feeds on leaves and severs the stems of newly emerged seedlings	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	weed free fallow fields from August to mid-September and good in-crop weed control significantly reduces egg laying	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC, permethrin	yes	4-5/m2	a population of 12 larvae/m2 can cause 10% yield loss and a population of 32 larvae/m2 can destroy a flax field, prefers drier conditions, apply insecticide in late evening or early morning when larvae most active
Cutworm, variegated *(Peridroma saucia)*	climbing cutworm, larva of a noctuid moth, migratory and overwinter as pupae, adults arrive in mid-April and larvae appear at the end of May, 2 to 3 generations/year	feeds on leaves, buds, flowers and bolls	susceptible to a viral disease and fungal diseases, beetles (ground, rove), flies (robber, bee), flies (snipe, stiletto, tachinid), bugs (assassin, damsel, minute-pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), snakeflies, harvestman spiders, birds	good weed and volunteer host control, fall cultivation to expose pupae to the environment	chlorpyrifos^, Coragen, deltamethrin, Labamba, Matador 120EC	no	4-5/m2 (nominal), 25-30% stand reduction (nominal)	apply insecticide in late evening or early morning when larvae most active

Table 1. Continued

Insect	Characteristics	Crop damage	Natural enemies	Cultural control	Chemical control	Concern?	Economic threshold	Comments
Grasshopper (2-striped, lesser migratory and Packard's)	chewing insect, overwinters as eggs that begin to hatch when the soil temperature reaches 4.5oC, 1 generation/year	feeds on buds, flowers and the stems of bolls, can cause bolls to drop, young grasshoppers can cause damage to seedlings	susceptible to a fungus, a microsporidian, thread worms, nematodes, mites, wolf spiders, flies (bee, flesh, muscoid, tangled vein, robber, stiletto, tachinid), wasps, beetles (blister, ground), field crickets, birds, small rodents, coyotes	fall cultivation may decrease egg survival, destruction of green growth on stubble at time of egg laying may significantly decrease young grasshopper populations, barrier strips of a non-preferred crop (e.g. oats, peas) may delay crop feeding, trap crop may attract grasshoppers and allow for effective chemical control, early seeding, good control in nearby crops will reduce the risk	Coragen, deltamethrin, lambda-cyhalothrin, malathion, Voliam Xpress	yes	2/m2 if boll drop occurring, 15 adults/ m2 otherwise	economic damage to the flax crop occurs late in the season when other food sources dwindle, most damage caused by 3rd to 5th nymphal stages, 19 grasshoppers/m2 can cause 22% yield loss, winged adults cause boll drop, adults are more resistant to chemicals than earlier instars, most effective chemical control when the majority are in the 3rd or 4th nymphal stage, most common species attacking flax is the two-striped grasshopper, parasites may control populations up to 60% depending on environmental conditions, cool wet weather in spring and heavy rainfalls may kill young nymphs
Leafhopper, aster *(Macrosteles quandrilineatus)*	sucking insect, adults migrate into Canada from the US in the spring via southerly winds, transmits the pathogens causing aster yellows and crinkle diseases, 2 generations/year	not typically noticeable because feeds on plant sap (refer to disease table for symptoms of aster yellows and crinkle diseases)	spiders (harvestman, jumping, wolf), predatory mites, bugs (assassin, damsel), wasps (chalcid, ichneumonid, trichogrammid), green lacewings	seed early, seed far from alfalfa, good control of perennial weeds	none registered	rarely	not established	also called the six-spotted leaf hopper, low levels of infection occur every year
Seed bug, dirt-coloured *(Peritrechus convivus)*	piercing-sucking insect, overwinters as adults, 1 or 2 generations/year, sometimes concentrated at field edges	nymphs feed on stems and leaves of seedlings, adults feed on seeds beneath the soil surface	Collops beetles?	none	none registered	yes	not established	the first significant damage to flax since the late 60s was reported in 2017, 2018 and 2019, nymphs and adults can be present in large densities, looks similar to a lygus bug, often associated with low-lying areas that were previously covered with water, broad host range
Thrips *(Frankliniella tritici, Thrips tabaci and T. nigropilosus, T. vulgatissimus)*	rasping-sucking insect, overwinter as adults or larvae in plant debris or adults migrate into Canada from the US in the spring via southerly winds, several generations per year	feeds on the sap of young leaves, growing points, buds and flowers, causes bud abortion, stunted growth, silvering of leaves, twisted leaves, deformation of the growing point and very upright main stem	ladybird beetles, anthocorid bugs, predatory thrips	sow after cereals and not peas or mustard	none registered	rarely	not established	easily drowned by heavy rain, readily reproduce in warm dry weather, highly attracted to the colour white, symptoms similar to damage caused by lygus bug
Variegated fritillary *(Euptoieta claudia)*	larva of a migratory brush-footed butterfly, rarely overwinters in Western Canada, 2 generations/ year	feeds on leaves, flowers and seeds, may cause boll drop	flies (robber, tachinid), bugs (assassin, damsel), wasps (braconid, chalcid, ichneumonid, trichogrammid), green lacewings, snakeflies, spider (crab, harvestman, jumping), birds	none	none registered	very rare;y	not established	populations hardly ever high enough to cause economic losses
Webworm, beet *(Loxostege stricticalis)*	larva of a crambid snout moth, overwinters as larvae and pupae, 2 generations/year	feeds on leaves, stems and flowers, removes patches of bark from stems and branches	beetles (ground, rove), flies (bee, robber, snipe, stiletto, tachinid), bugs (assassin, damsel, minute pirate), wasps (braconid, chalcid, ichneumonid, trichogrammid), green lacewings, snakeflies, spiders (crab, harvestman, jumping), birds	the process of harvesting kills a large number of larvae, good weed control of preferred weeds (lamb's quarters, Russian thistle) within and surrounding the crop	deltamethrin	rarely	10-11/m2	spins web among the leaves on upper parts of plants, prefers weeds to flax, causes more damage in hot, dry years, only the 2nd larval generation causes crop damage and these appear in mid-July, may migrate in large 'armies' in July and August if populations very high, apply insecticide only if a significant number of bolls are being damaged

Table 1. Continued

Insect	Characteristics	Crop damage	Natural enemies	Cultural control	Chemical control	Concern?	Economic threshold	Comments
Wireworm *(Agriotes spp.)*	larva of a click beetle, overwinter as adults and larvae, 1 generation per year	feeds on germinating seeds and the underground parts of young seedlings	susceptible to a fungus and bacteria diseases, nematodes, beetles (ground, rove), stiletto flies, small rodents, birds	shallow cultivation in spring to expose eggs and injure larvae, seed early, increase seeding rate, use an on-row packer, follow seeding practices that promote rapid germination and seedling growth, rotate with non -susceptible crops (e.g. legumes, buckwheat, mustard), keep summer fallow brown in June and July to starve first-year larvae, cultivate summer fallow in mid to late July to damage larvae and pupae	none registered	rarely	not established	populations have significantly increased in recent years due to the loss of effective insecticides and the transition to conservation tillage, average larval lifespan is 3 to 5 years but they can live up to 11 years, later stage larvae can live off of humus in the soil if no plants present, symptoms of feeding damage can be mistaken for cutworm damage or poor germination/emergence

Compiled from the following publications: Cutworm Pests of Crops on the Canadian Prairies, Field Crop and Forage Pests and their Natural Enemies in Western Canada, Flax The Genus Linum, Grasshopper Identification and Control Methods, Growing Flax, Insect Management in Oilseed Crops in Western Canada, Insects of Canola, Mustard and Flax in Canadian Grasslands and NDSU Flax Insect Pest Management and from communication with and presentations given by Prairie Pest Monitoring Network entomologists.

*the most common species of cutworm affecting flax in Western Canada

^ products containing this active ingredient will be de-registered in 2023 and unusable for application after December 2023.

Table 2. Insecticide options for flax

Active Ingredient(s)	Product(s)	# of applications allowed	Tank mix partners	Group(s)	PHI	aphid, potato	armyworm, bertha	bollworm, flax	bug, lygus	cutworm, army	cutworm, clover	cutworm, darksided	cutworm, dingy	cutworm, early	cutworm, pale western	cutworm, redbacked	cutworm, variegated	grasshoppers	leafhopper, aster	seed bug, dirt-coloured	thrips	webworm, beet	wireworm
chlorantraniliprole	Coragen~	3	Acapela, Assure II, MCPA amine, MCPA ester	28	1		y	y		y	y	y	y	y	y	y	y	y					
chlorpyrifos^	Lorsban 4E, Lorsban NT, Pyrinex 480EC, Nufos 4E, Citadel 480EC, Pyrifos 15G, Warhawk 480EC, Sharphos	1	Headline, Priaxor, MCPA amine, MCPA ester	1B	21		y			y		y			y	y	y						
deltamethrin	Decis 5 EC, Decis 100 EC, Poleci 2.5 EC Western, Advantage Deltamethrin 5 EC	3	Headline, Buctril M, Pardner, MCPA, Priaxor	3A	40		y*	y	y*	y	y	y	y	y	y	y	y	y				y	
dimethoate	Cygon 480 EC, Cygon 480-Ag, Lagon 480E	1		1B	21	y																	
lambda-cyhalothrin	Matador, Silencer 120 EC, Labamba	1A, 3G	Headline*	3A	7					y*	y*	y*	y*	y*	y*	y*	y*	y					
lambda-cyhalothrin, chlorantraniliprole	Voliam Xpress	3		3A, 28	7		y		y									y					
malathion	Malathion 85E, Malathion 500	2		1B	7													y					
permethrin	Pounce 384 EC, Perm-UP, Ambush 500 EC, IPCO Syncro	1A, 2G		3A	7					y		y			y	y							
Nosema locustae spores	Nolo Bait~				0													S					

Compiled from the 2022 AB, SK and MB crop protection guides. Check product labels for application rates and restrictions (environmental conditions, PPE, water volume, number of applications, application intervals, chemical rotation, tank mixes, crop and pest staging, pest specificity, beneficial insects, re-entry periods, buffer zones, re-cropping and pre-harvest intervals).
S=suppression only
^ products containing this active ingredient will be de-registered in 2023 and unusable for application after December 2023.
*certain products only
~ least hazardous insecticides to bees
# of applications allowed by either aerial or ground application except; A = aerial, G = ground

Disease and Environmental Disorder Monitoring and Control

Flax is susceptible to a number of diseases, however economic losses tend to be minimal in most years. This, combined with the fact that many diseases are unique to flax, makes it a great choice for incorporation into rotations.

Methods of Disease Control

- Chemical
  - Scouting for diseases and the accurate identification of them is critical before making chemical application decisions.
  - To maximize control and prevent the development of resistance, follow best practices for chemical control of insect pests; use the right product at the recommended rate at the proper stage when conditions are optimal.
  - Only four groups of foliar fungicides are registered for use on flax, so chemical rotation is important to reduce the risk of developing resistance.
  - Always follow the most restrictive label directions and use precautions when tank mixing.
  - Consult product labels and provincial crop protection guides for application rates and restrictions related to environmental conditions, personal protective equipment (PPE), water volume, number of applications, application intervals, chemical rotation, tank mixes, crop staging, re-entry periods, buffer zones, re-cropping and pre-harvest intervals.
  - Using pest control products that are not registered on flax or are applied outside of the recommended pre-harvest interval (PHI) can result in marketing and trade issues related to maximum residue limits (MRLs).
- Host Tolerance/Resistance
  - Refers to the ability of a plant to suppress, prevent or tolerate the growth of a pathogen.
  - Genetic resistance to plant disease is a good way to reduce the crop's susceptibility to the disease.
  - Host resistance in flax is available for: rust, Fusarium wilt and powdery mildew.
    - All commercially available flax varieties are immune to rust.
    - The majority of flax varieties are rated as moderately resistant to powdery mildew
    - Fusarium wilt resistance of currently available flax varieties ranges from moderately resistant to resistant.
  - No commercially available varieties of flax are genetically resistant to pasmo.
  - Disease resistance ratings of flax varieties can be found in the provincial seed guides:
    - Alberta
    - Saskatchewan
    - Manitoba
  - Host resistance can be overcome through mutation of the pathogen. Adherence to recommended pesticide rates and product rotation is important to reduce the chances of the pathogen reproducing and mutating.
- Cultural
  - Includes mechanical, environmental or other non-chemical or non-biological methods of controlling a disease (e.g. crop rotation).
- Biological
  - Refers to natural enemies of the pest.
  - Can include parasitoids, predators and diseases.
  - These organisms play a largely behind the scenes role in controlling the populations of many pest species on the Prairies and are collectively referred to as 'beneficials'.

Integrated Disease Management (IDM)

- Integrated Disease Management is the practice of evaluating all available methods of pest control (chemical, host tolerance/resistance, cultural and biological) and making decisions on which single or combination of methods to use based on economics, environmental safety and efficacy.
- Most diseases are best managed through an integrated approach which includes multiple management strategies. This will improve the effectiveness of disease control and will reduce selection pressure on the pathogen which can lead to the development of fungicide insensitivity.

- This crop management practice has gained prominence in recent years because of public concern over the safety of pesticides and their effect on beneficial organisms.
- Six elements of IDM:
    - Prevention of disease problems
    - Accurate identification and knowledge of diseases, their damage and natural enemies
    - Surveillance of diseases, crop damage, natural enemies and weather conditions
    - Application of economic thresholds
    - Suppression of disease populations
    - Evaluation of results

Scouting

- Continuous monitoring of diseases and environmental disorders throughout the growing season is important for the effective implementation of control measures.
- Scouting should be done on a weekly basis and more frequently when conditions are favourable for an outbreak (e.g. humid conditions, crop lodging, heavy weed pressure, etc.).

The accurate identification of diseases and environmental disorders, knowledge about their lifecycles and methods of prevention and control are key to making good crop management decisions. Below are descriptions of the various diseases and environmental disorders that you may come across in your flax crop and the methods that can be used to prevent or control them.

Table 3. Diseases of flax

Disease	Causal organism(s)	Characteristics	Symptoms	Cultural control	Chemical control	Concern?	Comments	Unique to flax?
Alternaria blight	*Alternaria spp.*	seed and residue-borne fungus	seedling stage: dark red lesions on seedling leaves and stems, roots with water-soaked brown appearance, older plants: dark red to brown spots on older leaves and flower parts, leaf death, bud death, seed abortion	follow standard flax rotation, control flax volunteers	none	very rarely	seed that is black in colour may be infected with Alternaria	no
Aster yellows	Phytoplasma	bacterial parasite transmitted by aster/six-spotted leaf hoppers (Macrosteles quadrilineatus) blown in from the US via southerly winds, moves through the plant via the sugar-conducting tissues (phloem), overwinters in the roots of alfalfa and perennial broadleaved weed species	deformed flower parts that look like leaves and set no seed, uppermost sections of stems turn pale green to yellow, may affect single branches or entire plants, infected plants often stunted or taller than uninfected plants	seed early, good control of susceptible weeds (e.g. Canada thistle, chickweed, cleavers, dandelion, hawk's beard, redroot pigweed, shepherd's purse, sow thistle, stinkweed, wild mustard) especially perennial and winter annual weeds, seed far from alfalfa	none	very rarely	present every year at low levels, infection occurs early in the season but symptoms do not appear until flowering, symptoms tend to be worse in wet soils, severity of symptoms increases with earlier infections, epidemics in 1957 and 2012 due to unusually early leafhopper migrations during abnormally warm springs	no
Crinkle	Oat blue dwarf virus (OBDV)	virus transmitted by aster/six-spotted leaf hoppers blown in from the US via southerly winds, moves through the plant via the sugar-conducting tissues (phloem)	leaf puckering/wrinkling, stunted growth, reduced branching	seed early	none	very rarely	virus also infects barley, oats and wheat, disease more severe when plants infected early in the season	no
Fusarium wilt	*Fusarium oxysporum f. sp. lini*	primarily a soil-borne fungus but can also be residue and seed-borne, enters roots and moves through plant via water-conducting tissues (xylem), infection can occur at any growth stage, spores spread by wind and rain	the classic symptom at any stage is an upper stem bent like a shepherd's crook, early season infection results in seedling death before or shortly after emergence, later season infection causes yellowing of leaves at the top of the plant, brown spots on leaves, wilting (typically only on one side of the plant) and eventually plant death, infected plants often develop a tufted or top-heavy appearance, roots may turn an ashen grey colour	plant a resistant variety, plant clean seed (i.e. with very little chaff), seed early, seed at the higher end of the recommended rate, practice a 1 in 4 year rotation, never seed flax after flax, avoid using trifluralin on previously infected fields due to significant negative impact on the emergence of the subsequent flax crop, good control of flax volunteers	seed treatments-Insure Pulse, Maxim 480FS, Vitaflo	occasionally	currently registered varieties are moderately resistant (MR) or resistant (R), fungus grows best in warm (>23oC) dry soils, spores can survive in soil up to 10 years, innoculum very rapidly builds up in soils, symptoms more evident in warm weather, dead plants remain standing in the field for some time until they gradually decay, can cause 80-100% yield loss if a susceptible variety grown without rotation	yes
Grey mould	*Botrytis cinerea*	seed-borne fungus, attacks plants at all growth stages	seedling stage: brownish spots on the seedling stem close to the soil surface, wilted plants that fall over and die, older plants: stems turn light brown and become soft, plants parts above infected stem die followed by the death of the whole plant, under humid conditions a fuzzy grey coloured mould will appear on plant tissues	plant a lodging resistant variety, follow recommended fertilizer rates (i.e. avoid over-fertilizing), seed at the low end of the recommended rate, maintain good weed control	none	very rarely	fungus grows best in warm moist conditions	no
Pasmo	*Septoria linicola*	residue and seed-borne fungus, infects all above-ground plant parts at any growth stage, spores dispersed by wind, rain, dew and insects	circular yellow or greyish-green to brown spots on leaves early in the season, drying and curling of leaves, defoliation, bud and boll abortion, alternating green and brown/ black bands on stems (candy cane-like) and lesions on bolls, sepals and pedicels (boll stems) late in the season, small black dots in stem lesions, premature ripening, boll drop if plants left to stand for a long time before harvest or during heavy rain and wind, from a distance appears as reddish brown patches of lodging plants in the field during ripening	seed early, plant a lodging resistant variety, plant clean seed (i.e. with very little chaff), seed at the lower end of the recommended rate, follow recommended fertilizer rates, practice a 1 in 5 year rotation, plant flax crop as far away from previous year's crop as possible, maintain good weed and volunteer flax control	foliar fungicides-Acapela, Headline EC, Priaxor/Dyax	yes	currently registered varieties are susceptible (S) or moderately susceptible (MS), later maturing varieties often less affected by pasmo, stem lesions can weaken stems causing lodging, grows well in humid conditions (warm and moist) and best at 20 to 21oC, can cause yield losses up to 60% if a foliar fungicide is not applied, symptoms often not apparent until ripening, infection after seed fill causes no economic losses, seed that is grey or bluish black in colour may be infected with pasmo, can decrease seed weight	yes
Powdery mildew	*Oidium lini*	residue-borne fungus, tends to infect plants at later growth stages	begins as powdery white patches on the upper and lower surfaces of leaves which can spread to cover entire leaves causing leaf death and defoliation, can also infect stems and pedicels (individual flower stems) which in severe cases will cause stem breakage and boll drop	grow a moderately resistant (MR) variety, plant clean seed (i.e. with very little chaff), seed early, practice a 1 in 4 year rotation, follow recommended fertilizer rates (i.e. avoid over-fertilizing), bury infested residue, good control of weeds and flax volunteers	none	rarely	relatively new disease for flax (first observed in 1997), currently registered varieties are moderately susceptible (MS) or moderately resistant (MR), pathogen thrives under warm (20-25oC) humid conditions but does not do well under rainy conditions, more common in headlands and in years with high populations of potato aphids, has caused yield losses of 20-30% in research plots	yes

Table 3. Continued

Disease	Causal organism(s)	Characteristics	Symptoms	Cultural control	Chemical control	Concern?	Comments	Unique to flax?
Rust	*Melampspora lini*	residue-borne fungus, infects all above-ground plant parts, spores spread by wind	inconspicuous yellow pustules on the cotyledons and lower leaves of seedlings, large orange powdery pustules on the leaves, stems and bolls of older plants that eventually turn black, can lead to defoliation and stem girdling	plant a resistant variety, plant clean seed (i.e. with very little chaff), seed early, practice a 1 in 4 rotation, bury infested residue, good control of weeds and flax volunteers, plant flax crop as far away from previous year's crop as possible	none	no	was the most economically important disease of flax until the introduction of resistant varieties in the 1970s, caused yield losses from 25 to 50%, all currently registered varieties are resistant, growing a non-resistant variety may lead to the erosion of the current level of varietal resistance due to the development of new races, pathogen prefers high humidity, warm days and cool nights and higher soil temperatures	yes
Seed rot, seedling blight, root rot	*Rhizoctonia solani, Pythium spp., Fusarium spp.*	primarily soil-borne fungi but can be seed-borne, infect plants at later stages of development so symptoms often don't appear until after flowering	mushy seeds, seeds that fail to germinate, seedlings that fail to emerge and are brown, soft and water-soaked, seedlings with girdled stems, seedlings with discoloured (red to brown) cotyledons, leaves and stems, stunted roots, discoloured roots (reddish brown), stunted plants, wilted plants, premature ripening, gaps of plants in seed rows	do not seed deeper than necessary, plant high quality (i.e. not damaged) seed, seed at the high end of the recommended rate, ensure good soil fertility, good control of weeds, practice a 1 in 4 year rotation, specifically for Rhizoctonia solani: seed early, do not seed after legumes or sugar beet, do not sow on summerfallow, pack after seeding, practice conservation tillage	seed treatments-Insure Pulse, INTEGO Solo, Maxim 480FS, Vitaflo	rarely	Pythium is more common under cold soil temperatures and excess soil moisture at seeding, Rhizoctonia more common in warm, loose soil, conditions that slow germination and emergence expose seed and seedlings to rot and blight pathogens for longer and increase the chance of seed rot/seedling blight/root rot, yellow seeded flax may be more susceptible due to a thinner seed coat	no
Sclerotinia	*Sclerotinia sclerotiorum*	soil-borne fungus	water-soaked elongated lesions on stems, stem girdling, premature ripening leading to bleached/grey stems, white mould growth on stems, dark brown/black sclerotia (fruiting bodies) develop inside stems, sclerotia look like mouse droppings	plant a lodging resistant variety, plant clean seed (i.e. sclerotia-free), increase row width, follow recommended seeding and fertilizer rates (i.e. avoid overseeding and overfertilizing), avoid seeding after highly susceptible crops (e.g. borage, canola, sunflower), good control of weedy hosts (e.g. Canada thistle, dandelion, knapweeds, lamb's quarters, redroot pigweed, sow thistles, stinkweed, wild mustard) and broadleaf volunteers, avoid water-logged soils	foliar fungicides-Priaxor/Dyax, Proline 480 SC/ Holdfast	very rarely	petals are the initial site of infection, tends to only occur in heavily lodged flax under high moisture conditions, flax crop is not a significant source of the disease the following year because the survival rate of the sclerotia is low compared to those produced on other crops, most broadleaved crops are susceptible but cereals are not affected	no
Stem break and browning	*Aureobasidium pullulans var. lini (Polyspora lini)*	primarily a seed-borne fungus but also residue-borne	water-soaked dark brown spots on early leaves which later develop purple borders, leaf lesions spread to the first node of the stem and may eventually cover a large portion of the stem turning the plant brown, lesions may also be present on bolls, plants often fall over when in bud or early flower stage due to a canker at the first node	seed early, do not plant seed harvested from an infected field, practice a 1 in 3 year rotation, plant flax crop as far away from previous year's crop as possible, good control of flax volunteers	none	rarely	disease most common in the Parkland regions of AB and SK, fungus grows best under warm wet conditions, harvest losses occur due to plants laying on the ground that can't be picked up by the combine	yes

Compiled from the Diseases of Field Crops in Canada, Field Crop Disease Handbook, Flax the Genus Linum, Guidelines for the Control of Plant Diseases in Western Canada and Growing Flax publications, as well as from presentations given by and communications with prairie pathologists and oilseed specialists.

Table 4. Environmental disorders of flax

Disorder	Cause	Symptoms	Cultural control	Chemical control	Economic concern?	Comments	Unique to flax?
Boll blight	combination of several different diseases and environmental stresses	bud, flower and/or young boll death, abnormal (e.g. dark, discoloured, shrivelled) seeds inside bolls, fewer than normal or no seeds in bolls	none	none	very rarely	incidence often a result of warm, dry conditions following cold, wet weather	yes
Chlorosis	iron, manganese or zinc deficiency or waterlogged soils	otherwise healthy plants have pale green to yellow leaves with distinct green veins towards the top of the plant, slowed growth, prolonged conditions may cause dieback of the main stem and tillering, delays maturity	plant a resistant variety, seed later, apply deficient micronutrient in a test strip and if crop responds, apply to entire field	none	occasionally	seedlings on cool wet calcareous soils most susceptible, plants typically grow out of the condition once the soil dries out, AC Emerson is the most tolerant variety, soil and plant tissue samples can be sent to an accredited lab for determination of which micronutrient is lacking, research has shown that addition of the deficient micronutrient is rarely profitable	no
Frost canker	damage to seedling stem from frost	frost damage to seedlings at the soil surface may kill young seedlings or lead to the development of scar tissue (swollen, rough and cracked) near the soil surface which later causes plants to fall over and to tiller, plants will die if growing point damaged by the canker	seed later, seed at the higher end of the recommended rate, seed later, follow recommended agronomic practices to produce an even vigourous stand	none	occasionally	severity tends to be worse in low-lying areas, on light soils and when plant stands are thin	no
Heat canker	damage to seedling stem due to extreme soil heating	excessive heating of soil when seedlings are young (<6") damages the stem, may lead to seedling death or development of scar tissue (swollen, rough and cracked) near the soil surface which later causes plants to fall over and to tiller, plants often topple over after a high wind, plants will die if growing point damaged by the canker	seed at the higher end of the recommended rate, follow recommended agronomic practices to produce an even vigourous stand, seed in a north-south direction, seed early, practice conservation tillage	none	occasionally	increased incidence when the soil crusts, plant stands are poor and soils are light in texture and dark in colour	no
Weathering	exposure to the elements and saprophytic (decomposing) fungi and bacteria	greying/fading/ bleaching of stems and bolls, may be accompanied by the presence of black lesions on stems, reduced seed quality	seed flax earlier to limit exposure of the crop to poor weather at the end of the season, plant a variety with bolls that have a smaller opening at the top	none	occasionally	flax seed quality typically not compromised by weathering of plants but in severe cases can cause portions of the boll to stick to the seed making combining challenging, can discolour the seed, decrease seed weight and germination, increase fungal growth on seed and decrease oil content	no

Compiled from the Diseases of Field Crops in Canada, Field Crop Disease Handbook, Flax the Genus Linum, Guidelines for the Control of Plant Diseases in Western Canada and Growing Flax publications.

Table 5. Foliar fungicide options for flax

Active ingredient(s)	Product(s)	Crop stage	# of applications allowed	Tank mix partners	Group(s)	PHI	Pasmo (Septoria linicola)	Sclerotinia stem rot (Sclerotinia sclerotiorum)
fluxapyroxad, pyraclostrobin	**Dyax, Priaxor**	20-50% flowering	2*	Poast Ultra, quizalofop, Solo, Odyssey, Decis, Matador/Silencer 120EC	7, 11	21	y	S
mefentrifluconazole, pyraclostrobin	**Veltyma**	prior to disease development of at 20% flowering	2		3, 11	21	y	
picoxystrobin	**Acapela**	prior to disease development	2*	Assure ll, Coragen	11	28	y	
prothioconazole	**Proline 480 SC, Holdfast, Soratel**	prior to petals falling or 20-50% flowering	1	Decis, Matador, Lorsban	3	36		y
pyraclostrobin	**Headline EC**	20% flowering	2*	Decis, Matador, chlorpyrifos	11	21	y	

Compiled from the 2022 AB, SK and MB crop protection guides. Check product labels for application rates and restrictions (environmental conditions, PPE, water volume, number of applications, application intervals, chemical rotation, tank mixes, crop staging, re-entry periods, buffer zones, re-cropping and pre-harvest intervals).
S = suppression
*apply second application with a fungicide that has a different mode of action
^ products containing this active ingredient will be de-registered in 2023 and unusable for application after December 2023.

If you need help identifying an insect, disease or environmental disorder in your flax crop you can:

- Speak to a Crop or Pest Specialist at your regional Provincial Ministry of Agriculture Office
- Consult your Agronomist
- Submit a plant or insect sample to a Provincial Laboratory
    - British Columbia, Saskatchewan, Manitoba

RESEARCH NOTE: Revising the Crop Nutrient Uptake and Removal Guidelines for Western Canada

Dr. Fran Walley is leading a research project to revise the crop nutrient and removal guidelines for Western Canada and is looking for pre-harvest straw samples in 2022. If you are interested in having a flax field sampled e-mail Fran at fran.walley@usask.ca

FLAX DISEASE SURVEY: Sign-up sheet for crop disease monitoring

A Saskatchewan flax disease survey is planned for 2022 and permission to survey fields must be granted by landowners. If you are interested in supporting provincial pest survey efforts please sign up here: https://ca.surveygizmo.com/s3/50060966/Pest-Monitoring-Sign-up
or call Anne at SaskFlax at the number listed below.

For more information on insect pests and diseases of flax contact the following:

Anne Nerbas
Agronomist
Saskatchewan Flax Development Commission
(306) 664-1901
anne@saskflax.com

Dane Froese
Industry Development Specialist – Oilseeds
Manitoba Agriculture and Resource Development
(204) 750-2840
dane.froese@gov.mb.ca

Cory Jacob
Provincial Specialist, Oilseed Crops
Saskatchewan Ministry of Agriculture
(306) 787-4668
cory.jacob@gov.sk.ca

Useful links:

1. WEATHER DATA
    - AAFC agroclimate maps
    - Alberta Weather Station
    - Manitoba Weather Reports

2. CROP REPORT
    - Saskatchewan crop report
    - Alberta crop report
    - Manitoba crop report

3. PESTICIDES
    - Provincial Crop Protection Guides
        - Alberta, Saskatchewan, Manitoba
    - PMRA Pesticide Product Label Search:
        - Online
        - App
    - Pesticide Resistance
        - Manage Resistance Now
        - Resistant Wild Oat Action Committee
        - Fungicide Resistance Action Committee

4. INSECTS

(a) Provincial Government Pest Management Websites

- Alberta, Saskatchewan, Manitoba

(b) Insect Scouting, Identification and Management Information

- Pests and their Natural Enemies (AAFC)
- UofM Pest & Crop Management App:
  - Google Play
  - App Store
- Insect Management in Oilseed Crops (MB)
- Economic Thresholds of Insects (SK)
- Scouting
  - Sweep Net Scouting Tips (Field Heroes)
  - Field Scouting (AB)
- Aphids:
  - Scouting for Aphids (Field Heroes)
  - Aphids on Flax (MB)
- Bertha armyworm
  - Scouting for Bertha Armyworm (Field Heroes)
  - Monitoring Bertha Armyworm (PPMN)
  - Bertha Armyworm (AB)
    - Scouting (AB)
  - Bertha Armyworm (SK)
  - Bertha Armyworm (MB)
- Cutworms
  - Scouting for Cutworm (Field Heroes)
  - Monitoring Cutworms (PPMN)
  - Cutworm (AAFC)
  - Cutworm (MB)
  - Cutworm (AB)
  - Cutworm (SK)
- Armyworms
  - Armyworms (MB)
- Grasshoppers
  - Monitoring for Grasshoppers (PPMN)
  - Grasshopper (AAFC)
  - Grasshopper (AB)
  - Grasshoppers (SK)
  - Grasshoppers (MB)
  - Grasshopper (BC)
  - Grasshoppers (USDA)
- Leafhoppers
  - Leafhoppers (PPMN)
- Lygus bugs
  - Monitoring Lygus Bugs (PPMN)
  - Lygus Bugs (MB)
- Wireworms
  - Wireworms (MB)
  - Wireworm (AB)

(c) Beneficial Insects

- Field Heroes
- Pest and Predators Podcasts (Field Heroes/Real Agriculture)
- Natural Enemies of Pests (AAFC)
- Natural Enemies of Insect Pests (AB)
- Common Predators of Pests (MB)
- Value of Beneficial Insects (MB)
- Biological Control Website (Cornell University)

(d) Pest Monitoring Reports and Reporting Tools

- Prairie Pest Monitoring Network
- Insect Risk Map (PPMN)
- Manitoba Crop Pest Updates
- Alberta Insect Pest Monitoring Network
- Cutworm Survey map (AB)
- Cutworm Reporting Tool (AB)
- Grasshopper Survey and Maps (AB)
- Bertha armyworm Survey map (AB)

(e) Pesticides and Pollinators

- Protecting Pollinators (AAFC)
- Protecting and Supporting Pollinators (MB)
- Reducing Bee Pesticide Poisoning (PNW)

5. DISEASES

(a) Provincial Government Disease Management Websites

- Alberta, Saskatchewan, Manitoba

(b) Disease Identification, Scouting and Management Information

- Diseases of Field Crops in Canada
- Scouting
  - Scouting for Diseases (MB)
  - Plant Disease Scouting 101 (SK)
  - Diagnosing Plant Problems (AB)
  - Field Scouting (AB)
- Aster Yellows
  - Aster Yellows Disease (AB)
  - Aster Yellows (SK)
- Fusarium Wilt
  - Fusarium Wilt in Flax (MB)
- Pasmo
  - Pasmo in Flax (MB)
- Sclerotinia
  - Sclerotinia Diseases (SK)
- Seedling Blight
  - Seedling Blight (AB)