Western Committee on Crop Pests Guide to Integrated Control of Insect Pests of Crops

Insect Management In
Cereal Grains[1] in Western Canada

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[1]**Crops covered in this chapter of the guide include wheat, oats, barley, rye, corn, buckwheat, and millet.**

Aphids (Hemiptera: Aphididae)

English grain aphid (*Sitobion avenae*)
Oat-birdcherry aphid (*Rhopalosiphum padi*)
Greenbug (*Schizaphis graminum*)
Corn leaf aphid (*Rhopalosiphum maidis*)

Most abundant species: In western Canada the English grain aphid (*Sitobion avenae*) and the Oat-birdcherry aphid (*Rhopalosiphum padi*) can commonly be found on wheat, and the greenbug (*Schizaphis graminum*) occurs sporadically (1).
The corn leaf aphid (*Rhopalosiphum maidis*) may at times be present on corn or small grain cereals.

The oat-birdcherry aphid can be an important vector of barley yellow dwarf virus. English grain aphid can also vector barley yellow dwarf virus, but is not as efficient a vector as the oat-birdcherry aphid (2).

Monitoring: A sequential sampling plan developed in North Dakota for aphids in spring wheat (3) states:
- Sampling should begin greater than 30 m from the field edge,
- Randomly sample five individual stems (one set) from a $2m^2$ area, and record the number of aphids on each stem,
- A minimum of 20 samples (4 sets) should be taken before comparing with the sequential sampling tables.

A sampling plan developed in Oklahoma recommends in addition to counting aphids per tiller to determine the proportion of tillers with mummified aphids (12).

A mobile phone app called “Cereal Aphid Manager” can be used to factor common predators and parasitoids of aphids into management decisions. In addition to counts of three species of aphids (English grain aphids, oat-birdcherry aphids, and greenbugs) counts are made of adults and larvae of sevenspotted lady beetle and thirteenspotted lady beetle, green lacewing larvae, damsel bugs, minute pirate bugs, brown aphid mummies, and black aphid mummies. Recommendations are provided based on four thresholds (5, 10, 12, and 15 aphids per tiller) to account for an individual’s tolerance to aphids.

Economic Thresholds:

Wheat, barley, and oats: Economic injury levels for English grain aphid on spring wheat were 10 to 15 aphids per tiller (4). After the early dough stage insecticide treatments would not be cost-effective (4).

Action thresholds of 9, 13, and 17 aphids per stem, depending on management costs and crop value, are used in the sequential sampling plan from North Dakota (3).

If greater than 10% of the tillers have mummified aphids, aphid populations are expected to remain below or would quickly be suppressed below the economic threshold (12).

Cultural control –

Planting date: Research from Iowa showed that early planted spring cereals had less damage from barley yellow dwarf than cereals planted later (5). Research in South Dakota found that barley yellow dwarf virus was less in later plantings of winter wheat (6).

Tillage: In a study in Oklahoma, greenbug populations were substantially reduced where surface residue was moderate to high, compared to conventionally tilled plots where residues were low (7). However, conservation tillage may lead to higher populations of oat-birdcherry aphid in spring small grains, as increased surface residue provides a favorable microhabitat for this species of aphid (8).

Biological Controls-

For aphids found on cereal crops, a study in Manitoba found that the number eaten by one lady beetle in 24 hours depended on the species of lady beetle and the species of aphid eaten. One female transverse lady beetle, *Coccinella transversoguttata*, ate 168-176 oat-birdcherry aphids in 24 hours, whereas one parenthesis lady beetle, *Hippodamia parenthesis*, consumed 50-67 English grain aphids in 24 hours. (9)

Rain and wind may decrease populations of aphids on cereal crops. (10).

Chemical control -

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (Days)	References
Barley, Oats, Rye & Wheat				
Malathion Malathion 500 Malathion 85E	 1.48-1.98 L 1.10-1.35 L	 0.60-0.8 L 0.45-0.54 L	 7 7	-
Dimethoate Cygon (barley, oats, and wheat only)	0.425 L	0.17 L	35	11
Corn				
Sulfoxaflor (field, sweet, seed) Closer	75-150 ml	30-61 ml	7 (sweet and forage) 14 (grain)	
Acetamiprid (sweet corn only) Assail	56 – 86 g	23 – 35 g	10	
Spirotetramat (sweet corn only) Movento	220 – 365 ml	89 – 148 ml	7	
Methomyl (sweet corn only) Lannate	430 – 620 g	174 – 251 ml	3	

Restrictions –

malathion: Do not apply at air temperatures below 20°C.

References –

1. Migui. 1996. M.Sc. Thesis. University of Manitoba.
2. Halbert and Pike. 1985. Annals of Applied Biology. 107: 387-395.
3. Boeve and Weiss. 1998. The Canadian Entomologist. 67-77.
4. Johnston and Bishop. 1987. J. Econ. Entomol. 80: 478-482.
5. Wallin and Loonan. 1971. Phytopathology. 61: 1068-1070.
6. Hesler et al. 2005. J. Econ. Entomol. 98: 2020-2027.
7. Burton and Krenzer. 1985. J. Econ. Entomol. 78: 390-394.
8. Hesler and Berg. 2003. J. Econ. Entomol. 96: 1792-1797.
9. Malyk and Robinson. 1971. The Manitoba Entomologist. 89-95.
10. Malyk and Robinson. 1971. The Manitoba Entomologist. 79-88.
11. Harper, 1973. J. Econ. Entomol. 66: 1326.
12. Giles et al. 2003. J. Econ. Entomol. 975-982.

Armyworms *Mythimna unipuncta* (Haworth) (Lepidoptera: Noctuidae)

Monitoring –

Adults: Pheromone lures are available to attract and capture male armyworm moths using either sticky traps (1) or bucket traps (2).

Larvae: Check the soil surface for armyworms, and the plants for feeding, when monitoring in mid-June through early-August. At each stop shake plants and carefully check soil surface for dislodged larvae. During the day larvae may be under plant trash, soil clods or in soil cracks. Check the backs of armyworms for parasite eggs.

Threshold –

A nominal threshold is four unparasitized larvae, smaller than 2.5 cm (1 inch) per square foot. For armyworms migrating into the field: Treat a couple of swaths ahead of the infestation in the direction of movement to form a barrier strip.

A study in Arkansas found that at boot and anthesis stages, wheat can sustain up to 75% defoliation by armyworms with little loss in yield, and even at populations that resulted in 75% defoliation head cutting was negligible (3).

Biological Controls-

In Ontario, 23 species of primary parasites were reared from armyworms (4); 16 of these species were Hymenoptera and seven species were Diptera. Fifteen of these species were commonly observed.

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Barley, Oats And Wheat				
Chlorantraniliprole Coragen	250-375	101-152 ml	1	
Spinetoram Delegate	100 – 200 g	40-81 g	21	
Lambda-cyhalothrin Matador, Silencer	83 ml	34 ml	28	

Methomyl Lannate	270-540 g	0.1093-0.2185kg	20	5
Malathion Malathion 500 Malathion 85E	1.5-2 L 1.10-1.35 L	0.60-0.80 L 0.45-0.54 L	7 7	5
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	875 mL-1.2 L	0.354-0.486 L	60	
Rye				
Chlorantraniliprole Coragen	250-375	101-152 ml	1	
Spinetoram Delegate	100 – 200 g	40-81 g	21	
Carbaryl Sevin XLR Plus	2.5-5.25 L	1.01-2.12 L	14	5
Malathion Malathion 500 Malathion 85E	1.5-2 L 1.10-1.35 L	0.60-0.80 L 0.45-0.54 L	7 7	5
Corn				
Chlorantraniliprole Coragen	250 – 375 ml	101 – 152 ml	14	
Lambda-cyhalothrin Matador, Silencer	83 ml	34 ml	14 (silage) 21 (field corn)	
Lambda-cyhalothrin + Chlorantraniliprole Voliam Xpress	500 ml	202 ml	1 (sweet corn) 14 (silage) 21 (field corn)	
Millet				
Chlorantraniliprole Coragen	250-375	101-152 ml	1	
Lambda-cyhalothrin Matador	83 ml	34 ml	28	

Restrictions –

malathion: Do not apply at air temperatures below 20°C.

References –

1. Turgeon et al. 1983. Environ. Entomol: 891-894.
2. Hendrix and Showersi. 1990. J. Econ. Entomol. 596-598.
3. Steinkraus and Mueller. 2003. J. Entomol. Sci. 431-438.
4. Guppy. 1967. Can. Entomol. 94-106.
5. Smith, Pest. Res. Rep., 1976:177.

Brown Wheat Mite *Petrobia latens* (Müller) (Acarina: Tetranychidae)

Cultural Control –

Summerfallow; rotation with non-cereal crops. Mites cause greatest injury to grain stressed by water requirements. Mite damage is reduced by timely irrigation (2).

Chemical Control –

Insecticide	Rate(g or L/ha)	Rate (g or L/acre)	Preharvest Interval (days)	References
Barley, Oats And Wheat				
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	0.625 L	0.225 L	60	1

References –

1. Byers and Charnestski, Pest. Res. Rep. 1987:144.
2. Summers and Godfrey, UC IPM Guidelines, Pub 3339, 2000

Cereal Leaf Beetle *Oulema melanopus* L.(Coleoptera: Chrysomelidae)

Economic Threshold-

A study in Alabama and Georgia suggested an economic threshold of 0.4 larvae per stem between spike emergence and anthesis in winter wheat (1).

Biological Control-

The larval parasitoid *Tetrastichus julis* (Walker) (Hymenoptera: Eulophidae) has been released and established in many areas of the Canadian prairies where cereal leaf beetle is present (2). Provide unsprayed corner or border of cereal leaf beetle–infested crops to allow establishment of *T. julis*.
Some species of lady beetles will prey on eggs and larvae of cereal leaf beetle (3). Rainstorms may also cause some larval mortality (3).

Chemical Control-

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Wheat, Barley, Oats, Rye				
Malathion Malathion 500 Malathion 85E	 550 ml – 1.1 L 1075 ml	 223 – 445 ml 435 ml	 7 7	

References-

1. Buntin et al. 2004. J. Econ. Entomol. 97: 374-382.
2. Kher et al. 2011. Prairie Soils and Crops Journal. 4: 32-41.
3. Shade et al. 1970. Ann. Entomol. Soc. Am. 63: 52-59.

Corn Earworm *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae)

Damage to field corn by corn earworm is generally not considered economic. Corn earworm can be a major problem on sweet corn, however.

Monitoring – Adults: Pheromone lures and traps are available to attract and capture male corn earworm moths.

Cultural Control-

Resistant Cultivars – Some cultivars of Bt corn are resistant to feeding by corn earworm.

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Corn Only				
Chlorantraniliprole Coragen	250 – 375 ml	101 – 152 ml	14	
Novaluron (sweet corn only) Rimon	820 ml	332 ml	9 (hand harvesting), 1 (mechanical harvesting)	
Lambda-cyhalothrin Matador, Silencer	83 – 188 ml	34 ml – 76 ml	14 (silage) 21 (field corn)	
Cypermethrin Mako UP-Cyde	 175 ml 280 ml	 71 ml 113 ml	5	
Permethrin (sweet corn only) Ambush Pounce Perm-UP	 200 – 275 ml 275 – 375 ml 275 – 375 ml	 81 – 111 ml 111 – 152 ml 111 – 152 ml	 1 1 1	
Lambda-cyhalothrin + Chlorantraniliprole Voliam Xpress	500 ml	202 ml	1 (sweet corn) 14 (silage) 21 (field corn)	
Methomyl (sweet corn only) Lannate	430 – 625 g	174 – 253 ml	3	
Malathion Malathion 85E	1.10-1.35 L	0.45-0.54 L	5	

Corn rootworm - northern *Diabrotica barberi* S. & L.(Coleoptera: Chrysomelidae)

Cultural Control-

Crop Rotation – Larvae can survive only on the roots of corn and a limited number of grasses. Crop rotation is the primary management strategy for control of northern corn rootworm.

Resistant Cultivars – Some cultivars of Bt corn are resistant to feeding by corn rootworm. A table of registered Bt corn products in Canada (as of May 2018) is available at: https://www.cornpest.ca/bt-corn/bt-corn-products-traits-available-in-canada-as-of-may-2018/

Chemical Control-

Insecticide	Rate	Preharvest Interval (days)	References
Corn			
Thiamethoxam Cruiser Maxx Corn	830 ml Cruiser 5FS / 100 kg seed		
Clothianidin Poncho 600 FS Nipsit Inside	166.7 ml per 80,000 unit of seed		
Chlorpyrifos Pyrifos 15G	75 g per 100 m of row		

Restrictions-
Dust generated during planting of seed treated with neonicotinoid insecticides may be harmful to bees and other pollinators.
When using a seed flow lubricant for planting corn or soybean seed treated with the neonicotinoid insecticides clothianidin, thiamethoxam or imidacloprid, only a dust-reducing fluency agent is permitted to minimize the potential for abrasion that produces insecticidal seed dust. Talc and graphite are not permitted to be used as a seed flow lubricant for corn or soybean seed treated with these insecticides.To help minimize the dust generated during planting, refer to "Pollinator Protection and Responsible Use of Treated Seed- Best Management Practices" on the Health Canada webpage on pollinator protection at http://www.healthcanada.gc.ca/pollinators

Cutworms Lepidoptera (Noctuidae)

Redbacked cutworm (*Euxoa ochrogaster*)
Army cutworm (*Euxoa auxiliaris*)
Pale western cutworm (*Agrotis orthogonia*)

Identification and Biology: A cutworm identification guide for the Canadian prairies is available at http://publications.gc.ca/collections/collection_2017/aac-aafc/A59-42-2017-eng.pdf

Thresholds –

Pale western cutworm at 8.4 larvae/m^2 caused 25% loss in wheat and at 30/m^2 caused 100% loss. Control is usually justified when larvae exceed 3-4/m^2.
Nominal thresholds for redbacked and army cutworm are somewhat higher at 5-6/m^2. Well established fall-seeded crops or spring seeded crops with good moisture conditions can tolerate higher numbers.

Cultural Control –

Reduce egg laying by pale western cutworm adults in summerfallow fields by destroying all plant growth in July and allowing field to crust until 15 September. Severely infested fields should be treated before reseeding. In areas where redbacked cutworms are a problem, destroy weedy growth on fallow fields prior to August.

Studies and observations from Alberta show that pale western cutworm populations can be reduced by cultivating the soil and keeping it free of all plant growth for a 10-day period after the cutworms had hatched and before the crop was seeded (9).

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Wheat, Barley, Oats				
Chlorantraniliprole Coragen	250	101 ml	1	
Deltamethrin Decis Poleci	 200 ml 400 ml	 80 ml 162 ml	31 (oats) 40 (barley, wheat)	3-6,8,11
Cypermethrin Mako (wheat and barley only) UP-Cyde (wheat and barley only)	175 ml 285 ml	71 ml 115 ml	21	
Permethrin Pounce, Perm-UP Ambush	 180-390 ml 140-300 ml	 73-158 ml 57-121 ml	Treat prior to 6-leaf stage	1,2,6-9, 11, 12
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	0.875-1.2 L	0.354-0.486 L	60	1-6,8, 9, 11,12
Rye				
Chlorantraniliprole Coragen	250	101 ml	1	
Permethrin Pounce, Perm-UP Ambush	 180-390 ml 140-300 ml	 73-158 ml 57-121 ml	Treat prior to 6 leaf stage	
Corn				
Cyantraniliprole Fortenza	Seed Treatment: 83 – 167 ml / 100 kg seed			
Lambda-cyhalothrin Matador, Silencer	83 ml	34 ml	14	
Cypermethrin Mako UP-Cyde	 175 ml 285 ml	 71 ml 115 ml	21	
Permethrin Pounce, Perm-UP Ambush	 180-390 ml 140-300 ml	 73-158 ml 57-121 ml	Treat prior to 6 leaf stage	
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	2.4 L Pre-Plant treatment 1.2-2.4 L Seedling treatment	0.971 L Pre-Plant treatment 0.486-0.971 L Seedling treatment	70	1-6,8,11
Chlorpyrifos Pyrifos 15G	75 g per 100 m of row		70	

Buckwheat, Millet				
Chlorantraniliprole Coragen	250	101 ml	1	

It may take several days for optimum control from an insecticide application. Not all cutworms will surface to feed on any given night and come in contact with the insecticide on the soil and plants. One of the reasons is that during moulting periods (between larval stages) the cutworms are inactive (10).

Use low rates when larvae are small, high rates later in the season or under dry conditions. Apply in evening if possible.

Restrictions –

chlorpyrifos: Apply only once per season; do not apply to rye.
Deltamethrin: Do not graze fields. Apply only once per season for cutworms. Do not use at temperatures above 25°C.

References –

Army Cutworm

1. McDonald, 1979. J. Econ. Entomol. 72: 277.

Pale Western Cutworm

2. McDonald, 1981. J. Econ. Entomol. 74: 45.
3. Wise et al., Pest. Res. Rep. 1982:183,184
4. Wise, Pest. Rep. 1983:174.
5. Wise, Pest. Rep. 1984:189.
6. Charnetski and Byers, Pest. Res. Rep. 1985:185.
7. Hill and Byers, Pest. Res. Rep. 1985:183,186.
8. Byers and Charnetski, Pest. Res. Rep. 1986:129.
9. Salt and Seamans, 1945. Can. Entomol. 77: 150-155.
10. Byers *et al*. 1992. J. Econ. Entomol. 85: 1146-1149.

Redbacked Cutworm

11. McDonald, 1981. J. Econ. Entomol. 74: 593-596.
12. Philip and Dolinski. Pest. Res. Rep. 1977: 215-216.

European Corn Borer *Ostrinia nubilalis* (Hübner) (Lepidoptera: Crambidae)

Monitoring-

Adults: Pheromone-baited traps can be used to determine the onset and duration of European corn borer flight, and for initiating surveys of egg masses and shot hole damage (3). There are 2 pheromonal forms of the European corn borer, the Z or Iowa strain and the E strain. In the Canadian prairies, the European corn borer responds to the pheromone of the Iowa strain (4, 13). Delta-type traps were the most satisfactory of several tested for capturing moths under prairie conditions (4).

Eggs and leaf damage: Number of egg masses per plant and/or shot hole damage to leaves needs to be established to allow for timely implementation of control tactics. Sampling an entire corn plant is inefficient. Females are attracted to corn silks and deposit egg masses predominately on leaves near the ear (12).

Economic Thresholds –

Field Corn: For grain corn, the average grain weight reductions when stalk feeding was initiated during the 10-leaf, 16-leaf, blister and dough stages were 5.94, 5.01, 3.13, and 2.41 percent per larva per plant, respectively (11). Economic injury levels for larval populations initiating tunneling during different plant growth stages have been developed (11), and are of value in assessing the expected loss from European corn borer, however economic threshold values expressed in terms of the number of egg masses per plant need to be established to allow for timely implementation of control tactics.

Silage Corn: Economic injury levels have been developed for European corn borer on corn grown for silage, however these studies were performed in Wisconsin where there are 2 generations of European corn borer per year (2).

Cultural Control-
Resistant Cultivars - Cultivars of Bt corn (which express proteins from *Bacillus thuringiensis*) are resistant to feeding by European corn borer. If planting cultivars of Bt corn, a refuge of non-Bt cultivars is required to be planted to reduce the odds of European corn borer developing resistance to Bt corn. There are 2 types of refuge. Some cultivars of Bt corn will be purchased containing an integrated refuge (sometimes referred to as refuge-in-a-bag), where seeds of a refuge cultivar have been pre-mixed with seeds of the Bt cultivar in the bag. The refuge cultivar typically comprises 5% or 10% of the seeds in the bag. Bt cultivars without an integrated refuge blended in need to have blocks or strips of a cultivar susceptible to European corn borer planted within or adjacent to the Bt cultivar. This is called a structured refuge. Growers of Bt corn are also required to monitor their crop for the presence of European corn borer and any feeding damage. Details of the scouting requirements can be found at: http://www.cornpest.ca/index.cfm/resistance-management/scouting/scouting-ecb/
A table of currently commercialized *Bt* corn products in Canada (as of May 2018) is available at: https://www.cornpest.ca/bt-corn/bt-corn-products-traits-available-in-canada-as-of-may-2018/

Stalk Management – Primary tillage such as chisel plowing or moldboard plowing in the fall can reduce overwintering populations. Mowing corn stalks after harvest can reduce overwintering populations up to 85% (1).

Intercropping- In Ontario, intercropping of corn with clover significantly reduced European corn borer damage compared with monocropped corn at the same planting density (5).
A corn and soybean intercrop reduced the number of stalks with European corn borer (6).

Biological Control- Inoculative releases of *Trichogramma ostriniae* in sweet corn can reduce the number of European corn borer larvae, stalk tunnels, and damage to ears (7).
Honeydew from corn leaf aphid (*Rhopalosiphum maidis*) can potentially be an important within-field food resource that may increase the success of augmentative control of European corn borer by *Trichogramma ostriniae* released into cornfields (10).
Lady beetles were the most numerous predators of European corn borer in a study in North Dakota, while green lacewings and *Orius insidiosus* were also present (8). The insidious flower bug, *Orius insidiosus* (Anthocoridae) will search for and feed on eggs of European corn borer and other caterpillars on corn (14).

Chemical Control –
Caution: Honey bees will forage for pollen from corn, with peak foraging in the morning and early afternoon. A study in Delaware found that foraging by honey bees on corn occurred from 6:00 a.m. until 3:00 p.m. (15). If the corn is producing pollen and insecticides toxic to honey bees are to be used, insecticide application to corn should be timed to avoid this peak foraging activity of the honey bee.

Insecticide	Rate / ha	Rate / acre	Preharvest	References

			Interval (days)	
Corn				
Bacillus thuringiensis Dipel 2X DF	560-1120 g	0.23-0.45 kg	0	
Chlorantraniliprole Coragen	250 – 375 ml	101 – 152 ml	14	
Spinosad (sweet corn only) Success Entrust	 83 ml 50 g	 34 ml 20 g	 7 7	9
Spinetoram Delegate	120 – 210 g	49– 85 g	1 (sweet and seed) 28 (field)	
Deltamethrin Decis Poleci	 250-300 ml 500-600 ml	 100-120 ml 202-243 ml	N/A	
Lambda-cyhalothrin Matador, Silencer	 83 - 187 ml	 34 - 76 ml	14 (silage) 21 (field corn)	
Cypermethrin Mako UP-Cyde / Ship	 175 ml 280 ml	 71 ml 113 ml	 5 5	
Permethrin (sweet corn only) Ambush Pounce Perm-UP	 200 – 275 ml 275 – 375 ml 275 – 375 ml	 81 – 111 ml 111 – 152 ml 111 – 152 ml	 1 1 1	
Lambda-cyhalothrin + Chlorantraniliprole Voliam Xpress	500 ml	202 ml	1 (sweet corn) 14 (silage) 21 (field corn)	
Malathion Malathion 85E	 1.10-1.35 L	 0.45-0.54 L	 5	
Methomyl (sweet corn only) Lannate	 625 g	 253 ml	3	
Millet				
Chlorantraniliprole Coragen	250 – 375 ml	101 – 152 ml	1	

Reference –

1. Schaafsma et al. 1996. J. Econ. Entomol. 89: 1587-1592.
2. Myers and Wedberg. 1999. J. Econ. Entomol. 92: 624-630.
3. Palaniswamy et al. 1990. Can. Ent. 122: 1211-1220.
4. Struble et al. 1987. Can. Ent. 119: 291-299.
5. Lambert et al. 1987. J. Econ. Entomol. 80: 1192-1196.
6. Martin et al. 1989. J. Econ. Entomol. 82: 1455-1459.
7. Wright et al. 2002. Biological Control. 23: 149-155.
8. Frye. 1972. Environmental Entomology. 1: 535-536.
9. Musser and Shelton. 2003. J. Econ. Entomol. 96: 71-80.
10. Fuchsberg et al. 2007. Biological Control. 40: 230-236.
11. Bode and Calvin. 1990. J. Econ. Entomol. 83: 1595-1603.

12. Calvin et al. 1986. Environmental Entomology. 15: 1212-1219.
13. Smith et al. 2015. J. ent. Soc. Ont. 146: 41-49.
14. Reid. 1991. Journal of Economic Entomology. 84: 83-86.
15. Mason and Tracewski. 1982. Environmental Entomology. 11: 187-188.

Grasshoppers (Orthoptera: Acrididae)

Pest species:

Species that may damage cereal crops and grain corn in Western Canada include the migratory (*Melanoplus sanguinipes*), twostriped (*Melanoplus bivittatus*), Packard (*Melanoplus packardii*), and clearwinged (*Camnula pellucida*) grasshoppers. The redlegged, *Melanoplus femurrubrum*, and Carolina, *Dissosteira carolina*, grasshoppers are rarely pests, but are known to feed on corn, wheat and barley. Do not control grasshoppers unless damage is apparent and thresholds are exceeded. Avoid control actions until hatching of the pest species is nearly complete (usually after ca. June 5). Crop damage is more rapid in warm, dry weather and if the crop is drought-stressed.

Non-pest species:

Do not control any grasshoppers seen before late May or any grasshopper with red, yellow or orange hindwings (seen when flying).

Identification and Biology: A guide to identification and control of grasshoppers in the Canadian prairies is available to download at: https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/rsv13511/$FILE/Mar11_2008_grasshopper_book_DJ.pdf

Economic Thresholds – (refers to non-irrigated crops during warm, dry weather, June 1 – harvest))

Control	Field No./m^2	Roadside No./m^2
Control not usually required	0-6	0-12
May be Required	7-12	13-24
Control usually Required	13+	25+

Damage-

Two-striped grasshoppers at 5/m^2 from boot stage to maturity reduced yield of wheat by 25%. (6)

Ten grasshoppers/0.1 m^2 caged over wheat at 4-leaf stage destroyed the wheat in 72 hours. (4)

One grasshopper nymph/plant reduced yield by 25-44%. 11-27 /m^2 caused no damage, 45/m^2 caused 27-43% loss in cage tests (5); 8/m^2 clipped 20% of mature heads of wheat, and 16/m^2 reduced yields by 23%, 65%, and 62% in 1975. (l)

Cultural Control –

- No tillage methods will provide crop protection but fall stubble cultivation has reduced egg pod survival in some cases.
- Barrier strips of a non-preferred crop like oats, seeded at the margin of a field next to an infested area, may slow down young hoppers from invading susceptible crops. (16)

- Destroying green growth on stubble in the spring at the time of hatching may help to starve the young hoppers.
- Traps strips of weeds or barley, left in a summerfallow field adjacent to cropped land, attracts migrating hoppers to the strip where they can be controlled efficiently with insecticides. (17)

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Wheat, Barley, Oats				
Spreadable Bran Baits				
Carbaryl Eco bran	2-4 kg	0.8-1.6 kg	14 (oats, wheat) 28 (barley)	
Nosema locustae Nolo Bait	Minimum of 1.12 kg	Minimum of 0.45 kg	0	
Sprays				
Chlorantraniliprole Coragen	125-250 ml	51-101 ml	1	
Deltamethrin Decis 5EC Poleci	Decis: 100-150 ml (ground); 150 ml (air) Poleci: 200-300 ml (ground); 300 ml (air)	Decis: 40-60 ml (ground);60 ml (air) Poleci: 81-121 ml (ground); 121 ml (air)	31 (oats) 40 (wheat, barley)	6,8,15,18,19
Cypermethrin Mako (wheat and barley only) UP-Cyde (wheat and barley only)	50-70 ml 81-114 ml	20-28 ml 33-46 ml	30 (wheat) 45 (barley)	
Lambda-cyhalothrin Matador, Silencer (young grasshoppers only)	63-83 ml (ground), 83 ml (aerial)	25-34 ml (ground) 34 ml (aerial)	Do not apply within 28 days of harvest or 14 days of livestock foraging	-
Malathion Malathion 500 Malathion 85E	1.7 L 1.10-1.35 L	0.68 L 0.45-0.54 L	7 7	
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	580-875 ml	235-354 ml	60	5,6,7,13,14
Dimethoate Lagon / Cygon 480EC	Nymphs: 550 ml Adults: 850 ml-1 L	Nymphs- 0.22 L Adults- 0.34-0.40 L	35	4
Rye				
Spreadable Bran Baits				
Carbaryl Eco bran	20-40 kg	0.8-1.6 kg	14	
Nosema locustae Nolo Bait	Minimum of 1.12 kg	Minimum of 0.45	0	

		kg		
Sprays				
Chlorantraniliprole Coragen	125-250 ml	51-101 ml	1	
Malathion Malathion 500 Malathion 85E	 850 1.10-1.35 L	 0.69 L 0.45-0.54 L	 7 7	
Dimethoate Lagon / Cygon 480EC	Nymphs: 550 ml Adults: 850 ml-1 L	Nymphs- 0.22 L Adults- 0.34-0.40 L	35	4
Corn				
Spreadable Bran Baits				
Carbaryl Eco bran	20-40 kg	0.8-1.6 kg	1	
Nosema locustae Nolo Bait	Minimum of 1.12 kg	Minimum of 0.45 kg	0	
Buckwheat, Millet				
Chlorantraniliprole Coragen	125-250 ml	51-101 ml	1	

Product notes and Restrictions –

Nolo Bait: Nolo Bait contains spores of *Nosema locustae* applied to wheat bran. Infected grasshoppers become lethargic and reduce their feeding. Youngest grasshoppers usually die within 3 weeks of eating it, death of older grasshoppers may take longer. Healthy grasshoppers may cannibalize infected grasshoppers. This is a long-term suppression product.

Decis and Matador: Do not make more than 3 applications per year (only two applications per year by air). Best control is obtained if application is made when the grasshoppers are in the 2 – 4 nymphal stage.

Malathion: Do not apply at air temperatures below 20°C.

References –

1. Jacobson and Farstad, 1941. Can. Entomol. 73: 158.
2. Man. Dep. Agric. Bull., Agdex 605.
3. Pickford and Mukerji, 1974. Can. Entomol. 106: 1219.
4. Holmes et al., 1965. J. Econ. Entomol. 58: 77.
5. Charnetski, Pest. Res. Rep. 1975 : 210.
6. McDonald, Pest. Res. Rep. 1974:7.
7. Rourke and Baudic Fehr, Pest. Res. Rep. 1985:171,176.
8. Stephen and Hagborg, Pest. Res. Rep. 1985:172.
9. Johnson et al., Pest. Res. Rep. 1985:174.
10. Reichardt et al., Pest. Res. Rep. 1986:124.
11. Stephen et al., Pest. Res. Rep. 1986:148.
12. Wise and Scholtz, Pest. Res. Rep. 1986:149.
13. Mackasey et al., Pest. Res. Rep. 1986:147.
14. Rourke and Buth, Pest. Res. Rep. 1986:125.
15. Johnson et al., 1986. J. Econ. Entomol. 79:181-188.
16. Olfert, Grasslands and Grassland Health. 2000: 61-70.
17. Olfert, 1986. Can. Entomol. 118: 133-140.
18. Wise and Long, Pest. Res. Rep. 1985: 180.
19. Leader, Durling and Mader. Pest. Res. Rep. 1986: 153.

Hessian Fly *Mayetiola destructor* (Say) (Diptera: Cecidomyiidae)

Economic Threshold: Not established.

Damage – Death of individual wheat and barley tillers or of the entire plant may result if numerous larvae are present (more than several per plant). Flaxseed-shaped puparia may be found at the base of plants.

Cultural Control –
- Never plant wheat in the same field 2 years in a row in areas where Hessian flies are a problem.
- Winter wheat planted in September will likely be free of Hessian flies.
- Eliminating or reducing volunteer wheat host plants may reduce fly population.
- Early seeded spring wheat is less susceptible to stem breakage caused by Hessian fly than later seeded wheat (1). Crop damage in Manitoba was found to be highest when spring wheat was sown in the first two weeks in June and was caused by the feeding of second generation larvae.
- The spring wheat cultivar Superb is partially resistant to Hessian fly (2,3).

Chemical Control -
- No insecticides are registered for the control of Hessian flies in cereals.

References -
1. Wise, 2007. Proc. Ent. Soc. Man. 63: 8-22.
2. Wise, Pest Man. Res. Rep. 2003:134-135.
3. Wise *et a*l. 2006. Can. Entomol. 138: 638-646.

Seedcorn Maggot *Delia platura* (Meigen) (Diptera: Anthomyiidae)

Chemical Control –

Insecticide	Rate	Preharvest Interval (days)	References
	Corn Only		
Thiamethoxam Cruiser Maxx Corn	83 – 166 ml Cruiser 5FS / 100 kg seed		
Clothianidin Poncho 600 FS Nipsit Inside	33.3 – 66.6 ml per 80,000 unit of seed		

Restrictions-
Dust generated during planting of seed treated with neonicotinoid insecticides may be harmful to bees and other pollinators.
When using a seed flow lubricant for planting corn or soybean seed treated with the neonicotinoid insecticides clothianidin, thiamethoxam or imidacloprid, only a dust-reducing fluency agent is permitted to minimize the potential for abrasion that produces insecticidal seed dust. Talc and graphite are not permitted to be used as a seed flow lubricant for corn or soybean seed treated with these insecticides.To

help minimize the dust generated during planting, refer to “Pollinator Protection and Responsible Use of Treated Seed- Best Management Practices” on the Health Canada webpage on pollinator protection at http://www.healthcanada.gc.ca/pollinators

Spider Mites

Spider mites (on corn)

Populations of spider mites may increase significantly under hot and dry conditions.

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
Corn				
Spiromesifen Oberon	400 – 600 ml	162 – 243 ml	Green forage – 5 Grain or stover - 30	

Levels of spider mites may be increased by the use of synthetic pyrethroid insecticides (1) and some fungicides. Avoiding unnecessary pesticide applications and careful choice of products is encouraged when the risk of spider mites is high.

References -

1. Gerson and Cohen 1989. Experimental and Applied Acarology. 29-46.

Thrips (Thysanoptera: Thripidae)

Thrips (on barley, oats, and wheat)

Monitoring-

A sequential sampling plan has been developed for barley thrips (*Limothrips denticornis* Hal.) on barley (1). Adult barley thrips are counted on the top 2 leaf sheaths of barley on a minimum of 9 plants.

Decision limits[a] for cumulative counts of barley thrips adults on the top 2 leaf sheaths of barley.

No. barley plants sampled	No treatment required	Treatment required
9	32	85
18	80	154
27	130	221
36	181	287

[a]If the cumulative count is less than or equal to the lower limit, an insecticide treatment is not recommended.. If the cumulative count is greater than or equal to the upper limit, an insecticide application is recommended. Values between limits indicate a decision cannot be made and another nine samples must be taken.

Economic Threshold-

Research from North Dakota found that one adult barley thrips per stem of barley resulted in a loss of 0.4 bushels per acre (2).

Treat when thrips are equal to or greater than the number calculated by:
Threshold (Thrips/stem) = (Cost of Control ÷ expected $ value per bushel)/0.4
Insecticide treatments for barley thrips on barley are only economical when applied before heading is complete (3).

Chemical Control –

Insecticide	Rate / ha	Rate / acre	Preharvest Interval (days)	References
		Wheat, Barley & Oats		
Methomyl Lannate	300 g	0.1214 kg	20	
Dimethoate Lagon / Cygon	1 L	0.40 L	35	4

References -

1. Bates *et al*. 1991. J. Econ. Entomol. 1630-1634.
2. Bates *et al*. 1991. NDSU Extension Service : E-1007
3. Post. 1958. Dakota Farmer. 30-31.
4. Butts, Pest. Res. Rep. 1985:144.

Wheat Midge — *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae)

Economic Threshold -
For yield only: 1 adult midge per 4 to 5 heads. At this level of infestation, common and durum spring wheat yields will be reduced by approximately 15% if the midge is not controlled.
To maintain optimum grade: 1 adult midge per 8 to 10 wheat heads during the susceptible stage.

Damage –
Research in Saskatchewan found that infestations of 30, 60 and 90% of kernels infested reduced spring wheat yields by 40, 65 and 80% (1).

Midge Tolerant Wheat –

- There are many varieties of wheat resistant to feeding by wheat midge. For an updated list of varieties and information to protect their effectiveness see: http://www.midgetolerantwheat.ca/farmers/

Cultural Control –

- Rotate Crops – Continuous wheat cropping encourages higher wheat midge populations.
- Seed alternate crops including barley.
- Farming practices which promote greater crop uniformity during heading and flowering (uniform seeding depth, higher seed rates to reduce tillering) reduce midge kernel damage but may not eliminate the need for chemical control.

Biological Control – A parasitoid, *Macroglenes penetrans*, was found to control an average of 33% of the wheat midge in Saskatchewan (10).

Chemical Control –

Insecticide	Rate (g or L/ha)	Rate (g or L/acre)	Preharvest Interval (days)	References
Wheat Only				
Chlorpyrifos Lorsban, Pyrinex, Nufos, Citadel, Warhawk	0.83-1 L	0.336-0.405 L	60	5,6, 7,8,9
Dimethoate Cygon, Lagon	1 L	0.40 L	35	5,6,8,9

When applied 3 to 6 days after oviposition begins, chlorpyrifos provides ca. 20-30% better kernel protection than carbofuran (presently deregistered) or dimethoate. Sprays should be applied in the late afternoon or evening when temperatures exceed 15°C and the wind speed is less than 10 km/ha. To obtain full benefits from insecticidal sprays, thorough coverage of the wheat heads is essential. In general, application methods which improve the uniformity and amount of spray deposited on wheat heads (higher water volumes, finer spray droplets, 45^0 nozzle orientation) provide better kernel protection and subsequent grade or yield improvements. Use the higher rate of Lorsban 4E for aerial application, with water volumes of 20-35 L/ha.

References -

1. Olfert et al., 1985. Can. Entomol. 117:593-598.
2. Fox et al. 2010. Can. J. Plant Sci. 90: 71-78.
3. Wise et al., 2008. Pest Man. Res. Rep. 100-102.
4. Fox et al. 2009. Can. J. Plant Sci. 89: 929-936.
5. Dexter et al., 1987. Can. J. Plant Sci. 67:697-712.
6. Elliot, 1988. Can. Entomol. 120:615-626.
7. Wise and Leader, Pest. Res. Rep. 1985:181-182.
8. Sask. Ag. Midge Bull. 1988. 2 pp.
9. Elliot, 1988. Can. Entomol. 120:941-954.
10. Olfert et al., 2003. Can. Entomol. 135:303-308.

Wheat Stem Maggot — *Meromyza americana* Fitch (Diptera: Chloropidae)

Plants with wheat stem maggot may have white heads which contain no kernels at a time when uninfested heads are still green (1).

Cultural Control – Crop rotation can limit damage in small grain cereals.

Biological Control – Six species of hymenopterous parasites of wheat stem maggot were found in cereal crops in South Dakota (2).

References -

1. Branson et al. 1967.
2. Morrill and Kieckhefer. 1971. J. Econ. Entomol. 64: 1129-1131.

Wheat Stem Sawfly — *Cephus cinctus* Norton (Hymenoptera: Cephidae)

Can be an economical pest of wheat. Wheat stem sawfly can complete its life cycle in all cereal crops except oats. Durum wheat and barley are not as susceptible to stem lodging as the bread wheat class (6).

Economic Thresholds -

Control required if 10-15% of crop in previous year is cut by sawfly. Infested stems of wheat averaged 17% (11-22%) loss in yield. (1)

Cultural Control -

Solid-stem wheat varieties (such as the Canada Northern Hard Red varieties AC Lillian, AC Abbey, AC Eatonia, and the durum varieties AAC Raymore and CDC Fortitude) can reduce damage by wheat stem sawfly larvae compared to susceptible varieties (2, 3, 4, 7, 8), however the level of control can vary depending on environmental conditions.

Biological Control -

A parasitoid, *Bracon cephi* (Hymenoptera: Braconidae), can reduce populations of wheat stem sawfly in localized areas (5).

Parasitoids of wheat stem sawfly can be conserved by increasing stubble height at harvest and by restricting insecticide applications during peak flight of the adult parasitoids (6).

Chemical Control -

No insecticides are registered for wheat stem sawfly.

References -

1. Holmes, 1977. Can. Entomol. 109:1591.
2. Beres et al. 2007. J. Econ. Entomol. 79-87.
3. DePauw et al., 1994. Can. J. Plant Sci. 821-823.
4. DePauw et al., 2005. Can. J. Plant Sci. 397-401.
5. Holmes et al. 1963. Can. Entomol. 95: 113-126.
6. Beres et al. 2011. Can. Entomol. 143: 105-125.
7. Singh et al. 2014. Can. J. Plant Sci. 94: 1289-1296.
8. Pozniak et al. 2015. Can. J. Plant Sci. 95: 1013-1019.

White Grubs — (Coleoptera: Scarabaeidae)

Chemical Control –

Insecticide	Rate	Preharvest Interval (days)	References
Corn Only			
Clothianidin Poncho 600 Nipsit Inside	33.3 mL per 80,000 unit of seed	-	-

Restrictions-

Dust generated during planting of seed treated with neonicotinoid insecticides may be harmful to bees and other pollinators.
When using a seed flow lubricant for planting corn or soybean seed treated with the neonicotinoid insecticides clothianidin, thiamethoxam or imidacloprid, only a dust-reducing fluency agent is permitted to minimize the potential for abrasion that produces insecticidal seed dust. Talc and graphite are not permitted to be used as a seed flow lubricant for corn or soybean seed treated with these insecticides.To help minimize the dust generated during planting, refer to “Pollinator Protection and Responsible Use of Treated Seed- Best Management Practices” on the Health Canada webpage on pollinator protection at http://www.healthcanada.gc.ca/pollinators

Wireworms (Coleoptera: Elateridae)

Commom wireworms in the Canadian prairie provinces include *Hypnoidus bicolor*, the prairie grain wireworm, *Selatosomus destructor*, and in the western part of the prairies the sugarbeet wireworm, *Limonius californicus*, can be common. Other species of wireworms are more common in other regions of Canada.

Cultural Control -

Shallow seeding into moisture and firm packing may reduce damage.

Biological Control –

The fungus *Metarhizium anisopliae* Sorokin (Hypocreales: Clavicipitaceae) can infect and kill wireworms (3).

Chemical Control –

Insecticide	Rate	Preharvest Interval (days)	References
Wheat, Barley, Oats And Rye			
Thiamethoxam Cruiser Vibrance Quattro Cruiser 5FS (wheat, barley, and rye only)	325 ml / 100 kg seed 17-50 ml / 100 kg seed	-	
Imidacloprid Raxil ProShield (wheat, barley and oats only) Raxil WW (wheat, barley and oats only) Alias 240 SC (wheat, barley and oats only) Sombrero 600 FS (wheat, barley, and oats only)	42-125 ml per 100 kg of seed 17 – 50 ml / 100 kg seed		
Clothianidin Nipsit Suite Cereals (wheat only) Nipsit Inside	326 ml / 100 kg seed 17 – 100 ml / 100 kg seed		
Corn			
Thiamethoxam Cruiser Maxx Corn	83 ml Cruiser 5FS / 100 kg seed	-	

Clothianidin Poncho 600FS Nipsit Inside	33.3-66.6 ml per 80,000 unit of seed	-	-
Imidacloprid Sombrero	0.16 mg per kernel		
Cyantraniliprole Fortenza			

Wireworms exposed to neonicotinoid insecticides (clothianidin, thiamethoxam, imidacloprid) become intoxicated long enough for the crop to become established, but the wireworms may fully recover later in the season.
Some neonicotinoid insecticides may result in wireworms moving to the soil surface where they may be at greater risk of desiccation or predation (1).
The efficacy of insecticides for wireworm control may be affected by the species of wireworm present (2).

Restrictions-
Dust generated during planting of seed treated with neonicotinoid insecticides may be harmful to bees and other pollinators.
When using a seed flow lubricant for planting corn or soybean seed treated with the neonicotinoid insecticides clothianidin, thiamethoxam or imidacloprid, only a dust-reducing fluency agent is permitted to minimize the potential for abrasion that produces insecticidal seed dust. Talc and graphite are not permitted to be used as a seed flow lubricant for corn or soybean seed treated with these insecticides.To help minimize the dust generated during planting, refer to “Pollinator Protection and Responsible Use of Treated Seed- Best Management Practices” on the Health Canada webpage on pollinator protection at http://www.healthcanada.gc.ca/pollinators

References -

1. Vernon et al. 2008. J. Econ. Entomol. 365-374.
2. van Herk et al. 2007. J. Entomol. Soc. Brit. Columbia. 55-63.
3. Kabaluk and Ericsson. 2007. Environmental Entomology. 36: 1415-20.