



# HORT SNACKS

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Welcome to another month and another edition of Hort Snacks. We've gone from cool and wet (mostly), to blistering hot and dry, with a sprinkling of severe summer storms to add spice. While I am grateful to my Danish and Scottish ancestors for many things, if they could have been a little less pasty and anti-sun, it would have been appreciated...

This is somewhat of a record-breaking edition; it is a big one! Inside, you'll find many different events that you should consider attending, quite a few tidbits of knowledge that you might glean for your use and a bunch of big reference tables. The tables outline the different modes of action that make up chemical (pesticide) groups/families, putting into somewhat easier-to-understand language, what they actually do and how they actually work. When you have a few free moments, consider what some of the MOAs do and what that means for your chemical applications. Effective chemical use is an important tool in an integrated pest management system.

Since the newsletter is so long, I'll keep the intro short. We hope to get out and about to see many of you this summer, or that we'll at least see you at a field day, workshop or some other event. If you have questions, concerns, suggestions, ideas, reports or just want to chat, give us a call. We love to hear from you. Stay safe, take a moment or two for yourself once in a while and enjoy the sunshine.

Rob Spencer / Dustin Morton, Commercial Horticulture Specialists  
Alberta Ag-Info Centre  
Alberta Agriculture and Rural Development  
310-FARM (3276)



## Featured Website

INTRODUCING THE NEW...

### Horticulture Microsite

[www.agriculture.alberta.ca/horticulture](http://www.agriculture.alberta.ca/horticulture)



August 2014

### *In this edition of Hort Snacks*

▪ Featured Website	.....1
▪ Things to do / Things to think about this month	.....2
▪ In the News / Interesting Articles	.....2
▪ Upcoming Conferences / Workshops	.....3
▪ Hort Field Day – Aug 2014	.....3
▪ Mental Snacktime – Weather	.....3
▪ For Sale – 3 door cooler	.....3
▪ Bus Tour poster	.....4
▪ Hort Pest Surveillance project	.....6
▪ Q&A	.....6
▪ Insect of the Month – Raspberry Sawfly	.....7
▪ Disease of the Month – Physiological Disorders – Heat/Drought, etc.	.....8
▪ Pesticide Groups – What are they & what do they mean	9
▪ Insecticide Mode of Action List	.....10
▪ Herbicide Mode of Action List	.....14
▪ Fungicide Mode of Action List	.....19

## THINGS TO DO / THINGS TO THINK ABOUT THIS MONTH

### **Strawberries**

- 2<sup>nd</sup> nitrogen application should be made to June bearing strawberries mid-August → 15-20 lbs actual N/ac
- Continue to cultivate June bearers between rows (same direction) after harvest to ensure good aeration and incorporation of straw and decrease next year's disease and slug population
- Maintain uniform soil moisture to facilitate rooting of runners
- Continue nitrogen feeding of day-neutrals until end of August → 10-20 lbs actual N/ac/month applied in weekly or bi-monthly applications
- Apply field cooling to day-neutrals if temperatures remain high (over 30°C)
- Application of herbicides after harvest (June bearers) if quackgrass or other grass is a problem
- Application of herbicides before mid-August (after harvest) for control of hard-to-control broadleaf weeds (June bearers only)
- Line up a clean wheat or rye straw for a mulch supply. Run straw through the combine twice to reduce the number of weed seeds (or volunteer grain) in the straw or have it ammoniated (Note: ammoniation is a dangerous and costly process)

### **Raspberries**

- Increase watering until harvest completion
- Continue irrigation after harvest to maintain growth of new canes
- Trellis primocane raspberry canes (if required)
- Cultivation between rows after harvest to break up compacted soil
- Delay spent cane removal on floricanes until September

### **Saskatoon Berries**

- Prune diseased plants
- Remove non-species plants

### **Vegetables**

- Continue to supply water through to crop maturity, particularly during the fruit filling or maturation process
- Small amounts of foliar nutrient applications may be required to maintain plant growth and health

### **General / Other**

- Maintain good weed control (harbouring of disease and insect pests)
- Commence or complete harvest operations, ensuring crops are harvested carefully, at appropriate mature stages and cooled quickly to prolong post-harvest lifespan
- For most fruit crops, particularly tree or bush fruit, reduce the supply of water towards the middle of the month and do not water after the end of the month – watering can slow or prevent the onset of dormancy and can increase winter kill in some crops
  - e.g. Apples – will not shut down growth if water continues to be available
- Visit a fellow producer

### **Pest Monitoring / Management**

- Continue to monitor for pests and diseases, controlling as required, remembering to adhere to Pre-Harvest Intervals
- Strawberries
  - Continue to monitor for Tarnished Plant Bug and apply appropriate control measures
- Raspberries
  - Control mites as required

### **In the News / Interesting Articles**

[Twisted fruit, vegetables get new lease on life](#) – Fruit & Veggie Magazine article

[Plants are talking and these sensors let us hear what they're saying](#) – Treehugger.com article

[Urban Produce to open first patented high density vertical growing unit](#) – HortiDaily article

[Flea Beetles on Crucifer Crops](#) – OMAF article

[Do Organic farmers feel happier than conventional ones? An exploratory analysis](#) – Ecological Economics journal article

[Plant growth researchers play with Lego. For science](#) – wired.co.uk article

### **NEWSLETTER USE RESTRICTIONS**

Please feel free to share all or portions of this newsletter with other interested parties.

If you want to use content from this newsletter in other media, please request permission before doing so.

## UPCOMING EVENT

### Horticulture Field Day

A summer field day is planned for the Lacombe area on **August 11<sup>th</sup>, 2014**. We will be visiting Billyco Junction Gardens and Wolf's Botanicals, east of Lacombe. The following is the tentative agenda:

**11:30-Noon:** Registration

**Noon – 1 pm:** Lunch at Billyco Junction Gardens (about 8 km east of Lacombe on Hwy 12, south on Prentiss Road (RR 26-0) about 4.4 km)

**1 – 3 pm:** Tour of Billyco Junction Garden (CSA, U-pick fruit/veg, Honeyberry Café, Honeyberry Inn B&B)

**3 – 3:15 pm:** Travel to Wolf's Botanicals (just north and east of Billyco Junction Gardens)

**3:15 – 4:30 pm:** Tour Wolf's Botanicals (greenhouse, garden centre, nursery, raspberry planting, wedding venue)

There is no cost to attend this event.

R.S.V.P. to Alberta Farm Fresh Producers Association (1-403-558-0189) or email

[info@albertafarmfresh.com](mailto:info@albertafarmfresh.com) by **AUGUST 5, 2014**

### MENTAL SNACKTIME – Weather

"Sunshine is delicious, rain is refreshing, wind braces us up, snow is exhilarating; there is really no such thing as bad weather, only different kinds of good weather." – John Ruskin

"Climate is what we expect, weather is what we get." – Mark Twain

"It is only in sorrow bad weather masters us; in joy we face the storm and defy it." – Amelia Barr

"If you want to see the sunshine, you have to weather the storm." – Frank Lane

"We may achieve climate, but weather is thrust upon us." – O. Henry

"A change in the weather is sufficient to recreate the world and ourselves." – Marcel Proust

## Upcoming Conferences / Workshops

### August 2014

- Horticulture Field Day  
August 11, 2014 – Lacombe area, AB  
[www.albertafarmfresh.com](http://www.albertafarmfresh.com)
- NAFDMA Advanced Learning Retreat 2014  
Aug 15-18, 2014 – Anderson's Farm – Erie, Colorado, USA  
<http://www.farmersinspired.com/alr2014/>
- Independent Garden Centre Show  
August 19-21, 2014 - Navy Pier - Chicago, Illinois  
[www.igcshow.com](http://www.igcshow.com)
- North American Strawberry Growers Association (NASGA) Summer Tour  
August 20-21, 2014 – Abbotsford, British Columbia area  
[www.nasga.org](http://www.nasga.org)
- Farwest Show  
Aug 21-23, 2014 – Oregon Convention Centre – Portland, OR  
<http://www.farwestshow.com/>

### September 2014

- Potato Europe 2014  
Sept 3-4, 2014 - Brokerode (near Hanover), Germany  
<http://www.potatoeurope.com/>
- 2014 Canada's Outdoor Farm Show  
Sept 9-11, 2014 – Woodstock, ON  
[www.outdoorfarmshow.com](http://www.outdoorfarmshow.com)
- Leading the Way – Innovators in Farm Direct Marketing (Bus Tour)  
Sept 10, 2014 – Edmonton area  
See ARD Coming Events for details
- 11<sup>th</sup> Canadian Urban Forest Conference – Urban Forests by Design  
Sept 30 – Oct 2, 2014 – Victoria ConfCentre – Victoria, BC  
<http://www.cufc11.ca/en/>

### October 2014

- CanWest Horticulture Show  
Oct 1-2, 2014 – Vancouver Convention Centre – Vancouver, BC  
[www.canwesthortshow.com](http://www.canwesthortshow.com)
- Canadian Greenhouse Conference  
October 7-9, 2014 – Scotiabank Convention Centre, Niagara Falls, ON  
[www.canadiangreenhouseconference.com](http://www.canadiangreenhouseconference.com)
- Fresh Summit International Convention & Exposition  
October 17-19, 2014 – New Orleans, Louisiana, USA  
<http://www.freshsummit.com/>



### FOR SALE

- 3 door cooler
- Fine working condition
- Used during harvest time
- Asking \$795.00 OBO
- Contact **The Blooming Field** (Didsbury, AB)





invite you to

## Leading the Way: Innovators in Farm Direct Marketing

Farm direct producers are invited to join us September 10 for a one-day tour of innovative farm direct production and marketing operations in the Edmonton area.

### Content for the Day

#### 8:00 am departure

##### Southwest Edmonton Farmers' Market

- The bus will depart promptly from the Terwilligar Recreation Centre parking lot just north of 23rd Avenue at 2051 Leger Road.

##### Riverbend Gardens

- See Riverbend Gardens through the eyes of Janelle Herbert, co-owner and operator. Discover new media marketing strategies from this social media maven as you learn about their thriving CSA operation and vibrant farmers' market sales.

##### Horse Hill Berry Farm

- This pesticide-free U-pick has received rave reviews from clients since opening in 2008. Their unique location along with their strong ag-vocacy have established their profile in the Edmonton area and made them leaders in their industry. Jackie Clark will share secrets to their success and perspectives from inside the U-pick.

##### Prairie Gardens and Adventure Farm

- Tam Andersen runs this incredible U-Pick, CSA, market garden and agritourism hub near Bon Accord. Andersen is a marketing guru when it comes to agritainment and her ability to connect with her clients is second-to-none. Learn agritourism tips from one of the best in the industry.

##### Kuhlmann's Market Garden

- In business since 1962, three generations effectively operate this family owned business. Anita McDonald will discuss this incredibly diverse operation and how it has changed through the years to suit their clients.

#### 6:00 pm return

##### Southwest Edmonton Farmers' Market

- Get the inside scoop on entering the market, customer demographics, up and coming products and potential areas of expansion from a SWEFM board member. As you tour the market, talk to our tour stop hosts and others who vend there for their insider view of the market.

### Registration and Information

**Date:** September 10, 2014

**Registration deadline:** September 2, 2014

**Time:** 8:00 am – 6:30 pm

**Cost:** \$50 per person, includes snacks and lunch

### For More Information

Dustin Morton  
Alberta Agriculture and Rural Development  
403-742-7571  
[dustin.morton@gov.ab.ca](mailto:dustin.morton@gov.ab.ca)



# Leading the Way: Innovators in Farm Direct Marketing

Join us for this one-day tour in the Edmonton area

## September 10, 2014

Registration deadline: **September 2, 2014**

Name(s): \_\_\_\_\_

Business Name (if applicable): \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ Province: \_\_\_\_\_ Postal Code: \_\_\_\_\_

Phone: \_\_\_\_\_ Cell phone: \_\_\_\_\_

Email address: \_\_\_\_\_

Website: \_\_\_\_\_

### \$50 per person

(includes lunch, snacks and bus transportation)

Cheque enclosed in the amount of: \$ \_\_\_\_\_

Please make registration cheque payable to: **AFFPA**

Please note: **you are not registered until your payment is received by Alberta Agriculture and Rural Development.**

**To register, mail this form and cheque to:**

Delores Serafin  
Alberta Agriculture and Rural Development  
Room 200, 7000 113 ST NW  
Edmonton, AB T6H 5T6  
780-427-4611

(for toll-free calling in AB, dial 310-0000 then the number)

**For more information about the tour contact:**

Dustin Morton at [dustin.morton@gov.ab.ca](mailto:dustin.morton@gov.ab.ca) or  
403-742-7571

(for toll-free calling in AB, dial 310-0000 then the number)

The information that may identify you on this form is being collected by both Alberta Agriculture and Rural Development and Alberta Farm Fresh Producers Association for the registration and administration of this workshop. The collection is done under the authority of and subject to the Freedom of Information and Protection of Privacy Act (FOIP Act). If you have any questions about this collection or how your information will be used, please contact the Local Market Specialist, Alberta Agriculture and Rural Development, 780-853-8223, 4701 52 Street, Vermilion AB T9X 1J9, [eileen.kotowich@gov.ab.ca](mailto:eileen.kotowich@gov.ab.ca).





## Hort Pest Surveillance Project monitors for threats and emerging pests

In recent years, there have been many reports of disease issues in a number of different crops, in some cases going beyond what is expected or breaking free from the status quo. As a result, a collaborating group of pathologists and entomologists, industry and government specialists is undertaking a Horticulture Pest Surveillance project in Alberta for 2014 and 2015.

Over the last few years, there has been a great deal of concern in Alberta surrounding a serious disease called Late blight that affects mainly potatoes and tomatoes. This disease is caused by a fungal pathogen called *Phytophthora infestans*. The favourable conditions for disease development, combined with the presence of the pathogen, have resulted in multiple outbreaks of Late blight in commercial, market garden and urban potato and tomato crops throughout parts of Alberta. A number of different strains of the pathogen have been identified in different years, each being more or less aggressive on either potatoes or tomatoes. For 2014, this disease continues to be a risk for all Solanaceous crops (potato/tomato family) grown in Alberta. Surveillance and awareness activities are ongoing across potato, market garden, greenhouse vegetable and garden centre industries, as well as to the public. Information and help is readily available for all. If you find plants showing suspicious lesions, it is recommended that you can contact 310-FARM (3276) to determine if further testing is required and to discuss management. Please do not hesitate to report an incidence, as early detection will help to prevent and contain an outbreak and can help others to protect their crops. To this point, sporangia are being trapped in spore traps, but the disease has not yet been reported. High temperatures and dry conditions are less desirable for the disease.

### Information on Late Blight

#### [FAQ – Late Blight of Potatoes and Tomatoes](#)

At the same time, the project team is collecting samples from **onion/garlic crops** that exhibit symptoms of a range of diseases. Soil testing is also planned for several sites. If you are a grower of garlic or onions, you are encouraged to monitor crop and submit samples as they appear.

Weather stations and insect traps have been installed at 10-12 locations across Alberta to monitor for potential/emerging pests, including Spotted Wing Drosophila (SWD), Brown Marmorated Stink Bug (BMSB) and Swede Midge.

If you want more information on any or all of these monitoring projects, please feel free to contact Rob Spencer at 310-FARM (3276).



### Q: How do you deal with problem customers?

A: I have broken this down into 2 types of customers: someone with a complaint and someone who is being disruptive/disrespectful/refusing to pay.

For the complaining customer I teach my staff 3 things: Listen, Listen, Listen! In our experience, at least 50% of their frustration and forcefulness disappears when they feel they've really been listened to. The next most important thing is that the 1st person they speak to about their problem can give them a compelling answer (solve their problem, or take it upon themselves to make sure it is resolved). I find customers get more agitated every time they need to tell their story to another staff member. I give my staff scripts; not exact words to say, but I do tell them what to say so they don't panic, look like a deer in the headlights in front of an angry customer and run for the nearest manager. When the customer feels confident that the staff person is going to work with them towards a solution and stick with them until the issue is resolved, they are far more cooperative and willing to accept what we offer. 98% of people will continue to do business with you if you can resolve their issue on the spot.

For the disruptive/disrespectful customer or one refusing to pay their bill I do prefer to bring in a manager. Although this rarely happens we deal with it by being firm and bringing the conversation down to facts, not emotions. i.e.: "The contract we signed states that you have agreed to pay this amount and we have provided you with the services described here. Your obligation is now to pay in full." Or "Let's talk about what exactly has gone wrong here." I believe that addressing these issues immediately is very important. When a customer has had to wait longer than they feel is fair, they become more and more forceful. They will add to their list of grievances "And I left multiple messages and never got a call back". You're going to have to deal with it anyway, you might as well deal with it quickly so you can both move on. – Judy Kolk Kayben Farms

A: While I don't have paying customers (and I HATE conflict), I simply do my best to listen, try not jump to conclusions, gather as much information as I can and then provide the best answer that I can, as quickly as I can. I try to show that I want to help, even if we come to the mutual understanding that I can't. If that means getting someone else to help, then so be it. By being friendly and genuine, I try to erode any animosity or confrontation. It isn't a perfect system, but I'm going with it. – Rob Spencer (AARD)

Next Month's ? → [Biggest Issues with post-harvest?](#)

# INSECT OF THE MONTH

## Raspberry sawfly

*Monophadnoides geniculatus*

**Crops Affected:** all caneberry crops (raspberry, blackberry, loganberry) and possibly gooseberry

### Life Cycle:

- Adults emerge in spring
- Lay eggs at flowering in leaf tissues
- Larvae feed for 2-3 weeks on leaf undersides, flower buds, young fruit, growing shoots and tender bark of new growth
  - Particularly destructive on primocanes due to lush growth later in season
- Drop to ground and overwinter in a cocoon
- Pupation occurs in spring
- 1 generation per year

### Symptoms:

- Adult are small, black insects with a yellow band on their abdomen and clear wings
- Larvae are light green caterpillars with white bristles, which can reach 10-18 mm in size
  - Typically difficult to see larvae on leaves due to their colouration and feeding location
- Larval feeding on the leaves produces small, elongated holes between the leaf veins
- Heavy infestations results in skeletonized leaves (veins intact)

### Monitoring:

- Visually inspect leaves in June
- Determine the number of larvae present
- Determine whether skeletonization is occurring and if controls are required
- Damage by raspberry fruitworm larval early season feeding on fruiting cane laterals can be confused with raspberry sawfly damage, which is mainly on new primocane growth

### Management:

- Vigorous plantings can tolerate a fair amount of feeding and damage before controls are required
- Chemical controls are available if significant damage is occurring



Raspberry sawfly feeding damage – Note elongated holes between veins – light skeletonization

**Rob Spencer, BSA, MSc, P.Ag.**  
**Commercial Horticulture Specialist**

**robert.spencer@gov.ab.ca**

Alberta Ag-Info Centre

**310-FARM** (3276)

August 2014 FAX: 403-742-7527

[Pest Management Regulatory Agency \(PMRA\) – Electronic Label Search Engine](#)

Search the database for electronic labels

## Physiological Disorders – Heat / Drought related Deformities

**Crops Affected:** range of crops (depending on disorder)

**Symptoms / Conditions Favouring Development:**

### *Hollow Heart (potatoes)*

- Common in oversized or rapidly growing, early tubers
- Very dependent on cultivar
- Most severe under rapid tuber growth conditions
  - Uneven moisture (dry followed by wet) or fertility
  - Wide plant spacing or missing plants
- No visible external symptoms
- Internal symptoms – tan to brown walled cavities that develop from brown areas at or near the centre of tubers

### *Hollow Stem (broccoli and cauliflower)*

- No visible external symptoms
- Small cracks occur internally, which coalesce to form a hollow central stem
- Cause is suggested to be related to plant nutrient balance, as well as growth conditions after head initiation

### *Forking (carrots)*

- Cause can be a result of disease or pest damage, compacted or heavy soils, excessive plant densities, or other factors that damage the root tips
- Location of the fork can give an indication of when the damage occurred and may suggest probable cause

### *Growth Cracks (carrots, rutabaga, turnips, potatoes, cabbage, tomatoes, cherries)*

- Rapid tissue growth leads to vertical cracking, with cracks varying in size
  - Cracks may originate along root or tuber or in neck areas
  - Older cracks may have a layer of rougher wound tissue over the inside of the crack
  - More typical on larger roots
- Fruit cracking can occur as radial or concentric cracks
  - Can occur as “bursting” when very rapid
- Is typically the result of fluctuating soil moisture levels, specifically when abundant moisture follows a dry spell

### *Jelly End Rot (potatoes)*

- Most prevalent in Russet Burbank potatoes
- Stem end tissues of tubers become glassy, jelly-like and shrivels and dries up
- Favoured by high soil temperatures and dry conditions followed by excellent moisture
- Often associated with misshapen tubers

### *Brown Bead (broccoli)*

- Buds of broccoli florets turn tan or brown and can fall off easily
- Associated with rapid growth in high temperatures following abundant moisture

### *Sunscald (various crops)*

#### *Bulb crops*

- Soil level tissues shrivel, and the plant withers and dies
- Young, sensitive plants are damaged by hot, sunny conditions in dry springs

#### *Beans / Fruit crops (e.g. tomatoes)*

- Small, water-soaked spots on plant parts only on exposed sides of the plant, typically in intense, direct sunlight following cloudy, high humidity and high temperature conditions
- Spots become brown to white and grow together to form large necrotic lesions; may be sunken

### **Management:**

- Maintain adequate (and uniform, if possible) moisture levels throughout the growing season
  - This may involve the use of irrigation, improving soil moisture hold capacity, etc.
- Ensure plants are uniformly spaced within the row
- Avoid excess or inadequate fertilization (particularly nitrogen)
- For some disorders (e.g. hollow heart / hollow stem), there are varietal differences in susceptibility
- If possible, adjust planting dates to avoid having susceptible stages present during hot, dry conditions.
- Avoid irrigation to ripe fruit (susceptible to cracking)

# DISEASE OF THE MONTH



## Pesticide Groups – What are they and What do they mean?

There are many different chemical pesticides out there to choose from as a part of a pest management program. Whenever a pesticide is recommended for use in managing a particular pest, there is often the suggestion (strongly but quietly worded) that producers should rotate to different chemical groups or “families” when repeat applications are required. The purpose of this is essentially to come at each pest from a different angle, to keep them off balance and to prevent a buildup of resistance to a particular product within a population of pests. Resistance lowers the efficacy of applied products and increases associated costs (losses, repeat applications, etc.). Chemical families or groups are organized based on the mode of action of the active ingredients contained in the product.

Knowing the chemical family (and associated mode of action) will help you to have a better understanding of how the pesticide works, so that you can use it most effectively, by matching it with the pest cycles, application timings and recognizing how the pesticide will affect the pests.

For example, on the surface, glyphosate and diquat are somewhat similar, providing non-selective control of weed species. However they are entirely different in their activity. Glyphosate translocates back into the plant, whereas diquat essentially burns off any green tissue above the ground. Contact insecticides usually work to poison the pest (in some way); other insecticides may need to be injected (introduced into the stomach) by the insect and will cause them to stop feeding, leading to death. The difference in time to actual insect death can be significant and should be taken into consideration when using these products.

At the same time, understanding how a chemical works can help you to recognize damage symptoms from misapplications (in the case of herbicides). It can also help to recognize products that may have a narrow spectrum of control or activity, which may decrease their environmental impact or duration of activity / longevity. Knowing the Mode of Action will also help you to avoid the buildup and development of a resistant population, as you are able to come at pests from different directions, keeping them on their toes, rather than selecting for a pest that can tolerate your controls.

The following is a list of the various chemical families of insecticides, fungicides and herbicides, with a general description of their mode of action and the overview of what the mode of action means (e.g. how does it actually kill the target pest). Products that are registered for use in various crops in Canada are presented, although the following tables do not represent a comprehensive list of registered products or their associated crops or pests. Please consult the actual product labels for rates, timing, registered crops and pests. Not all products are registered in all areas of Canada. Not all chemical classes have registered products. Not all active ingredients are presented. Some classes were formerly registered in Canada, but are no longer registered (and are listed as Historical).

### Insecticides – Mode of Action List

Group	Mode of Action	Chemical Class	Example active ingredients	Examples of Products (Common Name)
1	Acetylcholinesterase inhibitors	1A Carbamates	aldicarb	HISTORICAL
			carbaryl	Sevin
			carbofuran	Furadan
			formetanate	Carzol
			methiocarb	HISTORICAL
			methomyl	Lannate
			oxamyl	Vydate
			pirimicarb	HISTORICAL
			propoxur	Konk, etc.
		1B Organophosphates	acephate	Orthene
			azamethiphos	Salmosan
			azinphos-methyl	Guthion / Sniper
			chlorfenvinphos	HISTORICAL
			chlorpyrifos	Lorsban / Nufos / Pyrifos / Pyrinex / Citadel / Dursban
			coumaphos	Co-Ral
			demeton-S-methyl	HISTORICAL
			diazinon	Diazinon
			dichlorvos	DDVP / Vapona
			dimethoate	Lagon / Cygon
			disulfoton	HISTORICAL
			ethion	HISTORICAL
			fenitrothion	HISTORICAL
			fenthion	HISTORICAL
			malathion	Malathion
			methamidophos	Monitor
			methidathion	HISTORICAL
			naled	Dibrom
			oxydemeton-methyl	HISTORICAL
			parathion	HISTORICAL
			phorate	Thimet
			phosalone	Zolone Flo
			phosmet	Imidan
propetamphos	Catalyst			
sulfotep	HISTORICAL			
temephos	HISTORICAL			
terbufos	HISTORICAL			
tetrachlorvinphos	Ultraguard			
trichlorfon	HISTORICAL			
<p><i>This mode of action causes an interruption in the transmission of nerve impulses by tying up the cholinesterase. This results in a constant signal for cells to keep sending impulses. This means that messages become confused. As a result, insects can't function normally and die.</i></p>				
2	Gamma-aminobutyric acid (GABA) – gated chloride channel antagonists	2A Cyclo-diene organochlorines	endosulfan	Thionex
	GABA – gated chloride channel antagonists	2B Phenylpyrazoles (Fiproles)		No products registered in CDA
<p><i>This mode of action causes interference with neuron receptors resulting in repetitive nervous discharges. Nerve cells fire spontaneously and the insect goes into spasms and will eventually die.</i></p>				

Group	Mode of Action	Chemical Class	Example active ingredients	Examples of Products (Common Name)
3	Sodium channel modulators	3A Pyrethroids / Pyrethrins	allethrin	Range of different domestic products
			bifenthrin	Capture
			cyfluthrin	Tempo / Cylence / Cylent
			cypermethrin	Up-Cyde / Ripcord
			cyphenothrin	Gokilaht
			dicofol	Kelthane
			deltamethrin	Decis
			etofenprox	Nylar Squeeze On
			fenvalerate	HISTORICAL
			flucythrinate	HISTORICAL
			<i>tau</i> -fluvalinate	Apistan
			imiprothrin	Multicide Intermediate
			lamba-cyhalothrin	Matador / Silencer / Warrior
			permethrin	Pounce / Perm-Up / Dragnet / Ambush
			phenothrin	Various products
			resmethrin	Various domestic products
		tefluthrin	Force	
tretramethrin	Onguard / etc.			
tralomethrin	HISTORICAL			
pyrethrins	Pyrenone / Ecosense / etc.			
		3B DDT Methoxychlor		
<i>This mode of action interferes with sodium channels of nervous systems causing repetitive nervous discharge, leading to a slowing of the nervous system and paralysis.</i>				
4	Nicotinic acetylcholine receptor (nAChR) antagonists	4A Neonicotinoids	acetamiprid	Assail / Tristar / Vault
			clothianidin	Titan / Poncho / Clutch / Emesto / Prosper
			imidacloprid	Alias / Grapple / Admire / Genesis / Merit / Intercept
			thiachloprid	Calypso
			thiamethoxam	Actara / Cruiser / Flagship
		4B Nicotine	nicotine	HISTORICAL
4C Sulfoxaflur	sulfoxaflur	Transform / Closer		
4D Butenolides	flupyradifurone	No products registered in CDA		
<i>This mode of action disrupts nerve transmission. Insects exhibit jumpiness, leg tremors, rapid wing motion, stylet (mouthpiece) withdrawal, disoriented movement, paralysis and death.</i>				
5	Nicotinic acetylcholine receptor (nAChR) allosteric activators	Spinosyns	spinetoram	Delegate / Radiant
			spinosid	Entrust / Success / Conserve
<i>This mode of action affects the nervous system of insects, resulting in eventual death.</i>				
6	Chlorine channel activators	Avermectins / Milbemycins	abamectin	Avid / Agri-Mek
<i>This mode of action affects the nervous system of insects, resulting in eventual death.</i>				
7	Juvenile hormone mimics	7A Juvenile hormone analogues	kinoprene	Enstar
			methoprene	Apex
		7B Fenoxycarb	fenoxycarb	No products registered in CDA
	7C Pyriproxyfen	pyriproxyfen	Distance	
<i>Insect growth regulators affect the ability of immature insects to develop normally from one life stage to another, preventing them from maturing and reproducing. This particular mode of action prevents moulting (shedding skin) from larval to adult stage, resulting in eventual death (may take several weeks).</i>				

Group	Mode of Action	Chemical Class	Example active ingredients	Examples of Products (Common Name)
8	Misc. non-specific (multi-site) Inhibitors (Fumigants)	Alkyl halides	methyl bromide	Methyl bromide
		Chloropicrin	chloropicrin	Chloropicrin
		Sulfuryl fluoride	sulfuryl fluoride	Profume
		Borates	borax	Various products (ant killers)
		Tartar emetic	tartar emetic	No products registered in CDA
<i>This mode of action is a broad spectrum toxin that kills everything within the contact area.</i>				
9	Modulators of chordotonal organs (Selective homopteran feeding blockers)	9B Pyrethroids	pyrethroids	Endeavor / Fulfill
		9C Flonicamid	flonicamid	Beleaf
<i>This mode of action inhibits the feeding of piercing and sucking insect pests (e.g. aphids/whiteflies), which leads to their death by eventual starvation.</i>				
10	Mite Growth Inhibitors	10A Clofentezine	clofentezine	Apollo
		Hexythiazox	hexythiazox	No products registered in CDA
		Diflovidazin	diflovidazin	No products registered in CDA
		10B Etoxazole	etoxazole	No products registered in CDA
<i>Another type of Insect Growth Regulator (IGR)</i>				
11	Microbial disruptors of insect mid-gut membranes	11A <i>Bacillus thuringiensis</i> (and insecticidal proteins they produce)	<i>Bacillus thuringiensis</i> subsp. <i>israelensis</i>	No products registered in CDA
			<i>Bacillus thuringiensis</i> subsp. <i>aizawai</i>	No products registered in CDA
			<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i>	Thuricide / Bioprotec / Jazz / Foray
			<i>Bacillus thuringiensis</i> subsp. <i>tenebrionis</i>	Novodor
		11B <i>Bacillus sphaericus</i>	<i>Bacillus sphaericus</i>	Vectolex
<i>The bacterial microorganism is introduced into the target pest during feeding. The microorganism releases toxic compounds into the gut of the target pest resulting in gut paralysis, cessation of feeding and eventual death due to starvation within a short time.</i>				
12	Inhibitors of mitochondrial ATP synthase	12A Diafenthion	diafenthion	No products registered in CDA
		12B Organotin miticides	fenbutatin oxide	Vendex
		12C Propargite	propargite	HISTORICAL
		12D Tetradifon	tetradifon	No products registered in CDA
<i>This mode of action disrupts the production of energy processes, resulting in the insect "running out of gas" and dying as a result.</i>				
13	Uncouplers of oxidative phosphorylation via disruption of the proton gradient	Chlorfenapyr	chlorfenapyr	Mythic / Pylon
		DNOC	DNOC	No products registered in CDA
		Sulfuramid	sulfuramid	No products registered in CDA
<i>This mode of action causes cell death through the destruction of proton gradients, which is tied to energy production processes.</i>				
14	Nicotinic acetylcholine receptor (nAChR) channel blockers	Nereistoxin analogues		No products registered in CDA
<i>This mode of action affects insect nervous systems.</i>				
15	Inhibitors of chitin biosynthesis (type 0)	Benzoylureas	diflubenzuron	Dimilin
			novaluron	Rimon
<i>This mode of action slows or stops the production of chitin (which is the major part of the insect exoskeleton), preventing the insect from moulting and completing development. The insect soon dies.</i>				
16	Inhibitors of chitin biosynthesis – Type 1 – Homopteran	Buprofezin	buprofezin	No products registered in CDA
<i>This mode of action affects the production of chitin, preventing moulting and development in piercing/sucking insects (e.g. whiteflies)</i>				



Group	Mode of Action	Chemical Class	Example active ingredients	Examples of Products (Common Name)
17	Moulting disruptor – Dipteran	Cyromazine	cyromazine	Citation / Govenor
<i>This mode of action disrupts the moulting and subsequent development of the “true flies” (Diptera).</i>				
18	Ecdysone receptor agonist / moulting disruptor	Diacylhydrazines	methoxyfenozide	Intrepid
			tebufenozide	Confirm
<i>This mode of action results in a precocious moult by immature target insects, resulting in cessation of feeding, weight loss and eventual death. Part of Moulting Acceleration Compounds (MACs)</i>				
19	Octopamine receptor agonists	Amitraz	amitraz	Preventic / Apivar
<i>This mode of action affects the nervous system of the insects.</i>				
20	Mitochondrial complex III electron transport inhibitors (coupling site II)	20A Hydramethylnon	hydramethylnon	Maxforce (ant/roach killer)
		20B Acequinocyl	acequinocyl	Shuttle / Kanemite
		20C Fluacrypyrim	fluacrypyrim	No products registered in CDA
<i>This mode of action affects cellular energy production.</i>				
21A	Mitochondrial complex I electron transport inhibitors	21A MITI acaricides & insecticides	pyridaben	Dyno-Mite / Sanmite / Nexter
21B		21B Rotenone	rotenone	Rotenone (for some types of application – not crops)
<i>This mode of action affects cellular energy production.</i>				
22	Voltage-dependent sodium channel blockers	22A Indoxacarb	indoxacarb	No products registered in CDA
		22B Metaflumizone	metaflumizone	No products registered in CDA
<i>This mode of action shuts down the nervous system, resulting in paralysis and death.</i>				
23	Inhibitors of acetyl-CoA carboxylase – lipid synthesis, growth regulation	Tetronic & Tetramic acid derivatives	spirotetramat	Movento / Kontos
			spiromesifen	Oberon / Forbid
			spirodiclofen	Envidor
<i>This mode of action mimics compounds produced by some insects, affecting lipid (fat) synthesis, resulting in death.</i>				
24	Mitochondrial complex IV electron transport inhibitors	24A Phosphine	aluminum phosphide	Phostoxin / Fumitoxin / Gastoxin
			phosphine	Eco2Fume
			zinc phosphide	Various rodent baits
		24B Cyanide	cyanide	Sodium cyanide
<i>This mode of action affects energy processes.</i>				
25	Mitochondrial complex II electron transport inhibitors	Beta-ketonitrile derivatives	cyenopyrafen	No products registered in CDA
			cyflumetofen	Cyflumetofen
<i>This mode of action affects energy processes.</i>				
28	Ryanodine receptor modulators	Diamides	chlorantraniliprole	Altacor / Coragen / Rynaxypyr / Voliam
			cyantraniliprole	Verimark / Benevia / Cyazypyr / Exirel / Fortenza / Minecto
<i>This mode of action results in the uncontrolled release of calcium, causing muscle contractions. High activity in Lepidopteran insects (butterflies and moths).</i>				
UN	Unknown or uncertain MoA	azadiractin		Treazin
		benzoximate		No products registered in CDA
		bifenazate		Floramite / Acramite
		bromopropylate		No products registered in CDA
		chinomethionat		HISTORICAL
		cryolite		No products registered in CDA
		dicofol		HISTORICAL
		pyridalyl		No products registered in CDA
pyrifluquinazon		No products registered in CDA		

Other Insecticides		
Insecticidal Soaps	Contacts and penetrates the outer covering of insect bodies, dissolving into cells and causing the cellular contents to leak out. This results in dehydration and death.	
Insecticidal Oils	Smother insect eggs by preventing oxygen exchange	
Diatomaceous Earth	Absorbs the waxy coating on insects' exoskeletons, causing rapid water loss and death	
Mode of Action (MoA) Group Descriptors	MoA Groups included	Comments
Nerve & Muscle Targets	Groups 1-6, Group 9, Group 14, Group 19, Group 22, Group 28	Generally fast acting
Growth & Development Targets	Group 7, Group 10, Groups 15-18, Group 23	Act by mimicking one of 2 hormones (juvenile hormone or ecdysone) or directly messing up the formation or deposition of cuticles or the synthesis of lipids. Generally slow to moderately slow acting
Respiration Targets	Groups 12-13, Groups 20-21, Groups 24-25	Interfere with the energy storage, release and production processes. In some cases, it prevents cells from using the energy that is produced. Generally fast to moderately fast acting
Midgut Targets	Group 11	Specific to Lepidopteran (caterpillar) insects Messes up midgut membranes, causing septicemia (blood poisoning)
Unknown or Non-specific Targets	Group 8, Group UN	Actions are either unknown or act non-specifically on multiple target sites

### Herbicides – Mode of Action List

Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)
1	Inhibition of acetyl CoA carboxylase (ACCase)	Aryloxyphenoxy-propionate (FOPs)	clodinafop-propargyl	Horizon / Ladder / Signal / Harmony
			diclofop-methyl	Hoe Grass
			fenoxaprop-P-ethyl	Excel Super / Puma Super / Vigil / Cougar
			fluazifop-P-butyl	Venture
			quizalofop-P-ethyl	Assure II / Yuma
		Cyclohexanedione (DIMs)	clethodim	Select / Arrow / Centurion
			sethoxydim	Poast Ultra
			tepraloxymim	Equinox / Aramo
		Phenylpyrazoline (DEN)	tralkoxydim	Achieve / Bison / Challenger
			pinoxaden	Broadband / Axial / Crestivo / Traxos

*A.K.A. Grass Growing Point Disintegrators. Only affects post-emergence grassy plants. Systemic. This mode of action blocks the production of lipids used in building the new membranes needed for cell growth in meristem tissues (growing points). Symptoms develop slowly. Growth of growing points ceases shortly after application. Young / actively growing tissues first exhibit leaf chlorosis followed by necrosis.*

Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)
2	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	Sulfonylurea (SUs)	chlorimuron-ethyl	Classic / Reliance / Chaperone
			chlorsulfuron	Glean / Telar / Bold / Truvist
			ethametsulfuron	Muster
			foramsulfuron	Tribute Solo / Option
			halosulfuron-methyl	Sandea / Permit / Sledgehammer
			iodosulfuron	Tribute Solo
			mesosulfuron	Silverado
			metsulfuron-methyl	Ally / Express Pro / Accurate / Navius / Rejuvera
			nicosulfuron	Ultim / Accent
			primisulfuron-methyl	Beacon / Summit
			prosulfuron	Peak
			rimsulfuron	Prism / Elim / Ultim / Engarde
			sulfometuron-methyl	Oust
			sulfosulfuron	Sundance
			triasulfuron	HISTORICAL
		tribenuron-methyl	Refine Extra / Express / Nuance / Inferno	
		trifensulfuron-methyl	Refine / Deploy / Barricade / Pinnacle / Boost	
		triflurosulfuron-methyl	Upbeet	
		Imidazolinone (IMIs)	imazamox	Odyssey / Solo / Viper / Ares
			imazapyr	Arsenal / Ares
imazamethabenz-methyl	Assert / Avert / Phantom			
imazethapyr	Pursuit / Odyssey			
Triazolopyrimidine	florasulam	Broadband / Frontline XL / Spitfire / Battlefield		
	flumetsulam	Broadstrike / Fieldstar		
Pyrimidinyl(thio) benzoate	bispyribac-Na	Velocity		
Sulfonylaminocarbonyl-triazolinone	flucarbazone-Na	Everest / Sierra		
<p><i>This mode of action gradually starves the plant of specific amino acids needed in DNA synthesis. Works on both grassy and broadleaf plants. Moves readily through the plant (Phloem mobile – can move up or down the plant, depending on flow patterns). Growth rapidly stops then stunting, some root pruning, chlorosis and necrosis of the growing points develops within a couple weeks.</i></p> <p><i>Products are tightly bound to soil particles and organic matter (more so at lower pH) = low mobility</i></p>				
3	Microtubule assembly inhibition	Benzamide	propyzamide	Kerb
		Dinitroaniline	benzoic acid	No products registered in Canada
			ethalfuralin	Edge
			pendimethalin	Prowl / Valor
			trifluralin	Rival / Treflan / Bonanza / Advance
		Phosphoroamidate		No products registered in Canada
		Pyridine	dithiopyr	Dimension
Phthalic acid	DCPA	Dacthal		
<p><i>The mode of action of this herbicide is to disrupt the processes of mitosis in cell division. This leads to inhibition of roots. Roots are stopped from extending and may be short, stubby, thick and swollen/club-shaped and may be pruned. Plants are stunted.</i></p> <p><i>Products don't move within plants and should be applied Pre-Plant Incorporated or Pre-Emergence, with low leaching potential. Controls grasses and broadleaf weeds.</i></p>				

Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)
4	Action like indole acetic acid (synthetic auxins)	Phenoxy-carboxylic-acid	2,4-D	2,4-D / DyVel / Target / etc.
			2,4-DB	Embutox / etc.
			dichlorprop = 2,4-DP	Turboprop / Estaprop
			MCPA	MCPA / range of mixes
			MCPB	MCPA / Topside / etc.
			mecoprop = MCPP	Various products
		Benzoic acid	dicamba	Banvel / etc.
		Pyridine carboxylic acid	clopyralid	Lontrel / Curtail M
			fluroxypyr	Starane / etc.
			picloram	Tordon / Grazon
triclopyr	Garlon / Remedy			
Quinoline carboxylic acid	quinclorac	Triton / Accord		
Other		No products registered in Canada		
<p><i>Natural auxin levels influence plant growth through a careful balance. This mode of action works by disrupting the balance in plants, leading to deregulated plant growth. Application leads to uncontrolled cell division and growth (low concentrations) or inhibited cell division (high concentration). Products are highly phloem mobile. Treated plants exhibit epinastic bending and twisting of stems and petioles, stem swelling &amp; elongation and leaf malformations (cupping, crinkling, parallel veins, leaf strapping). Later, chlorosis of growing points, growth inhibition, wilting and necrosis will be observed. Plants die slowly (3-5weeks). Rate of product breakdown by microbial or other means influenced by temperature, moisture, pH and OM content. Mobility in soil varies with product.</i></p>				
5	Inhibition of photosynthesis at photosystem II	Triazine	atrazine	Atrazine / Marksman / Primextra / Laddock / Converge / Propero / Lumax
			cyanazine	HISTORICAL
			prometon	HISTORICAL
			prometryne	Gesaguard
			simazine	PrincepNine-T / Simazine / etc.
		Triazinone	hexazinone	Velpar / Pronone
			metribuzin	Sencor / Lexone / Tricor / Boundary
		Triazolinone		No products registered in Canada
		Uracil	bromacil	Hyvar / Krovar
			terbacil	Sinbar
Pyridazinone	pyrazon = chloridazon	Pyramin FL		
Phenyl-carbamate	desmedipham	Betamix / Betanex		
	phenmedipham	Betamix / Spin-Aid / Betanal		
<p><i>This mode of action blocks electron transport and the transfer of light energy, resulting in a reduction in carbohydrate (plant sugar) production. Only moves upwards in plants. Initial symptoms include interveinal chlorosis of leaves and margins. Older and larger leaves are affected first. The chlorosis progresses to necrosis and leaf tip browning may occur. May be subject to leaching. Most products work better on small emerging weeds.</i></p>				
6	Inhibition of photosynthesis at photosystem II	Nitrile	bromoxynil	Pardner / Buctril / Badge / Enforcer / Thrasher
		Benzothiadiazinone	bentazon	Basagran / Laddock / Viper
		Phenyl-pyridazine	Pyridate	HISTORICAL
<p><i>Same / Similar mode of action to Group 5. Chlorosis begins within 1-2 days, followed by complete necrosis within approximately 1 week.</i></p>				
7	Inhibition of photosynthesis at photosystem II	Urea	diuron	Diurex / Karmex
			Linuron	Linuron / Lorox
			methbenzthiazuron	HISTORICAL
			monolinuron	HISTORICAL
			siduron	HISTORICAL
		tebuthiuron	HISTORICAL	
Amide	propanil	HISTORICAL		
<p><i>Same / Similar mode of action to Group 5. Chlorosis of leaves starts within 3-5 days. Chlorosis later progresses to foliar desiccation and necrosis.</i></p>				



Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)
8	Lipid Synthesis inhibitors – not ACCase inhibition	Thiocarbamates	butylate	HISTORICAL
			cycloate	HISTORICAL
			EPTC	Eptam / Eradicane
			pebulate	HISTORICAL
			triallate	Avadex / Fortress
			vernolate	HISTORICAL
		propyzamide	Kerb	
		Phosphorodithioates	bensulide	Prefar / Betasan
<p><i>This mode of action affects the processes that maintain a waxy layer on the outside of seedlings which prevents moisture loss. Products must be incorporated into the soil. Products tend to affect shoots more than roots. Most weeds fail to emerge; shoots are stunted &amp; emerge poorly from the soil. Injured grassy crops may have twisted leaves with leaves tightly rolled in the whorl, whereas broadleaf plants will exhibit cupped or crinkled leaves with a leathery texture.</i></p>				
9	Inhibition of EPSP synthase	Glycine	glyphosate	Roundup / etc.
<p><i>This mode of action affects the synthesis of amino acids which leads to an accumulation of toxic intermediates (affects different amino acids than ALS herbicides). Non-selective. Translocates readily via the phloem – timing of application will affect efficacy of movement through plants (e.g. spring vs. fall). Symptoms in treated plants include inhibited growth followed by general chlorosis and necrosis within 4-20 days. Symptoms first appear on younger plant parts. Product has no soil residual activity. Adheres strongly to soil, resulting in inactivation.</i></p>				
10	Inhibition of glutamine synthetase	Phosphinic acid	glufosinate ammonium	Liberty / Harvest / Ignite
<p><i>This mode of action acts by inhibiting ammonia assimilation into organic compounds which leads to a rapid increase in accumulated ammonium, a rapid decrease in photosynthesis, growth inhibition, chlorosis and death. Non-selective, applied post-emergent. Rapid activity in plants limits translocation. Treated weeds rapidly exhibit chlorosis and wilting followed by necrosis – more rapid symptom development in high sunshine, humidity and soil moisture. Products are highly mobile and break down rapidly in soil. No residual activity.</i></p>				
11	Bleaching: Inhibition of carotenoid biosynthesis (unknown target)	Triazole	amitrole	Amitrol
<p><i>Pigment inhibitor. This mode of action inhibits the accumulation of chlorophyll and carotenoids in the light. As a result, leaves &amp; shoots become bleached (white to translucent), particularly in growing points and young leaves. Tissues wilt and become necrotic. In some cases, plants may emerge white before dying.</i></p>				
12	Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)	Pyridazinone		No products registered in Canada
		Pyridinecarboxamide	picolinafen	AC900001
		Other		No products registered in Canada
<p><i>Pigment inhibitor. This mode of action blocks carotenoid synthesis. As carotenoids play a role in dissipating oxidative energy, this leads to a chain reaction that destroys chlorophyll and membrane lipids, resulting in leaky membranes and rapid desiccation of tissues. Treated plant parts become bleached (white to translucent).</i></p>				
13	Bleaching: Inhibition of carotenoid biosynthesis (unknown target)	Isoxazolidinone	clomazone	Command
		Urea		No products registered in Canada
		Diphenylether		No products registered in Canada
<p><i>Pigment inhibitors. Seedlings either emerge bleached (white and translucent) and become necrotic within a few days or treated plant parts become bleached.</i></p>				

Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)
14	Inhibition of protoporphyrinogen oxidase (PPO)	Diphenylether	acifluorfen-Na	Blazer / Sportcoat
			fomesafen	Reflex / Flexstar
			oxyfluorfen	Goal
		Phenylpyrazole	pyraflufen-ethyl	Pyro
		N-phenylphthalimide	flumioxazin	Broadstar / Chateau / Sureguard / Yardmaster / Fierce
		Thiadiazole		No products registered in Canada
		Oxadiazole	oxadiazon	Ronstar
		Oxazolidinedione		No products registered in Canada
		Pyrimidindione		No products registered in Canada
		Triazolinone	carfentrazone-ethyl	Aim / Quicksilver
	sulfentrazone	Authority		
	Other	No products registered in Canada		
<i>Cell membrane disrupters. This mode of action works by disrupting specific enzyme activity that results in a chain reaction that leads to a loss of chlorophyll and carotenoids. This results in leaky membranes which causes cells and organelles to dry out and disintegrate. Burner-type herbicides; most are Post-emergent contact herbicides. Emerging plants turn necrotic and die very quickly after being exposed to sunlight; rapid chlorosis, desiccation and necrosis with foliar applications.</i>				
15	Inhibition of cell division: Inhibition of VLCFAs	Chloracetamide	metolachlor	Dual II
		Acetamide	napropamide	Devrinol
		Oxyacetamide	flufenacet	Axiom / Define
		Tetrazolinone		No products registered in Canada
		Other		No products registered in Canada
<i>Shoot growth inhibitor. Soil applied. Most weeds fail to emerge, but doesn't affect seed germination. Emerging grassy plants are malformed with leaves tightly rolled in the whorl and are unable to unroll. Broadleaved plants may exhibit "draw-string" or "heart-shaped" appearance. There may be a root effect with some products, producing shorter, thicker roots with few laterals.</i>				
16	Lipid synthesis Inhibitors	Benzofuran	ethofumesate	Nortron / Etho
<i>This mode of action affects the processes that maintain a waxy layer on the outside of seedlings which prevent moisture loss. Affects shoots more than roots. Affected weeds often fail to emerge; shoots are stunted &amp; emerge poorly from the soil. Products must be incorporated into the soil.</i>				
17	Unknown	Organoarsenical		No products registered in Canada
<i>This mode of action is unknown.</i>				
18	Inhibition of DHP (dihydropteroate) synthase	Carbamate	asulam	Benchmark / Frontline
<i>This mode of action inhibits cell division and expansion in plant growing points. Symptoms include a slow chlorosis of young leaves, planting stunting and necrosis. Growing points are killed within 1-2 weeks and older parts slowly senesce.</i>				
19	Inhibition of auxin transport	Phthalamate Semicarbazone	naptalam	HISTORICAL
			diflufenzopyr-Na	Distinct / Overdrive
<i>This mode of action causes an abnormal accumulation of natural auxins in growing points (roots &amp; shoots), resulting in a disruption of the balance needed for growth. Symptoms vary with product but may include stunting, strong epinasty in some plants or an anti-geotropic effect (geotropism = natural curvature of roots down &amp; shoots to light).</i>				
20	Inhibition of cell wall (cellulose) synthesis	Nitrile	diclobenil	Casoron / Stryke
<i>This mode of action disrupts cell division and inhibits actively dividing growing points in roots and shoots, as well as inhibiting seed germination. Systemic. Soil applied. Seedlings do not usually emerge.</i>				
21	Inhibition of cell wall (cellulose) synthesis	Benzamide	isoxaben	Gallery
<i>This mode of action disrupts cell division and inhibits actively dividing growing points in roots and shoots, as well as inhibiting seed germination. Most weeds fail to emerge. Any broadleaf plants that emerge will be stunted, with reduced root growth and root distortions. Foliar exposure results in growth inhibition, swelling and cracking of stem.</i>				

Group	Mode of Action	Chemical Family	Example active ingredients	Examples of Products (Common Name)	
22	Photosystem-I-electron diversion	Bipyridylium	diquat	Reglone / Reward / Diquash	
			paraquat	Gramoxone	
<i>Cell membrane disrupter. This mode of action disrupts internal cell membranes and prevents cells from manufacturing food. A chain reaction is created that destroys the integrity of cell membranes, causing intercellular leaking and rapid leaf wilting and desiccation. Symptoms include rapid wilting, interveinal chlorosis and desiccation, with complete necrosis within 1-3 days. Products are non-selective, fast-acting, contact herbicides with foliar activity only. More active on either grasses (diquat) or broad-leaved (paraquat) plants. Products bind very tightly to soil and do not leach.</i>					
23	Inhibition of mitosis / microtubule organization	Carbamate	chlorpropham	SproutNip / CIPC	
<i>This mode of action inhibits cell division, disrupting mitosis and root/shoot growth. Products suppress transpiration and respiration in plants and inhibits root and shoot growth. They are used mainly for potato sprout inhibition in long-term storage.</i>					
24	Uncoupling (membrane disruption)	Dinitrophenol	dinoseb	HISTORICAL	
<i>This mode of action causes almost immediate membrane disruption and necrosis, serving as a contact-type foliar necrosis.</i>					
25	Unknown	Arylamino propionic acid	flamprop-M-methyl / isopropyl	HISTORICAL	
<i>This mode of action is suggested to be a mitotic disrupter.</i>					
26	Unknown	Chlorocarbonic acid	TCA	HISTORICAL	
		Pyrazolium	difenzoquat	Avenge	
		Quinoline Carboxylic acid	quinclorac	Triton / Accord	
<i>The mode of action is suggested to involve inhibition of fatty acid or lipid synthesis, which relates to maintaining a waxy layer on the outside of seedlings to prevent moisture loss. Products affect shoots more than roots.</i>					
27	Nucleic Acid Inhibitors / Cellulose Inhibitors / Non-descript MOA	Isoxazole	isoxaflutole	Converge	
		Pyrazole	difenzoquat	Avenge	
		Triketone	Mesotrione	Callisto / Lumax / Halex / Engarde	
		Other		fosamine	Krenite
			Dithiocarbamates	dazomet	Thion / Busan
metam	Vapam				
<i>The mode of action of these products is relatively unknown. Products may cause symptoms that include bleaching of new growth, failure of seedlings to emerge, leaf senescence or leaf chlorosis, depending on active ingredient.</i>					
28	Bleaching: Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	Pyrazole	difenzoquat	Avenge	
<i>This mode of action inhibits plant pigment synthesis and photosynthesis, resulting in chlorosis and bleaching symptoms.</i>					
29	????	???	Indaziflam	Alion / Esplanade	
<i>The mode of action of these herbicides is to inhibit cellulose biosynthesis, similar to Group 20, 21 and Group 28 herbicides.</i>					

### Fungicides – Mode of Action List

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
1	Mitosis & cell division – beta-tubuline assembly	B1	Methyl Benzimidazole Carbamates (MBCs)	benzimidazoles	benomyl	HISTORICAL
					carbendazim	Eertavas / Polyphase
					thiabendazole	Mertect / Apron / Metasol
				thiophanates	thiophanate-methyl	Senator
<i>This mode of action inhibits tubulin formation in the attacking fungus, which disrupts cell division and the ability to expand/grow (spore germination, mycelial growth, etc.). Can be used as a seed treatment or other systemic broad-spectrum protective application. Xylem-mobile (root to shoot movement).</i>						
<b>General comments on resistance:</b> Resistance is common in many fungi, making it a high risk group						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
2	Signal Transduction – MAP/Histidine-Kinase in osmotic signal transduction	E3	Dicarboximides	dicarboximides	iprodisone	Rovral / Overall / ID
					vinclozolin	HISTORICAL
<p><i>This mode of action disrupts signal transduction pathways in cells, messing up cell division and cellular metabolism by affecting DNA and RNA synthesis and metabolism. Inhibits spore germination and mycelial growth. Contact protectant products that control a range of fungal species.</i></p> <p><b>General comments on resistance:</b> Resistance is common in some fungal species (e.g. <i>Botrytis</i>); considered medium to high risk</p>						
3	Sterol biosynthesis in membranes – Inhibition – C14-demethylase in sterol biosynthesis	G1	Demethylation Inhibitors (DMIs) (SBI: Class I)	piperazines	triforine	Funginex
				pyridines		No products registered in CDA
				pyrimidines		No products registered in CDA
				imidazoles		No products registered in CDA
				triazoles	azaconazole	HISTORICAL
					difenoconazole	Dividend / Cruiser / Tribune / Inspire
					fenbuconazole	Indar
					flusilazole	Nustar
					hexaconazole	HISTORICAL
					ipconazole	Rancona / Vortex
					metconazole	Caramba / Quash / Tourney
					myclobutanil	Maxim / Nova / Eagle / Golden Eagle
					propiconazole	Topas / Mission / Tilt / Banner / Propel / Concert / Bumper
					tebuconazole	Folicur / Raxil / Palliser / Fuse /
					tetraconazole	Mettle
					triadimefon	HISTORICAL
triadimenol	HISTORICAL					
triticonazole	Charter / Armour / Gemini / Premis					
triazolinthiones	prothioconazole	Proline				
<p><i>This mode of action inhibits the synthesis of sterols in fungal cellular membranes. Sterols are critical components required in the building of cell membranes and to maintain cell membrane fluidity. DMIs disrupt membrane function. Xylem-mobile (root to shoot movement).</i></p> <p><b>General comments on resistance:</b> A wide range across activity spectrum; Resistance is known in some fungal species; Considered medium risk</p>						
4	Nucleic acid synthesis – RNA polymerase I	A1	Phenyl Amides	oxazolidinones		No products registered in CDA
				butyrolactones		No products registered in CDA
				acylalanines	metalaxyl	Apron / Allegiance
metalaxyl-M	Subdue / Apron / Ridomil Gold / Dividend					
<p><i>Inhibits RNA synthesis which causes a disruption cellular growth and development. Effective against Oomycetes (<i>Pythium</i>, <i>Phytophthora</i>, some Downy Mildews, etc.). Systemic, therefore can have somewhat of a curative effect. Readily translocated from roots to shoots (xylem-mobile).</i></p> <p><b>General comments on resistance:</b> Considered to be high risk; resistance known in some species (e.g. <i>Oomycetes</i>)</p>						
5	Sterol biosynthesis in membranes	G2	Amines (morpholines) (SBI: Class II)	morpholines	dodemorph	Meltatox
				piperidines		No products registered in CDA
				spiroketal-amines		No products registered in CDA
<p><i>This mode of action inhibits the synthesis of sterols in fungal cellular membranes. Sterols are critical components required in the building of cell membranes and to maintain cell membrane fluidity. This disrupts membrane function, resulting in death.</i></p> <p><b>General comments on resistance:</b> Considered low to medium risk of resistance development</p>						



Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
6	Lipids & membrane synthesis – phospholipid biosynthesis, methyltrans-ferase	F2	phospho-thialates	phospho-thialates		No products registered in CDA / HISTORICAL
			dithiolanes	dithiolanes		No products registered in CDA
<p><i>Disrupts the formation of cellular membranes, preventing growth and development.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk of resistance development, with resistance known for some specific fungi</p>						
7	Respiration – Complex II – succinate-dehydrogenase	C2	SDHI (Succinate dehydrogenase inhibitors)	phenyl-benzamides		No products registered in CDA
				phenyl-oxo-ethyl-thiophene amide		
				pyridinyl-ethyl-benzamides	fluopyram	Luna / Luna Tranquility / Propulse
				furan-carboxamides		No products registered in CDA
				oxathiin-carboxamides	carboxin	HISTORICAL
					oxycarboxin	Arrest / HRC Liquid
				thiazole-carboxamides		No products registered in CDA
				pyrazole-4-carboxamides	fluxapyroxad	Bas 700 / Priaxor / Acceleron
					penflufen	Emesto / Evergol
penthopyrad	Fontelis / Vertisan / Treoris					
pyridine-carboxamides	sedaxane	Vibrance				
pyridine-carboxamides	boscalid	Lance / Pristine / Cantus / Cadence				
<p><i>This mode of action works to disrupt mitochondrial respiration, inhibiting the oxidation of glucose and acetate. Affects the power pathways of the cell. Active on basidiomycetes. Considered to be locally systemic.</i>  <b>General comments on resistance:</b> Considered medium to high risk of resistance development, depending on fungal species</p>						
8	Nucleic acid synthesis – adenosin-deaminase	A2	hydroxy-(2-amino) pyrimidines	hydroxy-(2-amino) pyrimidines		No products registered in CDA
<p><i>This mode of action disrupts fungal DNA/RNA synthesis which disrupts cellular growth and development.</i>  <b>General comments on resistance:</b> Considered medium risk; resistance known in some species of powdery mildew</p>						
9	Amino acids & protein synthesis – methionine biosynthesis	D1	AP-fungicides (Anilino-Pyrimidines)	anilino-pyrimidines	cyprodinil	Vanguard / Switch / Astound / Palladium / Inspire Super / Cyproflu
					pyrimethanil	Scala / Luna Tranquility / ecoFOG-160
<p><i>This mode of action limits protein formation by inhibiting methionine, affecting cell division. Active on Botrytis, Monilinia and Venturia (some example fungi). Suggested to be most effective on earlier infestations. Considered to be locally systemic.</i>  <b>General comments on resistance:</b> Medium risk of resistance, with resistance known in several common species</p>						
10	Mitosis & cell division – beta-tubuline assembly	B2	N-phenyl carbamates	N-phenyl carbamates		No products registered in CDA
<p><i>This mode of action disrupts mitosis (genetic division) and cell division by inhibiting tubulin formation in the attacking fungus, which disrupts cell division and the ability to expand/grow (spore germination, mycelial growth, etc.).</i>  <b>General comments on resistance:</b> Considered high risk of resistance development, likely due to similarities to some other fungicide MOAs</p>						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
11	Respiration – Complex III – cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	C3	QoI-fungicides – (Quinone outside Inhibitors)	methoxy-acrylates	azoxystrobin	Quadris / Quilt / Dynasty / Abound / Blanket Xcel / Heritage
					picoxystrobin	Acapela
				Methoxy-acetamide		No products registered in CDA
				methoxy-carbamates	pyraclostrobin	Headline / Cabrio / Pristine / Stamina / Priaxor / Insure
					Oximino-acetates	kresoxim-methyl
				trifloxystrobin		Stratego / Flint / Compass / Trilex / Trilogy / Evergol
				oximino-acetamides		No products registered in CDA
				oxazolidine-diones	famoxadone	Tanos
				dihydro-dioxamines	fluoxastrobin	Evito / Disarm
imidazolinones	fenamidone	Reason				
benzyl-carbamates		No products registered in CDA				
<p><i>This mode of action works to prevent the establishment of fungi on plant surfaces, by affecting mitochondrial (cell powerhouse) respiration and subsequent energy production. Group can be referred to as the <b>Strobilurins</b>. Considered to be fairly broad spectrum and xylem mobile (upward movement within plants).</i></p> <p><b>General comments on resistance:</b> Considered high risk for resistance development; resistance is known in a number of species and across the MoA group</p>						
12	Signal Transduction – MAP/Histidine-Kinase in osmotic signal transduction	E2	PP-fungicides (PhenylPyrroles)	phenylpyrroles	fludioxonil	Maxim / Switch / Scholar / Stadium / Cyproflu / Vibrance / Palladium / Astound
<p><i>This mode of action disrupts signal transduction pathways in cells, messing up cell division and cellular metabolism by affecting DNA and RNA synthesis and metabolism. Inhibits spore germination and mycelial growth. Suggested to disrupt membrane integrity. Contact protectant products that control a range of fungal species.</i></p> <p><b>General comments on resistance:</b> Considered to be low to medium risk of resistance development with some resistance found sporadically</p>						
13	Signal transduction – unknown mechanism	E1	aza-naphthalenes	aryloxyquinoline	quinoxifen	Quintec
				quinazolinone		No products registered in CDA
<p><i>The exact details of this mode of action are unclear, other than it disrupts signal transduction pathways, which affects cell division and metabolism and therefore fungal growth and development.</i></p> <p><b>General comments on resistance:</b> Considered to be medium risk with known resistance in some species</p>						
14	Lipids & membrane synthesis – lipid peroxidation	F3	AH fungicides (Aromatic Hydrocarbons) (chlorophenyls, nitroanilines)	aromatic hydrocarbons	chloroneb	HISTORICAL
					quintozene	Quintozene
			heteroaromatics	1,2,4-thiadiazoles	etridiazole	Truban
<p><i>This mode of action works in a couple ways to disrupt cell membrane formation and function. Products are contact products that act on lipid synthesis and may be active on basidiomycetes (e.g. Rhizoctonia, rusts, etc.) and some ascomycetes (e.g. Sclerotinia, Botrytis, Monilinia, Rhizopus, etc.).</i></p> <p><b>General comments on resistance:</b> Considered to be low to medium risk of resistance development, however resistance is known in some species</p>						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
16.1	Melanin synthesis in cell wall – reductase in melanin biosynthesis	I1	MBI-R fungicides (Melanin Biosynthesis Inhibitors – Reductase)	isobenzo-furanone		No products registered in CDA
				pyrrolo-quinolinone		No products registered in CDA
				triazolobenzothiazole		No products registered in CDA
16.2	Melanin synthesis in cell wall – dehydratase in melanin biosynthesis	I2	MBI-D fungicides (Melanin Biosynthesis Inhibitors – Dehydratase)	cyclopropane-carboxamide		No products registered in CDA
				carboxamide		No products registered in CDA
				propionamide		No products registered in CDA
<p><i>This mode of action works to perhaps disrupt the ability of the attacking pathogen to protect against attack from hosts or damaging elements and stresses, which essentially can reduce virulence.</i></p> <p><b>General comments on resistance:</b> Resistance is known for MBI-D's and not for MBI-R's and are considered medium risk</p>						
17	Sterol biosynthesis in membranes	G3	hydroxyanilides (SBI Class III)	hydroxyanilides	fenhexamid	Decree / Elevate
				amino-pyrazolinone		No products registered in CDA
<p><i>This mode of action inhibits the synthesis of sterols in fungal cellular membranes. Sterols are critical components required in the building of cell membranes and to maintain cell membrane fluidity. This disrupts membrane function, resulting in death.</i></p> <p><b>General comments on resistance:</b> Low to medium risk</p>						
18	Sterol biosynthesis in membranes – squalene-epoxidase in sterol biosynthesis	G4	SBI Class IV	thiocarbamates		No products registered in CDA
				allylamines		No products registered in CDA
<p><i>This mode of action inhibits the synthesis of sterols in fungal cellular membranes. Sterols are critical components required in the building of cell membranes and to maintain cell membrane fluidity. This disrupts membrane function, resulting in death.</i></p> <p><b>General comments on resistance:</b> Resistance now known</p>						
19	Cell wall biosynthesis – chitin synthase	H4	polyoxins	peptidyl pyrimidine nucleoside		No products registered in CDA
<p><i>This mode of action affects the enzyme chitin synthase, which is tied to cell wall formation. Suggested to have single site activity. Considered to be xylem mobile (upward movement).</i></p> <p><b>General comments on resistance:</b> Considered to be medium risk of resistance development with resistance known</p>						
20	Mitosis & cell division – cell division	B4	phenylureas	phenylureas		No products registered in CDA
<p><i>This mode of action disrupts cell division by affecting mitosis.</i></p> <p><b>General comments on resistance:</b> Resistance isn't known</p>						
21	Respiration – Complex III – cytochrome bc1 (ubiquinone reductase) at Qi site	C4	Oil-fungicides (Quinone inside Inhibitors)	cyano-imidazole	cyazofamid	Torrent / Ranman
				sulfamoyl-triazole		No products registered in CDA
<p><i>This mode of action works to prevent the establishment of fungi on plant surfaces, by affecting mitochondrial (cell powerhouse) respiration and subsequent energy production. Similar activity to Strobilurins, with activity at a different site.</i></p> <p><b>General comments on resistance:</b> Risk of resistance is unknown but considered medium to high risk because of observed mutations in model species (a.k.a. indicator pathogen species have had mutations observed at this target site = increased risk)</p>						
22	Mitosis & cell division – beta-tubuline assembly in mitosis	B3	benzamides	toluamides	zoxamide	Zoxium / Gavel
			Thiazole carboxamide	ethylamino-thiazole-carboxamide		No products registered in CDA
<p><i>This mode of action disrupts mitosis (genetic division) and cell division by inhibiting tubulin formation in the attacking fungus, which disrupts cell division and the ability to expand/grow (spore germination, mycelial growth, etc.).</i></p> <p><b>General comments on resistance:</b> Considered low to medium risk for resistance development.</p>						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
23	Amino acids & protein synthesis – protein synthesis	D2	enopyranuronic acid antibiotic	enopyranuronic acid antibiotic		No products registered in CDA
<p><i>This mode of action limits protein formation, affecting cell division.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk of resistance development</p>						
24	Amino acids & protein synthesis – protein synthesis	D3	hexopyranosyl antibiotic	hexopyranosyl antibiotic	kasugamycin	Kasumin
<p><i>This mode of action limits protein formation, affecting cell division.</i>  <b>General comments on resistance:</b> Considered to be medium risk for resistance development, with known resistance in several fungal/bacterial pathogens</p>						
25	Amino acids & protein synthesis – protein synthesis	D4	glucopyranosyl antibiotic	glucopyranosyl antibiotic	streptomycin	Streptomycin
<p><i>This mode of action limits protein formation, affecting cell division. Mainly with activity on bacterial pathogens.</i>  <b>General comments on resistance:</b> High risk of resistance, with known bacterial resistance</p>						
26	Cell wall biosynthesis – trehalase & inositol-biosynthesis	H3	glucopyranosyl antibiotic	glucopyranosyl antibiotic		No products registered in CDA
<p><i>This mode of action interferes with the synthesis of glucan, which relates to cell walls.</i>  <b>General comments on resistance:</b> Resistance not known</p>						
27	Unknown mode of action	U	cyanoacetamide-oxime	cyanoacetamide-oxime	cymoxanil	Curzate / Tanos
<p><i>This mode of action, while unknown, is considered to be locally systemic with a short residual activity. Suggested to be active on Oomycetes.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk for resistance development</p>						
28	Lipids & membrane synthesis – cell membrane permeability, fatty acids	F4	carbarnates	carbarnates	propamocarb	Tattoo / Previcur / Banol
<p><i>Disrupts the formation and function of cellular membranes, altering membrane permeability. Suggested to have activity on Oomycetes.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk of resistance development</p>						
29	Respiration – uncouplers of oxidative phosphorylation	C5		dinitrophenyl crotonates	dinocap	HISTORICAL
				2,6-dinitro-anilines	fluazinam	Allegro
				pyrimidinone-hydrazones		No products registered in CDA
<p><i>This mode of action disrupts cellular energy pathways, affecting fungal growth and development.</i>  <b>General comments on resistance:</b> Resistance either unknown or considered low risk for development</p>						
30	Respiration – inhibitors of oxidative phosphorylation, ATP synthase	C6	organo tin compounds	Tri-phenyl tin compounds		No products registered in CDA
<p><i>This mode of action disrupts cellular energy pathways, affecting fungal growth and development.</i>  <b>General comments on resistance:</b> Some resistance is known but considered to be low to medium risk</p>						
31	Nucleic acid synthesis – DNA topoisomerase type II (gyrase)	A4	carboxylic acids	carboxylic acids		No products registered in CDA
<p><i>This mode of action disrupts fungal DNA synthesis which disrupts cellular growth and development.</i>  <b>General comments on resistance:</b> risk in bacteria is known, but unknown in fungal species;</p>						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
32	Nucleic acid synthesis – DNA/RNA synthesis	A3	heteroaromatics	isoxazoles		No products registered in CDA
				isothiazolones		No products registered in CDA
<i>This mode of action disrupts fungal DNA/RNA synthesis which disrupts cellular growth and development.</i> <b>General comments on resistance:</b> resistance not known						
33	Unknown mode of action	U	phosphonates	ethyl phosphonates	fosetyl-Al	Aliette
					phosphorous acid & salts	Confine / Rampart
<i>This mode of action is suggested to have multi-site activity, and may inhibit metabolic pathways, affecting mainly Oomycetes. May involve elicitation of Systemic Acquired Resistance (SAR) – a host defence response.</i> <b>General comments on resistance:</b> Considered to be low risk for resistance development						
34	Unknown mode of action	U	phthalamic acids	phthalamic acids		No products registered in CDA
35			benzotriazines	benzotriazines		No products registered in CDA
36			benzene-sulfonamides	benzene-sulfonamides		No products registered in CDA
37			pyridazinones	pyridazinones		No products registered in CDA
<i>These modes of action are unknown</i> <b>General comments on resistance:</b> Resistance is unknown						
38	Respiration – ATP production	C7	thiophene-carboxamides	thiophene-carboxamides		No products registered in CDA
<i>This mode of action disrupts energy production pathways in the mitochondria (cell powerhouses), which inhibits fungal growth and development.</i> <b>General comments on resistance:</b> Resistance is considered to be low						
39	Respiration – complex I NADH oxidoreductase	C1	pyrimidinamines	pyrimidinamines		No products registered in CDA
			Pyrazole-MET1	pyrazole-5-carboxamides		No products registered in CDA
<i>This mode of action disrupts energy production pathways in the mitochondria (cell powerhouses), which inhibits fungal growth and development.</i> <b>General comments on resistance:</b> Resistance isn't known						
40	Cell wall biosynthesis – cellulose synthase	H5	CAA-fungicides (Carboxylic Acid Amides)	cinnamic acid amides	dimethomorph	Acrobat / Zampro
	Lipids & membrane synthesis – phospholipid biosynthesis & cell wall deposition			valinamide carbamates		No products registered in CDA
				mandelic acid amides	mandipropamid	Revus / Micora
<i>This mode of action works to disrupt cell membrane and wall formation and function.</i> <b>General comments on resistance:</b> Considered to be low to medium risk of resistance development, with resistance possible across entire CAA group						
41	Amino acids & protein synthesis – protein synthesis	D5	tetracycline antibiotic	tetracycline antibiotic		No products registered in CDA
<i>This mode of action limits protein formation, affecting cell division.</i> <b>General comments on resistance:</b> High risk of resistance development, with known resistance						
42	Unknown mode of action	U	thiocarbamate	thiocarbamate		No products registered in CDA
<i>This mode of action is unknown.</i> <b>General comments on resistance:</b> Resistance is not known						
43	Mitosis & cell division – delocalization of spectrin-like proteins	B5	benzamides	pyridinylmethyl-benzamides	fluopicolide	Presidio
<i>This mode of action disrupts cell division by affecting mitosis.</i> <b>General comments on resistance:</b> Resistance isn't known						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
44	Lipids & membrane synthesis – microbial disrupters of pathogen cell membranes	F6	Microbial ( <i>Bacillus</i> sp.)	<i>Bacillus</i> sp. & fungal lipopeptides they produce	<i>Bacillus subtilis</i> strain QST 713 (syn. <i>B. amyloliquefaciens</i> )	Serenade / Rhapsody / Jazz
					<i>Bacillus subtilis</i> var <i>amyloliquefaciens</i> strain FZB24	Taegro
					<i>Bacillus subtilis</i> var <i>amyloliquefaciens</i> strain MBI600	Subtilex / Pro-Mix (growing medium with additives) / Biotak / Integral / Acceleron
<i>This mode of action works to disrupt cell membrane and wall function. FZB24 also elicits a host plant defence response in addition to this MoA</i> <b>General comments on resistance:</b> Resistance is not known						
45	Respiration – complex III – cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site	C8	QoSI-fungicides (Quinone outside inhibitor, stigmatellin binding type)	triazolo-pyrimidylamine	ametoctradin	Zampro / Bas 650
<i>This mode of action affects mitochondrial (cell powerhouse) respiration and subsequent energy production.</i> <b>General comments on resistance:</b> Considered to be medium to high risk of resistance, due to the single-site inhibitor action, but no cross resistance to similar types						
46	Lipid synthesis and membrane integrity – cell membrane disruption	F7	plant extract	terpene hydrocarbons and terpene alcohols		No products registered in CDA
<i>This mode of action works to disrupt cell membrane and wall function.</i> <b>General comments on resistance:</b> Resistance is not known						
P	Host Plant Defence Induction P1 – salicylic acid pathway	P1	benzo-thiadiazole BTH	benzo-thiadiazole BTH	acibenzolar-S-methyl	Actigard
		P2	benzisothiazole	benzisothiazole		No products registered in CDA
		P3	thiadiazole-carboxamide	thiadiazole-carboxamide		No products registered in CDA
		P4	natural compound	polysaccharides		No products registered in CDA
		P5	plant extract	complex mixture, ethanol extract	extract from <i>Reynoutria sachalinensis</i>	Regalia Maxx
<i>In general terms, these types of mode of action mimic or elicit natural plant defence responses in some way, which essentially increases the resistance of the plant to attack. The ways that these MOA work differ greatly.</i> <b>General comments on resistance:</b> Resistance is not known						
U6	Unknown mode of action	U	phenyl-acetamide	phenyl-acetamide		No products registered in CDA
<i>This mode of action is unknown.</i> <b>General comments on resistance:</b> Resistance in specific species						
U8	Unknown mode of action – actin disruption	U	aryl-phenyl-ketone	benzophenone		No products registered in CDA
				benzoylpyridine		No products registered in CDA
<i>This mode of action, while the details are unclear, works to disrupt actin, which plays a large role in microtubules and cell division.</i> <b>General comments on resistance:</b> Considered to be medium risk of resistance development, with some resistance in some species						

Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
U12	Unknown mode of action – cell membrane disruption	U	guanidines	guanidines	dodine	Syllit / Equal
<p><i>This mode of action, while specific details are unclear, disrupts cell membranes.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk for resistance with some resistance known in specific species</p>						
U13	Unknown mode of action	U	thiazolidine	cyano-methylene-thiazolidine		No products registered in CDA
<p><i>This mode of action is unknown.</i>  <b>General comments on resistance:</b> Resistance is not known</p>						
U14	Unknown mode of action	U	pyrimidonone-hydrazones	pyrimidonone-hydrazones		No products registered in CDA
<p><i>This mode of action is unknown.</i>  <b>General comments on resistance:</b> Resistance is not known</p>						
U15	Unknown mode of action – oxysterol binding protein (OSBP) inhibition	U	piperidinyl-thiazole-isoxazolines	piperidinyl-thiazole-isoxazolines		No products registered in CDA
<p><i>This mode of action, while specific details are unclear, inhibits OSP, which affects fungal growth.</i>  <b>General comments on resistance:</b> Considered to be medium to high risk for resistance as it acts on a single site</p>						
U16	Unknown mode of action – complex III: cytochrome bc1, unknown binding site	U	4-quinolyl-acetate	4-quinolyl-acetate		No products registered in CDA
<p><i>This mode of action affects mitochondrial (cell powerhouse) respiration and subsequent energy production, however the binding site is unknown.</i>  <b>General comments on resistance:</b> Considered to be low to medium risk for resistance with some resistance known in specific species</p>						
NC	Not classified – unknown	U	diverse	diverse	mineral oils	Superior 70 / Sunspray / Civitas
					organic oils	No products registered in CDA
					potassium bicarbonate	Milstop / Sirocco
					material of biological origin	No products registered in CDA
<p><i>These active ingredients have a wide range of activity and modes of action that have not been classified. Mineral oils often work by destroying cell walls or interfering with fungal attachment to plants. Other products (such as potassium bicarbonate) upset potassium ion balance in cells (specifically powdery mildew), causing cellular collapse. Biological controls either act directly on specific pathogens or may work to boost host plant resistance. These products have contact activity only.</i>  <b>General comments on resistance:</b> Resistance is not known</p>						
M 1	Multi-site contact activity	M	inorganic	inorganic	copper	Kocide / Copper / Parasol / Phyton-27
<p><i>Copper ions react with components of certain amino acids, causing denaturation of proteins and enzymes, disrupting energy transport systems and membrane integrity. These products have contact activity only.</i>  <b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 2	Multi-site contact activity	M	inorganic	inorganic	sulphur	Micro-sulphur / Kumulus / Microscopic Sulphur / Microthiol Disperss
<p><i>Sulphur interferes with electron transport and movement, depriving the cell of energy. Sulphur is also reduced to H<sub>2</sub>S, which is toxic and may contribute to killing the cells. These products have contact activity only.</i>  <b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						



Group	Mode of Action (MoA)	MoA Code	Group Name	Chemical Group	Example active ingredients	Examples of Common Products (Common Name)
M 3	Multi-site contact activity	M	dithiocarbamates & relatives	dithio-carbamates & relatives	ferbam	Ferbam
					mancozeb	Dithane / Manzate / Mancozeb / Acrobat / Ridomil Gold / Maxim / Genesis / Mancoplus / Condor / Solan / Fortuna
					maneb	HISTORICAL
					metiram	Polyram / Cabrio Plus
					propineb	No Products
					thiram	Thiram / Vitaflo / Granuflo
					zineb	HISTORICAL
					ziram	Ziram / Vancide
<p><i>This mode of action has multiple sites of activity, usually broad spectrum and protectant in nature. Products bind with sulfhydryl (SH) groups of amino acids and causes denaturation of proteins and enzymes. Contact activity only.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 4	Multi-site contact activity	M	phthalimides	phthalimides	captan	Agrox / Captan / Maestro / Supra Captan / Caption
					folpet	Folpan
<p><i>Similar mode of action to M3 group, with broad spectrum, contact activity. Reacts with sulfhydryl (SH) groups, denaturing proteins and enzymes.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 5	Multi-site contact activity	M	chloronitriles (phthalonitriles)	chloronitriles (phthalonitriles)	chlorothalonil	Bravo / Daconil / Echo / Tattoo / Treoris
<p><i>This mode of action has multi-site activity, affecting fungal respiration (energy pathways). Contact activity only.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 6	Multi-site contact activity	M	sulfamides	sulfamides	diclofluanid	HISTORICAL
<p><i>This mode of action has multi-site activity.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 7	Multi-site contact activity	M	guanidines	guanidines		No products registered in CDA
<p><i>This mode of action has multi-site activity. Differ from U12 group by active ingredient.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 8	Multi-site contact activity	M	triazines	triazines	anilazine	HISTORICAL
<p><i>This mode of action has multi-site activity.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 9	Multi-site contact activity	M	quinones (anthraquinones)	quinones (anthraquinones)		No products registered in CDA
<p><i>This mode of action has multi-site activity.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 10	Multi-site contact activity	M	quinoxalines	quinoxalines		HISTORICAL
<p><i>This mode of action has multi-site activity.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						
M 11	Multi-site contact activity	M	maleimide	maleimide		No products registered in CDA
<p><i>This mode of action has multi-site activity.</i></p> <p><b>General comments on resistance:</b> Considered to be low risk for resistance development</p>						