Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canada

Irrigated Crop Production

Update, January 2018

Fungicide Resistance

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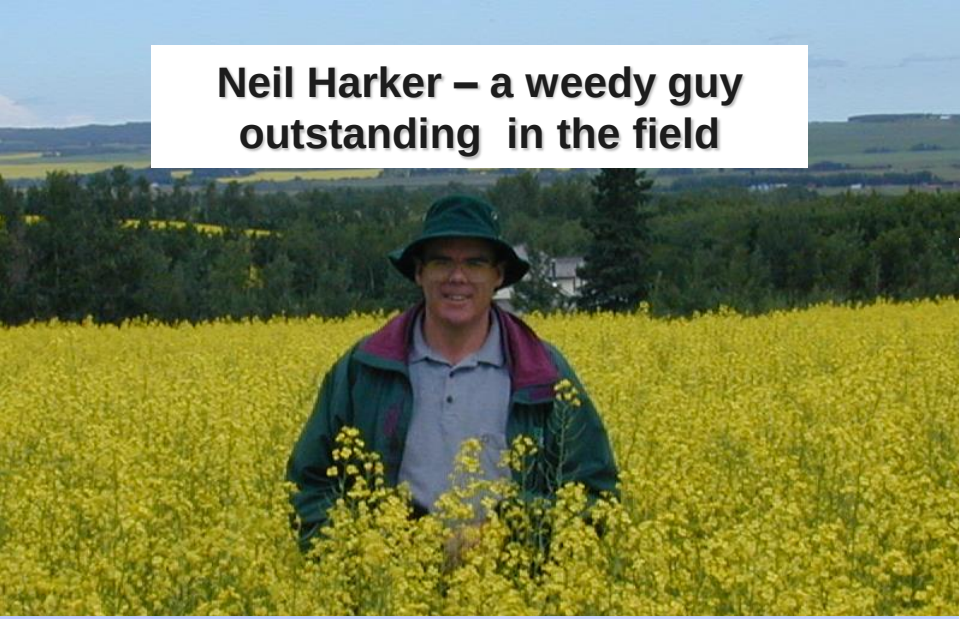
Acknowledgements

- Scientific colleagues and technical staff
- Industry collaborators
- Provincial Producer Commissions, WGRF, Rahr Malting Inc., DU
- Barley, Wheat, Pulse & WW DIAPs/Clusters
- Adele Harding and ICPU organizing committee



Neil Harker – a weedy guy outstanding in the field

Pathogen - infested cereal residues

Leaf Spot Reaction of Barley Varieties For Alberta

Based on Varieties of Cereal and Oilseed Crops For Alberta - 2013, AARD Agdex 100/32

T.K. Turkington [1], and K. Xi [2]

[1] Agriculture and Agri-Food Canada Lacombe, AB; [2] Alberta Agriculture and Rural Development (AARD), Lacombe, AB

Leaf Spot Reaction

Very Good (VG) Good (G) Fair (F)

Poor (P) Very Poor (VP)

Barley (row type)	Scald	Net form Net	Spot form Net	Spot Blotch*
General purpose				
AC Harper (6)	F	F	F	xx
AC Lacombe (6)	P	P	G	xx
AC Ranger (6)	P	F	G	G
AC Rosser (6)	VP	F	G	xx
Busby (2)	F	P	G	G
CDC Austenson (2)	VP	P	VG	G
CDC Coalition (2)	VP	VP	G	F
CDC Cowboy (2)	P	F	G	F
CDC Dolly (2)	F	VP	P	xx
CDC Helgason (2)	VP	G	G	F
CDC Maverick (2)	P	F	G	xx
CDC Mindon (2)	VP	VP	G	F
CDC Trey (2)	P	F	VG	F
Champion (2)	VP	VP	F	P
Chigwell (6)	G	F	G	G
Conlon (2)	VP	F	G	P
Gadsby (2)	VG	P	G	VP
Muskwa	G	P	G	F
Ponoka (2)	G	P	G	G
Seebe (2)	G	VP	P	xx
Sundre (6)	VG	P	F	F
TR07728 (2)	VP	F	F	VP
Trochu (6)	F	VP	G	xx
Xena (2)	VP	VP	F	VP

Tight rotation, susceptible variety … no worries, choose the right target and hit it good, hit it real good with fungicide! Problem solved … ???

Boise Gun Club Thanksgiving Turkey Shoot, Boise, Idaho, 2014

Brother: Brent T.

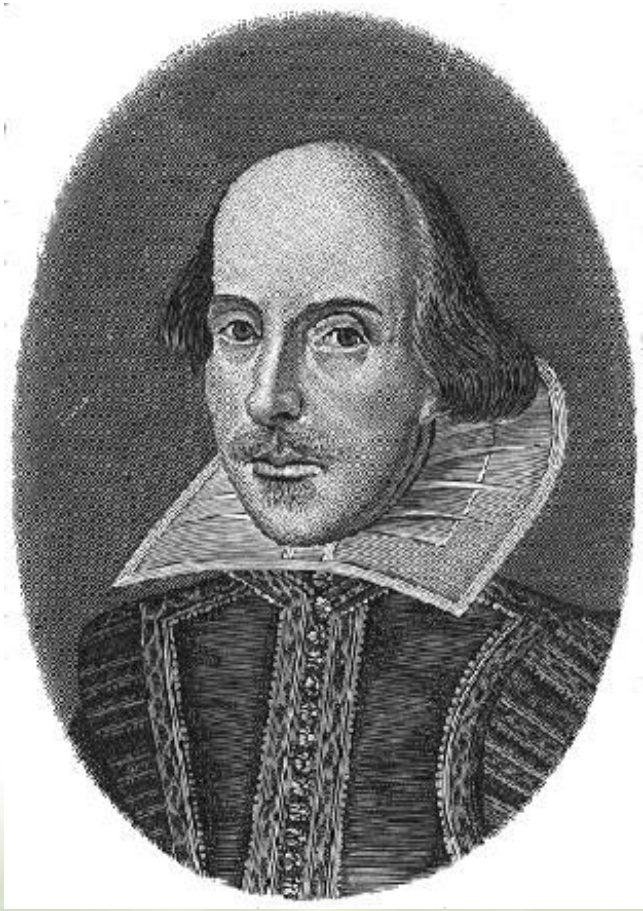
Nephew: Kyle W. – Armoury

Kelly T.
Haul = 1 turkey and 1 ham

Photo by C. Fisher (Brother-in-law)

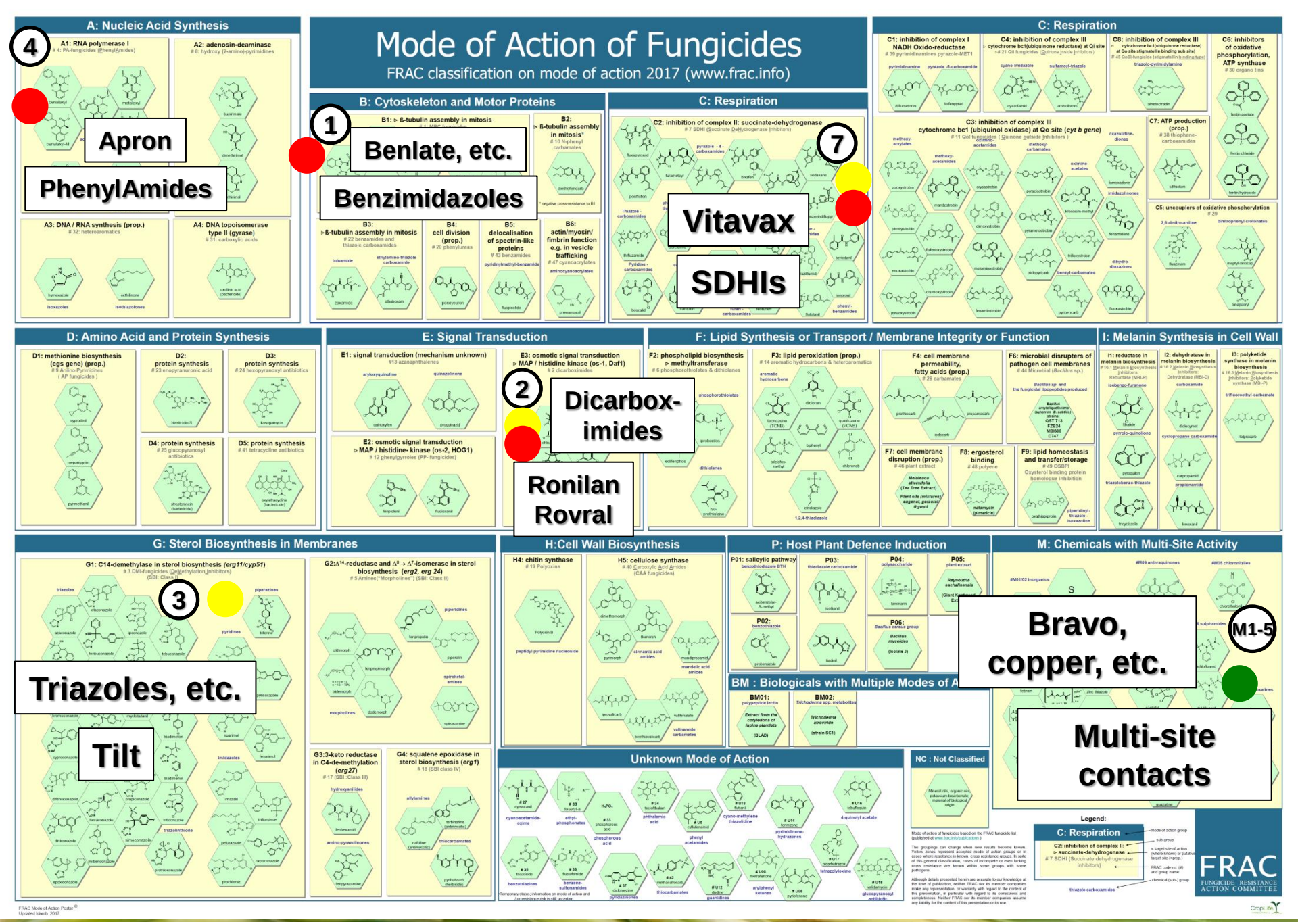
Fungicide issues

- To spray or not to spray?
  - Variation in disease risk
  - Cost/benefit concerns
  - Customer/consultant characteristics
    - Risk averse
      - Insurance spraying
    - Frugal nature
  - Scheduling
    - Weather and availability of applicator, chemical, etc.
- Fungicide resistance
  - Background, risk factors, and management strategies



William Spray-speare

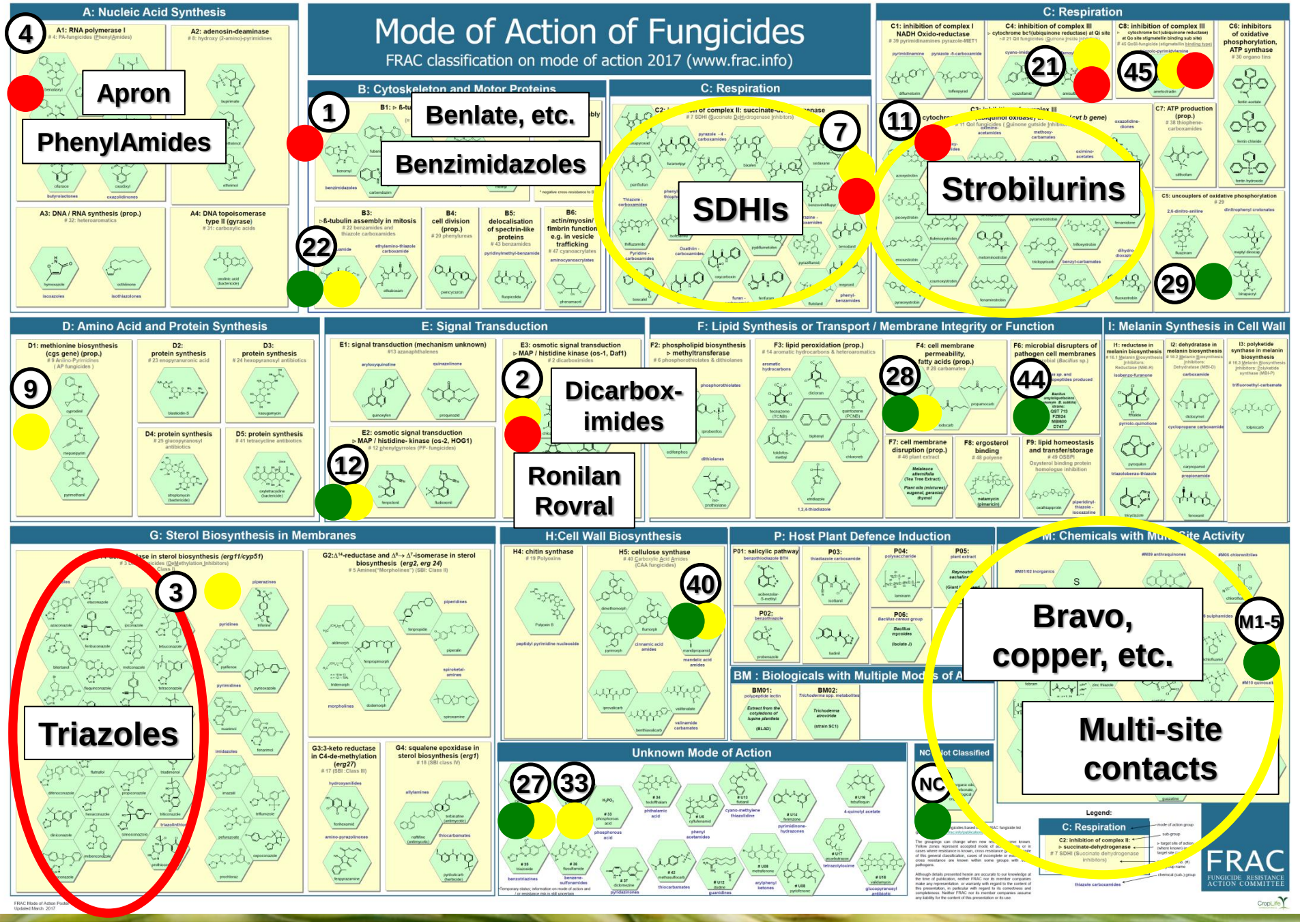
Agricultural Scientist in training, sclerotinia project, AAFC Melfort, 1985



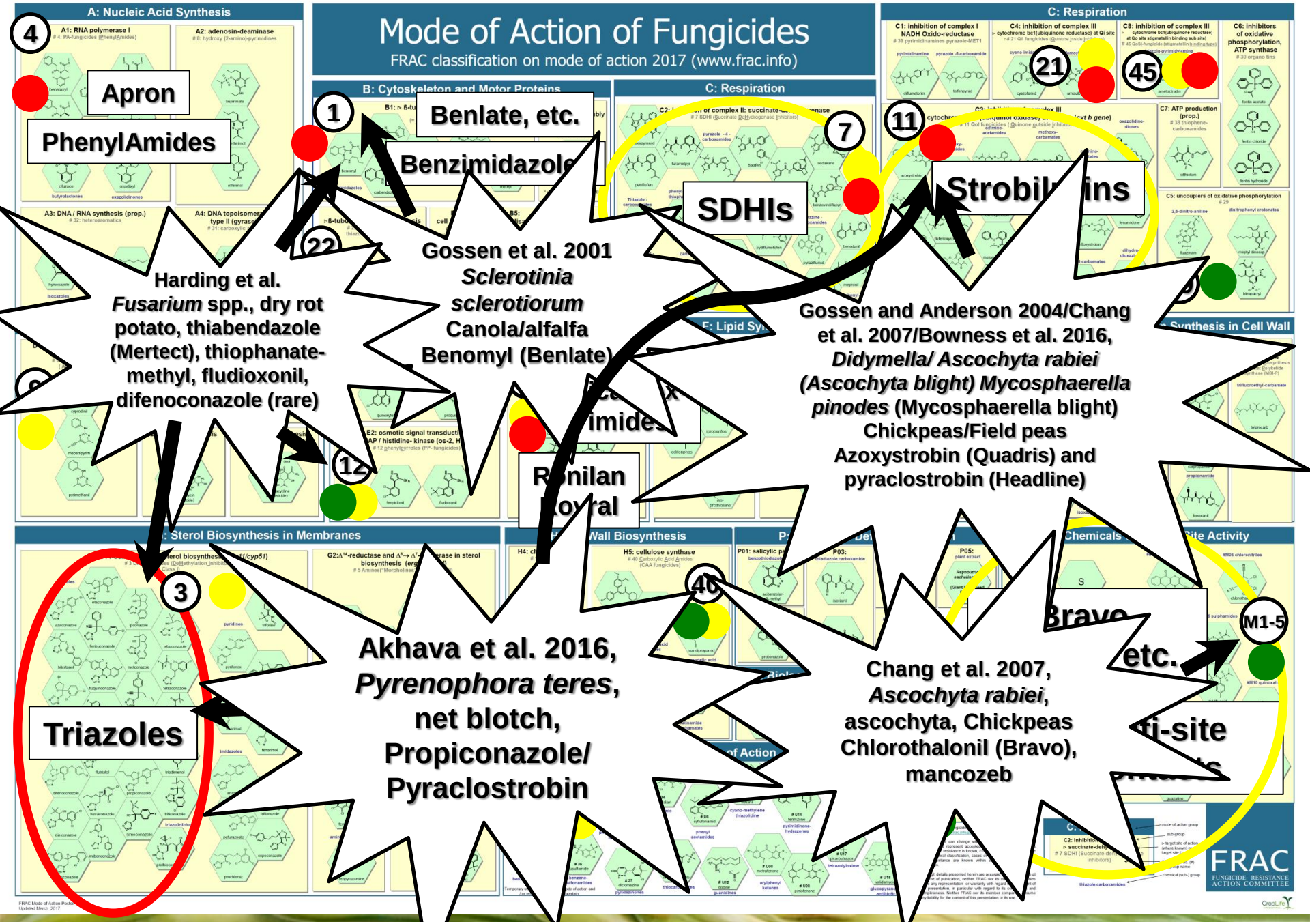
Fungicide options on the Canadian Prairies were limited in the 1980's, much like short length

Mode of Action of Fungicides

FRAC classification on mode of action 2017 (www.frac.info)



Fungicide options on the Canadian Prairies more plentiful in 2018. Triazoles are the main options.



Fungicide options on the Canadian Prairies more plentiful in 2018. Triazoles are the main options.

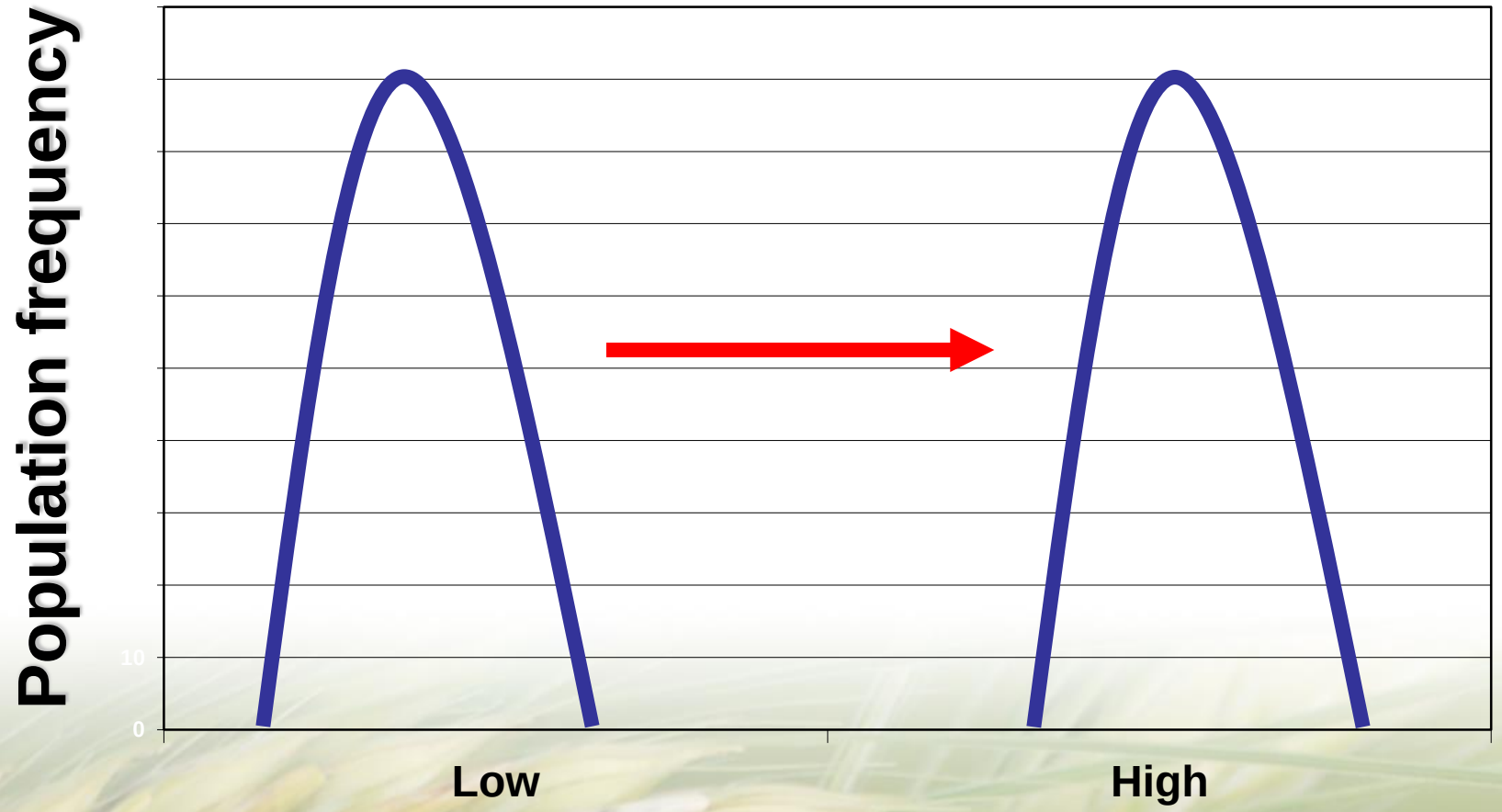
Fungicide resistance

- Genetic trait in the fungus
  - Stable & heritable
  - Not inherent resistance
- Reduced sensitivity
  - Typically observed in the field
    - Laboratory vs. field/practical resistance
- Acquired through selection pressure from fungicide applications
  - Original pathogen pop. largely sensitive
  - Selection for rare fungicide resistant types in the fungus population

Fungicide resistance

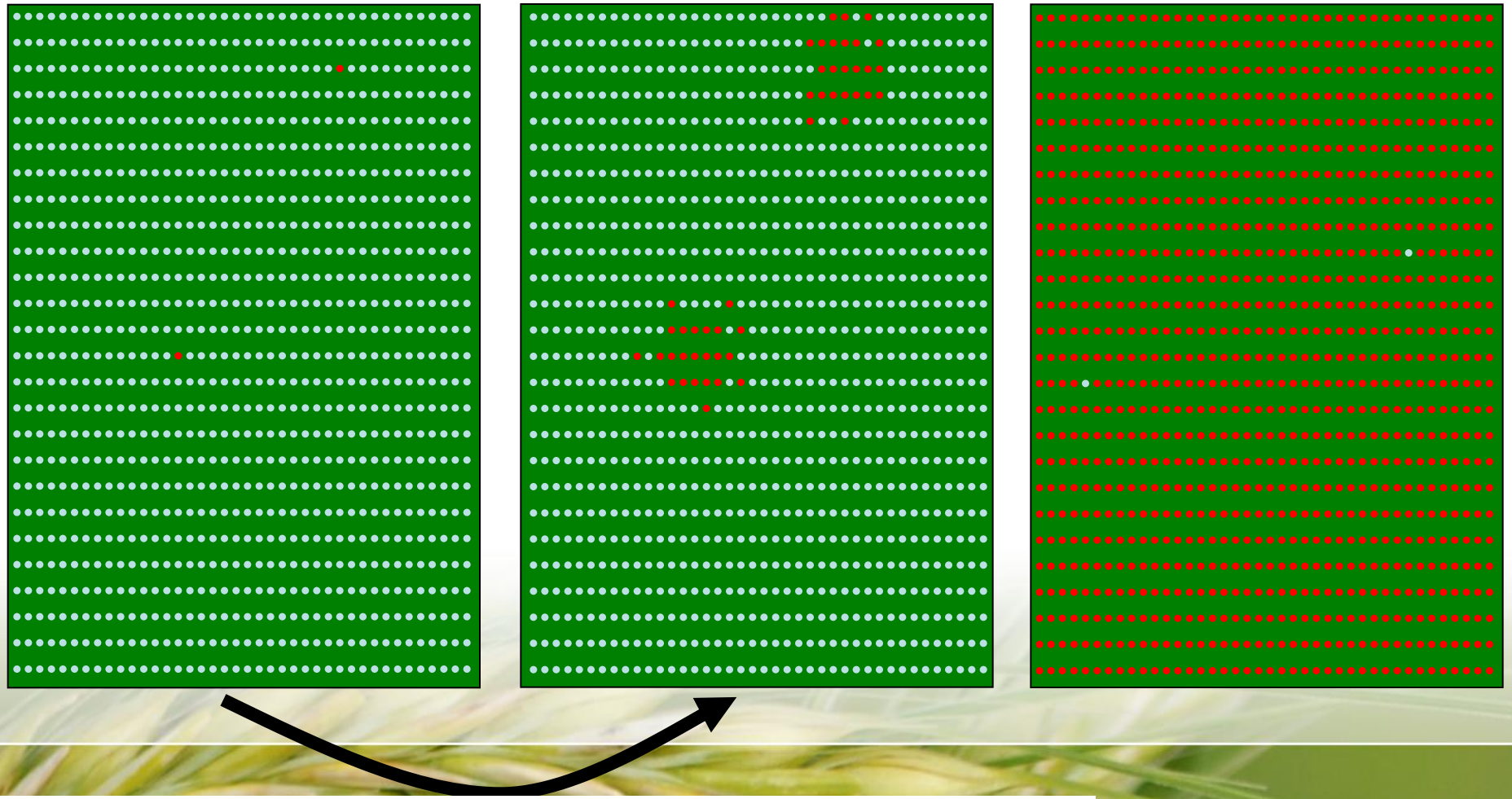
- Selection pressure
  - Repeated use within and/or between growing seasons
    - Same fungicide or similar fungicides
  - Selection for subpopulation of individuals with reduced sensitivity
  - Reduced sensitivity originally arises due to
    - Genetic mutations
    - Genetic recombination (sexual or asexual)
  - Fungicide is not changing the fungus
    - Influence is on population dynamics

Qualitative/single step/discrete resistance (e.g. strobilurins)



Quantitative/multi-step/continuous/progressive resistance (e.g. triazoles)

Repeated applications over a several successive seasons
Noticeable reduction in field performance followed by initiation of performance inquiry



Small number of repeated applications over a few seasons
No noticeable reduction in field performance

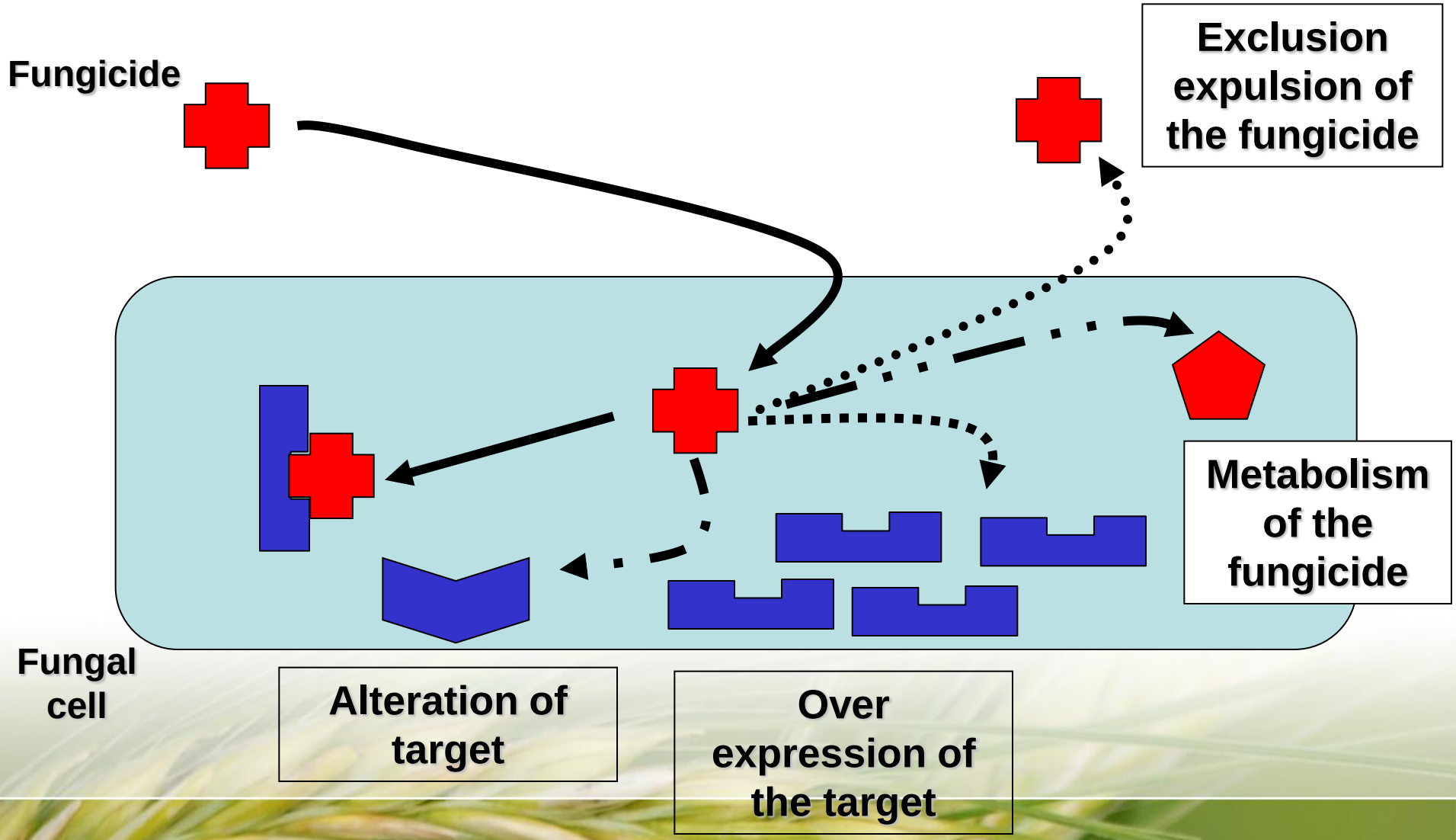
Factors influencing the development of fungicide resistance

- Frequency of active ingredient use
  - Within and between seasons
- Fungal population characteristics
  - Mating and reproduction systems
    - Outcrossing and sexual/asexual reproduction
  - Rare versus more frequently occurring
- Pathogen life cycle
  - Short versus long generation times
    - Polycyclic versus monocyclic pathogens
  - Sporulation potential

Factors influencing the development of fungicide resistance

- Fungicide activity
  - Single- versus multi-site target
- Application of fungicide to well-established infections and reduced-rate applications
  - Less effective control
  - Selection against a larger pathogen population

Resistance mechanisms



After J. Lucas, “Molecular basis for resistance in cereal pathogens

FRAC Classification

Quadris

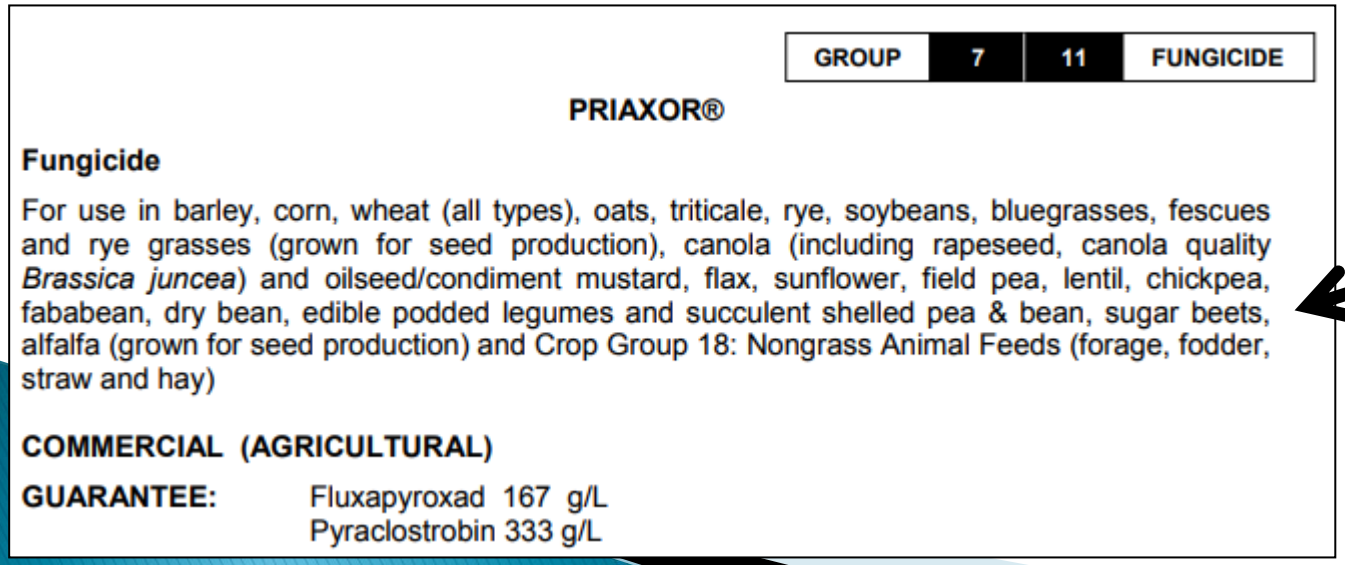
Flowable Fungicide

Broad spectrum fungicide for control of plant diseases

GROUP 11 FUNGICIDES

Active Ingredient:
Azoxystrobin: methyl (*E*)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate* 22.9%
Other Ingredients: 77.1%
Total: 100.0%
Contains 2.08 lbs. of active ingredient per gallon

FRAC codes for resistance management can be found on the front of fungicide labels and in resistance management guidelines within the label



GROUP 7 11 FUNGICIDE

PRIAXOR®

Fungicide

For use in barley, corn, wheat (all types), oats, triticale, rye, soybeans, bluegrasses, fescues and rye grasses (grown for seed production), canola (including rapeseed, canola quality *Brassica juncea*) and oilseed/condiment mustard, flax, sunflower, field pea, lentil, chickpea, fababean, dry bean, edible podded legumes and succulent shelled pea & bean, sugar beets, alfalfa (grown for seed production) and Crop Group 18: Nongrass Animal Feeds (forage, fodder, straw and hay)

COMMERCIAL (AGRICULTURAL)

GUARANTEE: Fluxapyroxad 167 g/L
Pyraclostrobin 333 g/L

For combinations, both FRAC codes should appear, e.g. Priaxor = fluxapyroxad + pyraclostrobin

Slide courtesy of Ron Howard

Management strategies to avoid fungicide resistance

- Avoid the exclusive use of a single product or mode of action
  - Products applied as mixtures with
    - Different modes of action
    - Different breadth of activity
      - Single- site and multi-site
      - Mixture of single site fungicides with different modes of action
  - Sequential use of different products as part of a “rotation” regime
    - Especially where repeated applications are used in a single growing season

Management strategies to avoid fungicide resistance

- Judicious use of fungicides
  - Reduce the potential number of selection events (i.e. fungicide applications with the same MOA)
    - Reduce number of applications per season
    - Choose the right target
    - Use only when required
      - When there is a risk of a significant impact on yield, quality, and/or economics
- Avoid eradicant use?
  - E.g. spraying only when a certain amount of disease is already present

Volunteer control

Management strategies to avoid fungicide resistance

- Follow recommended rates?
  - Reduced rates
    - Reduce input costs
      - Commodity prices are low relative to chemical/application costs
    - Disease risk is low or risk of substantial loss is reduced
    - Desire by government and industry to reduce chemical inputs into the environment
  - Reduced rates may favour survival of individuals with low levels of resistance that would be controlled with a full rate
    - Multi-step resistance

Management strategies to avoid fungicide resistance

- Follow recommended rates?
  - Organizations like FRAC advocate use of full rates
  - Relationship between reduced rates and increased risk of fungicide resistance is not clear
    - Reduced rates may be less effective at control
      - Leave greater proportion of sensitive types
    - Rates can vary under field conditions
  - Likely less of a concern for major vs. minor gene resistance

Effectiveness of different strategies for mitigating the development of fungicide resistance (van den Bosch et al. 2014)

Strategy	Potential for selection of fungicide resistance/insensitivity (number of experiments)		
	Increase	Neutral	Decrease
Increasing fungicide dose	16	1	2
Increasing the number of applications	6	0	0
Alternating active ingredients	1	4	0
Mixing active ingredients	1	5	43
Splitting doses (equivalent to reducing dose)	10	0	1
Early sprays	2	1	3

Effectiveness of different strategies for mitigating the development of fungicide resistance (van den Bosch et al. 2014)

Strategy	Potential for selection of fungicide resistance/insensitivity (number of experiments)		
	Increase	Neutral	Decrease
Increasing fungicide dose	Avoid 16	1	2
Increasing the number of applications	Avoid 6	0	0
Alternating active ingredients	? 1	4	0
Mixing active ingredients	Implement	5	43
Splitting doses (equivalent to reducing dose)	Avoid 10	0	1
Early sprays	? 2	1	3

Try not to rely exclusively on fungicides as your only defence against plant diseases

Use multiple tools from your crop/disease management toolbox

Fungicide resistance resources

- **Fungicide Resistance Action Committee**
  - http://www.frac.info/
  - http://www.frac.info/resistance-overview
  - http://www.frac.info/resistance-overview/mechanisms-of-fungicide-resistance
  - http://www.frac.info/publications/downloads
  - https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/fungicide-resistance-in-grain-crops

Fungicide resistance resources

- Other sources of information
  - https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/fungicide-resistance-in-grain-crops
  - http://www.springer.com/gp/book/9784431556411
  - Consult provincial guides to crop protection, and fungicide labels and manufacturers
    - https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex32

Thank you!

Lacombe, AB to Boise, Idaho Trip
Lolo Pass, Montana, end of August 2013