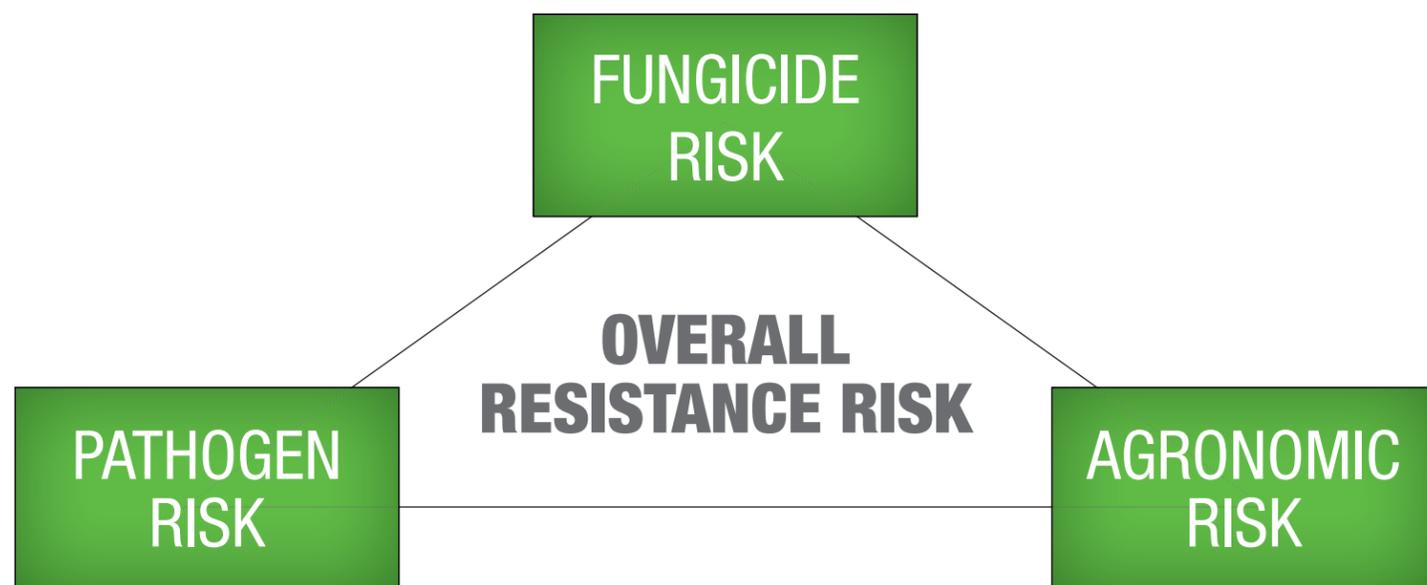


EVALUATING THE RISK OF FUNGICIDE RESISTANCE

With only three major modes of action (MOAs) widely used across Canadian crops for foliar application, it's not as simple or practical to just rotate your mode of action. You need to dig a little deeper to understand and assess your true risk of fungicide resistance.

When evaluating the potential for fungicide resistance, scientists who focus on this area consider three categories of risk:



It is in everyone's best interest to preserve the fungicide tools we currently have available and to avoid the situation we have with herbicide resistance. But it should be noted that there are some fundamental differences between the two situations.

Growers and agronomists need to consider three factors when assessing whether they are at risk in developing resistance. Assessing your resistance risk includes evaluating the combination of the fungicide MOA, the pathogen and the specific farming practices used.

COMBINED RESISTANCE RISK MATRIX

When you plot the pathogen risk against the fungicide risk and lastly by your agronomic risk (farming practices), you can estimate your overall potential for resistance risk development.

FUNGICIDE CLASS	FUNGICIDE RISK	AGRONOMIC RISK						COMBINED RISK
		Low	High	Low	High	Low	High	
Group 1 Group 11 Group 4 Group 2	High = 6	3	6	6	12	9	18	
Group 7 Group 9 Group 3	Medium = 3	1.5	3	3	6	4.5	9	
Multi Sites Resistance Indicated	Low = 1	0.5	1	1	2	1.5	3	
		Low = 1		Medium = 2		High = 3		
PATHOGEN RISK								
PATHOGEN GROUPS		Fusarium head blight Sclerotinia Pythium root rot Rhizoctonia Rusts	Ascochyta blight Anthracnose Septoria leaf spot Mycosphaerella leaf spot Net blotch Tan spot	Alternaria Grey mould Powdery mildew				

Source: www.frac.info

Check out the reverse side for a closer look at the considerations for each risk category. For more information on fungicide resistance, see our videos on YouTube – goo.gl/nllwSQ



THE PATHOGEN

1. Single vs. multiple disease cycles per year?
2. High spore production?
3. Soil vs. wind dispersed?
4. Infects all growth stages of the crop?
5. Does the pathogen have a sexual stage?
If asexual only, there is a lower risk.
6. Relative fitness after mutation?
7. Do they overwinter?

Based on the above factors combined with global real world documentation, below are some major western Canadian pathogens ranked from high to low risk in terms of the potential for resistance development.*

HIGH RISK PATHOGEN = 3	CROP	DISEASE EXAMPLES
<i>Alternaria alternata</i>	Various	Alternaria
<i>Botrytis cinerea</i>	Various (lentils)	Grey mould
<i>Blumeria graminis</i>	Wheat/barley	Powdery mildew
MEDIUM RISK PATHOGEN = 2	CROP	DISEASE EXAMPLES
<i>Ascochyta</i> spp.	Various (pulses)	Ascochyta blight
<i>Colletotrichum</i> spp.	Various (pulses)	Anthracnose
<i>Septoria tritici</i>	Wheat	Septoria leaf spot
<i>Mycosphaerella pinodes</i>	Peas	Mycosphaerella leaf spot
<i>Pyrenophora teres</i>	Barley	Net blotch
<i>Pyrenophora tritici-repentis</i>	Wheat	Tan spot
LOW RISK PATHOGEN = 1	CROP	DISEASE EXAMPLES
<i>Fusarium</i> spp.	Various	Fusarium head blight
<i>Sclerotinia sclerotiorum</i>	Various (canola/lentils)	Sclerotinia
<i>Pythium</i> spp.	Various	Pythium root rot
<i>Rhizoctonia</i> spp.	Various	Rhizoctonia
<i>Puccinia</i> spp.	Various	Rusts

*The listed pathogens may infect other crops not listed.

THE FUNGICIDE

1. Single target site?
2. Single gene controls resistance?
3. High and persistent activity?

Fungicides are classified by their typical resistance behavior pattern, even though resistance development risk may not be entirely uniform among members of a fungicide Group. Relative rankings shown below are based on the three factors above, plus global, real world documentation.

Fungicide Resistance Action Committee (FRAC) Classification of Fungicide Resistance Risk*

HIGH RISK = 6	Group 11 QoI (Strobilurins) Azoxystrobin Pyraclostrobin Picoxystrobin Trifloxystrobin
	Group 1 MBC (Benzimidazole) TPM Thiabendazole
	Group 4 (Phenylamides) Metalaxyl
MEDIUM TO HIGH RISK = 3	Group 7 SDHIs Boscalid Fluxapyroxad Fluopyram Penflufen Sedaxane
	Group 2 (Dicarboxamides) Iprodione
MEDIUM RISK = 3	Group 3 DMIs (Triazoles) Prothioconazole Propiconazole Metconazole Tebuconazole
	Group 9 AP (Anilino Pyrimidines) Pyrimethanil Cyprodinil
LOW TO MEDIUM RISK = 1	Group 40 CAA (Carboxylic Acid Amines) Dimethomorph
	Group 12 (Phenylpyrroles) Fludioxonil
	M3 (Dithiocarbamate) Mancozeb Thiram Maneb
	M1/2 (Inorganics) Copper Sulphur
UNKNOWN	Microbial membrane disruptors

*This is not an exhaustive list, but captures the majority of active ingredients that are relevant for Western Canada

AGRONOMIC PRACTICES

1. Climatic conditions favouring disease?
2. How many fungicide applications per year?
3. How many fungicide applications are targeted on the same pathogen year over year?
4. What rates are used? (Lethal versus sub-lethal rates)
5. Resistant cultivars available?
6. Irrigation potential?
7. Sanitary measures? (i.e., tillage)
8. Fertilization considerations?

The final step in assessing your overall risk is evaluating agronomic risk factors with an assigned score of 1 in high risk situations and 0.5 in low risk situations, which essentially means that if you do all things correctly from an agronomic standpoint, **you can cut your resistance risk in half!**

High risk agronomic practices for fungicide resistance development include:

- Utilizing the same mode of action against the same pathogen multiple times in the same growing season (in most cases, diseases that are controlled by seed treatments do not cause foliar symptoms in the same year)
- Applying a fungicide once the crop is already heavily infected vs. applying preventively, prior to heavy infection
- No complementary use of other non-chemical control measures
- Using susceptible cultivars/varieties
- Not burying heavily infected residue (tillage)
- Poor crop rotations – planting same crop year over year, or planting another crop that is susceptible to the same pathogens as the year previous

Fungicide resistance reports in cereal, pulse and canola pathogens are fairly rare in North America. The main pathogens of concern for Canadian growers, such as sclerotinia, rusts and fusarium, are all classified as low-risk pathogens. Additionally, agronomic and environmental conditions, which strongly influence resistance risk in Western Canada, are regarded as low. This means that while fungicide resistance is something growers should be aware of, the overall risk of fungicide resistance across the Prairies is quite low relative to other areas of the world.