# MAINTAINING EFFECTIVE DISEASE CONTROL IN HIGH YIELDING POTATO PRODUCTION

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# Fungicide Resistance Management

Why is it important?

Source: DPIRD 2024

1. Keeps products working
2. Drives new active discovery
3. Ensures sustainable agronomic programs
4. International standard

Fungicide Resistance Warning GROUP 7 12 FUNGICIDE

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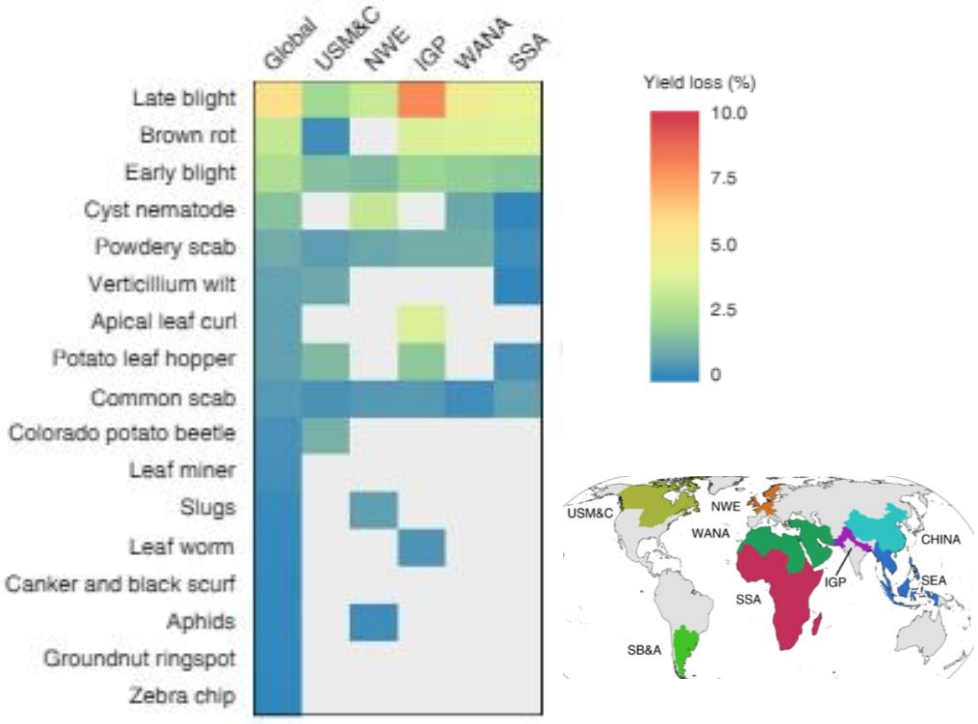
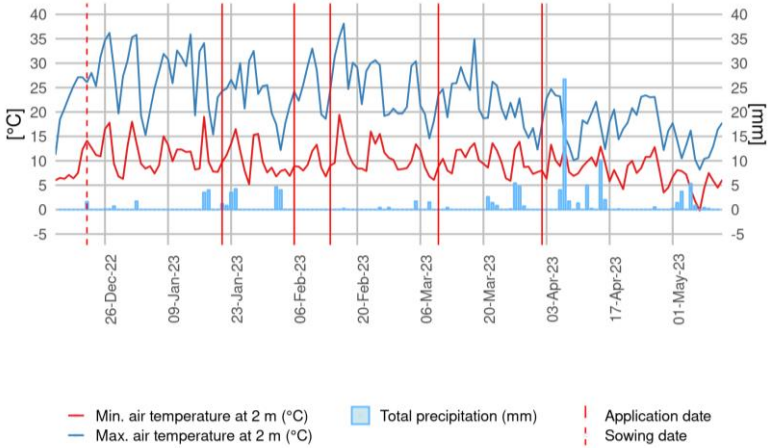
# Yield limiting factors




*Ref.* Savary S., et al.., The global burden of pathogens and pests on major food crops. *Nat. Ecol. Evol.* **3**, 430–439 (2019)

# Sustainable potato production

## Key pests and diseases

| Bacteria | Fungi | Viruses | Nematodes | Insects |
|---|---|---|---|---|
| Bacterial Wilt (*Psuedomonasola naceum*) | Powdery Scab (*Spongospora subterranean)* | Potato leaf roll | Potato cyst (*Globodera rostchiensis*) | Potato Moth |
| Seed Piece Decay (*Erwinia, Fusarium sp.*) | Silver Scurf (*Helminthosporium solani)* | Tomato spotted wilt | Root knot (*Meloidogyne spp)* | Green peach aphid |
| Common Scab (*Streptomyces scabies)* | Black dot (*Collectotrichum coccodes)* | Purple top wilt | Lesion nematode (*Pratylenchis spp)* | Potato aphid |
| Soft Rot (*Erwinia spp.)* | Black scurf (*Rhizoctonia solani)* | | | |
| Black leg (*Erwinia carotova)* | Late Blight (*Phytopthora infestans)* | | | |
| | Early Blight (*Alternaria solani*) | | | |
| | Dry Rot (*Fusarium sp.)* | | | |
| | Pink Rot (*Phytopthora erythroseptica)* | | | |

# Sustainable potato production

## Nutrition and crop protection program

| Timing | Fertiliser | Herbicide | Fungicide | First Commercial use |
|---|---|---|---|---|
| Pre-spread | MOP or SOP 500kg/Ha | | | |
| Planting | 11-13-19-1 1500kg/Ha | | Amistar 1.0L/Ha + Ridomil 480SL1.0L/Ha | 2005<br>1977 |
| Pre-emergence | | Boxer Gold 4-5L/Ha + Metribuzin 450g/Ha | | 2008<br>1975 |
| Emergence | | Sprayseed 2.5L/Ha + Metribuzin 450g/Ha | | 1969<br>1975 |
| Early post | | | Ridomil MZ 2.5kg/Ha | 1996 |
| Repeat 7-10 days | Urea 125kg/Ha | | Ridomil MZ 2.5kg/Ha | 1996 |
| Half row closure | Urea 125kg/Ha | | Miravis Prime 1.0L/Ha | 2021 |
| Row closure | Urea 125kg/Ha | | Bravo WeatherStik 1.8L/Ha | 1964 |
| Every 10-14 days | | | Bravo WeatherStik 1.8L/Ha | 1964 |
| 10-14 weeks post plant | | | Bravo WeatherStik 1.8L/Ha + Miravis 375mL/Ha | 1964<br>2007 |

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# Sustainable potato production

## Fungicide MOA groups by disease target

| Black Scurf *Rhizoctonia* spp | FRAC MOA GRP | Dry Rot *Fusarium solani* | FRAC MOA GRP |
|---|---|---|---|
| flutolanil | 7- SDHI | captan | M04 - multisite |
| iprodione | 2 - Dicarboxamide | thiophanate | 2 - Dicarboximide |
| mancozeb | M03 - multisite | imazalil | 3 - DMI |
| pencycuron | 20 - phenylurea | thiabendazole | 1 - MBC |
| quintozene | 14 - AH | | |
| thiabendazole | 1 – MBC's | | |
| thiophanate | 1 – MBC's | | |
| thifluzamide | 7 - SDHI | | |
| tolclofos-methyl | 14 - AH | | |

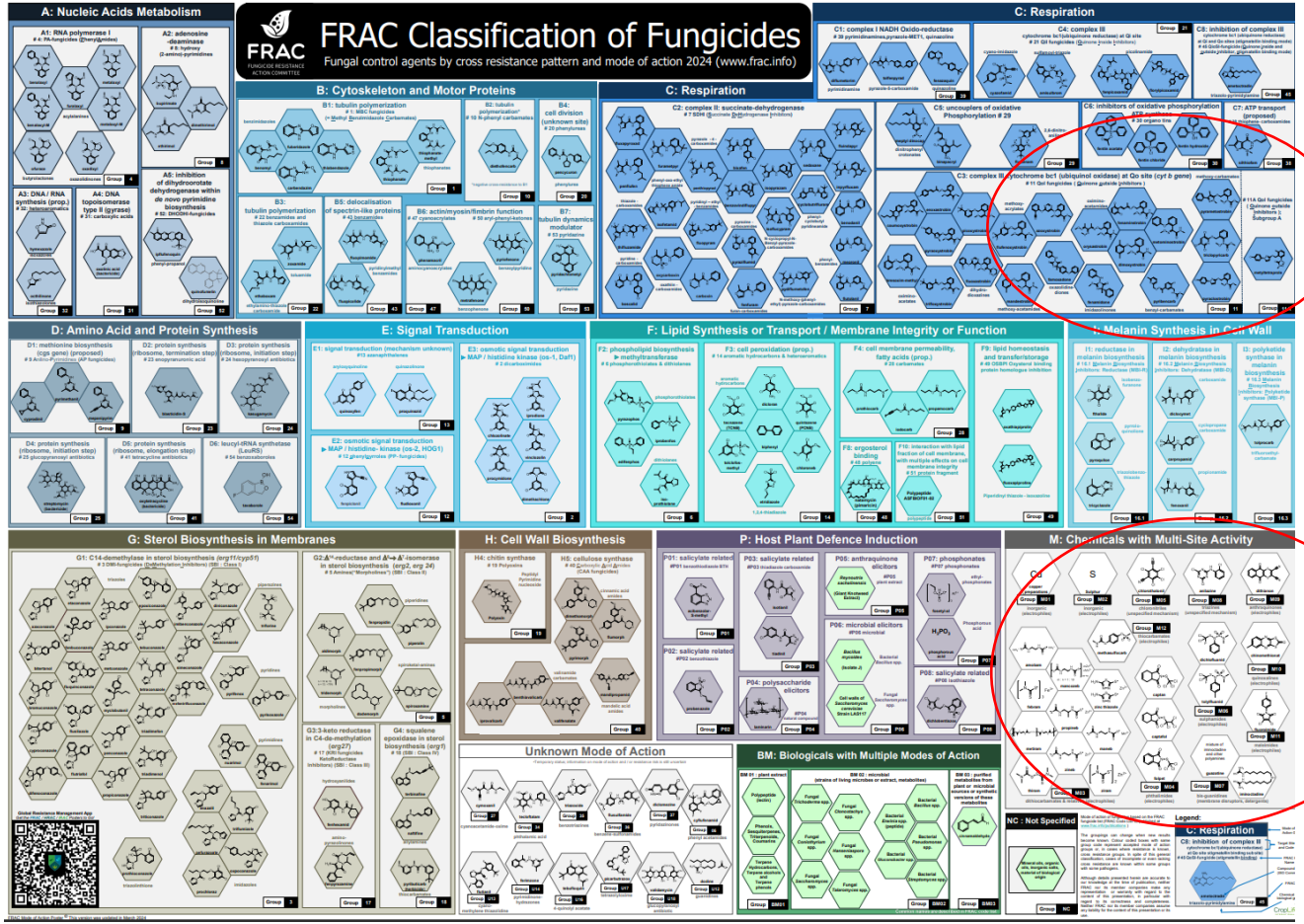
# Sustainable potato production

## Fungicide MOA groups by disease target

| Early Blight *Alternaria solani* | FRAC MOA GRP | Late blight *Phytopthora infestans* | FRAC MOA GRP | Late blight *Phytopthora infestans* | FRAC MOA GRP |
|---|---|---|---|---|---|
| azoxystrobin | 11 - Qoi | amisulbrom | 21 - Qii | kresoxim-methyl | 11 - Qoi |
| pydiflumetofen | 7 - SDHI | azoxystrobin | 11 - Qoi | mancozeb | M03 - multisite |
| chlorothalonil | M05 - multisite | benalaxyl | 4 - PA | mandipropamid | 40 - CAA |
| copper | M01 - multisite | chlorothalonil | M05 - multisite | metalaxyl | 4 - PA |
| cymoxanil | 27 - unknown | copper | M01 - multisite | metiram | M03 - multisite |
| difenoconazole | 3 - DMI | cyazofamid | 21 - Qii | iprovalicarb | 40 - CAA |
| fentin | 30 | cymoxanil | 27 - unknown | propamocarb | 28 - carbamate |
| fludioxonil | 12 | dimethomorph | 40 -CAA | propineb | M03 - multisite |
| kresoxim-methyl | 11 - Qoi | famoxodone | 11 - Qoi | pyraclostrobin | 11 - Qoi |
| mancozeb | M03 - multisite | fluazinam | 29 | | |
| | | fluopicolide | 43 - benzamide | | |

# Fungicide MOA - FRAC

| Compound | Mandipropamid, benthiavalicarb | Cyazofamid, Amisulbrom | Fluazinam |
|---|---|---|---|
| GROUP NAME | Carboxylic Acid Amides (CAA) | QiI fungicides (Quinone inside Inhibitors) | 2,6-dinitro-aniline |
| FRAC MoA Code | 40 | 21 | 29 |
| TARGET SITE AND CODE | F5 Cellulose synthesis | C4 - Quinone 'inside' (Qi) binding site of the cytochrome bc1 (ubiquinone reductase) | C5: uncouplers of oxidative phosphorylation |
| Uses | Oomycete diseases control in potatoes, grapevines, fruiting vegetables, leafy vegetables etc. | Oomycete diseases control in potatoes, grapevines, fruiting vegetables, leafy vegetables etc. | Foliar application: *Phytophthora infestans* on potato and tomato; *Sclerotinia* spp. on potato, beans, peanut, wheat, cotton, soybean, carrots; *Botrytis* spp. on beans, grapes, onion and ornamentals; *Venturia inaequalis* on pome fruit, Soil application: *Phytophthora infestans* on potato; *Plasmodiophora brassicae* on Brassica crops |
| Resistance Status | •Low to moderate.<br>•Specific resistance have been detected in Plasmopara viticola in<br>•No specific resistance identified in Phytophthora infestans.<br>•Resistance management required.<br>•Active resistance monitoring program for Plasmopara viticola and Phytophthora infestans. | •Medium to high risk.<br>•Specific resistance have been detected in Plasmopara viticola in France.<br>•No specific resistance identified in Phytophthora infestans.<br>•Resistance management required.<br>•Active resistance monitoring program for Plasmopara viticola and Phytophthora infestans. | The resistance risk is considered low<br>•Field resistance has been claimed in *Botrytis* in Japan (beans).<br>•Reduced sensitivity of *Phytophthora infestans* has been detected in a clonal lineage (EU: 37) in various European countries. |
| Recommendations | **Recommendations for potatoes**<br>•Apply CAA fungicides preferably in a preventive manner.<br>•Apply a maximum of 50 % of the total number of intended applications for late blight control during one crop cycle.<br>•Alternation with fungicides having other modes of action is recommended in spray programs. | **Recommendations for potatoes**<br>•Apply QiI fungicides preferably in a preventive manner.<br>•Apply a maximum of 50 % of the total number of intended applications for late blight control during one crop cycle.<br>•Alternation with fungicides having other modes of action is recommended in spray programs. | **Recommendations for potato (late blight)**<br>•Apply fluazinam preventatively.<br>•Maximum of six applications.<br>•In regions with reported resistance it is recommended to limit the number of fluazinam applications to max. 50% of all applications and use mixtures with fungicides belonging to other modes of action that provide satisfactory efficacy against *Phytophthora infestans*.<br>•No more than 3 sequential applications of fluazinam. In regions with resistance or reduced sensitivity apply a maximum of 2 sequential applications if product is used solo. |




- Over eighteen MOA groups
- 12 diverse multi-sites
- 7 Qoi's
- Diversity of target sites

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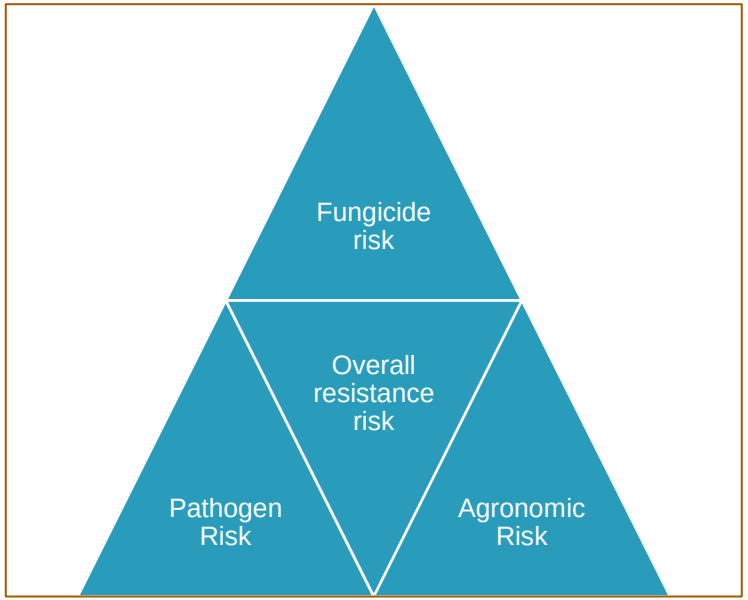
# Resistance risk assessment



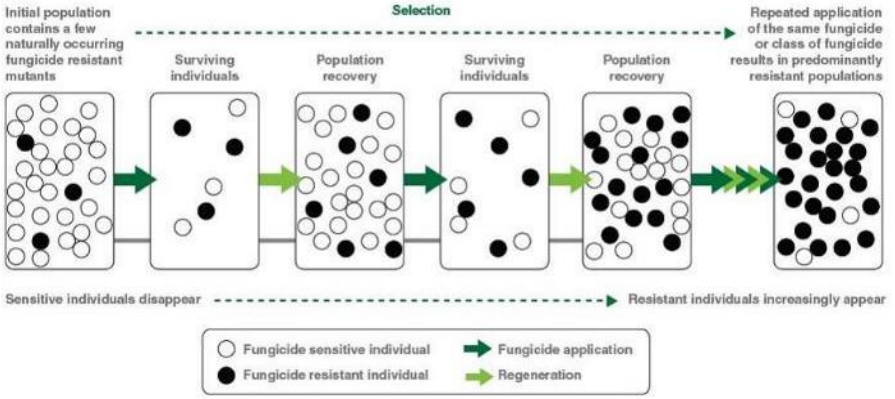

**Fungicide Risk**
- Efficacy degradation over time
- Site of action (single v. multi-site)
- Novel mode of action
- Resistance mechanisms

**Pathogen Risk**
- Epidemiology (cycles per season)
- Recombination opportunity
- History with other fungicides
- Dispersal factors

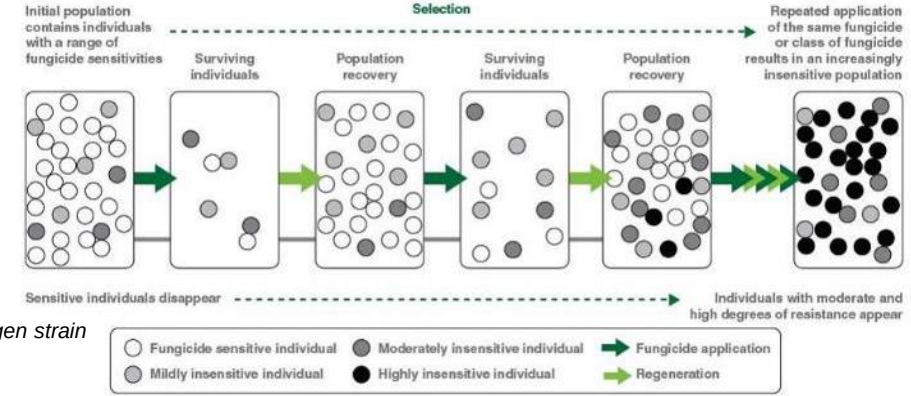
**Agronomic factors**
- Environment influences resistance development
- Cultural effects
- Varietal susceptibility
- Application practices

# Types of fungicide resistance

**Qualitative** – pathogen population contains sensitive and mutated individuals. Surviving pathogen passes on progeny




**Quantitative** – pathogen population has a range of sensitivities. Regular fungicide application results in insensitive population




*Pathogen population changing from a sensitive pathogen strain to an insensitive pathogen strain modified from Hewitt 1998*

# Fungicide resistance management

Selection pressure drives rate of resistance development

| | Increase Selection pressure | No Effect | Decrease Selection pressure |
|---|---|---|---|
| Increase Dose | 16 | 1 | 2 |
| Increase spray number | 6 | 0 | 0 |
| Add mixture partner | 1 | 6 | 46 |
| Alternate (replace sprays) | 1 | 2 | 9 |
| Adjust timing | 3 | 1 | 2 |

Table 1 Summary of the published evidence of the effectiveness of fungicide resistance management tactics

Van den Bosch et al. 2014 Governing principles can guide resistance management tactics
*Annual Review Phytopathology*
**analysis included P/infestans. P.viticola, P. cubensis and P. aphandiermatum*

# Sustainable potato production

## Basics of current crop protection program in place for over 25 years

### Key agronomic practices supporting longevity

- Paddock hygiene – clean seed, volunteers/weed control, minimized soil movement
- Paddock rotation and separation from previous crops
- Use of non-host rotational crops
- Crop protection resistance management – diversity of multisite/protectant and eradicant fungicides
- Varietal improvements – yield & disease tolerance
- Best practice application
- Early warning technologies – disease modelling, plant wearable tech

# Sustainable potato production

## Future challenges

- Abiotic stresses – increasingly variable climatic factors – heat & drought
- Increasing regulation limiting access to existing fungicides
- Pipeline of new MOA's
- Nutrient use efficiency
- Irrigation availability
- Soil structure decline

*John Cresswell – TAS – March 2024*