



Fungicide Resistance Management Strategies

Developed by the CropLife Australia Fungicide Resistance Management Review Group and industry researchers

Valid as at 7 June 2017

INTRODUCTION

1. WHAT IS FUNGICIDE RESISTANCE?

Resistance by fungal pathogens to fungicides usually evolves following the intensive use of fungicides for disease control. In any fungal population there are likely to be individuals that have some degree of natural resistance and which are less susceptible to fungicides, even before the chemicals are used. Resistance arises through the incorrect use of fungicides by selection of the resistant forms of fungi. Continued use of a fungicide or fungicide chemical group can result in a significant build-up of resistant individuals in the fungal population – to the point where that particular product, or other products from the same chemical group, is no longer effective. In some cases, removal of the selection pressure can result in the fungal population regaining its sensitivity to the fungicide group, but this is not always the case. The risk of fungicide resistance developing varies between different chemical groups and different fungal pathogens, such that specific strategies are recommended for those situations considered to carry the highest risk.

2. WHAT CAN BE DONE TO PREVENT OR DELAY RESISTANCE?

- 2.1 The most common approach to managing fungicide resistance is through responsible use of fungicides, of which the resistance management strategies presented in this document are good examples. In their most basic form, these strategies advocate rotation of fungicide products with a different chemical activity group to prevent over-use of any one product or activity group. More complex strategies safeguard against the development of cross-resistance or resistance to multiple chemical groups. In Australia, all fungicide products are labelled to identify which activity group they belong to. The activity group is indicated by a number (or letter/number combination) code on the product label.
- 2.2 Selecting the most effective or appropriate way to apply fungicides will make them work better and assist in delaying the development of resistance. A good understanding of the pathogen's life cycle and epidemiology will also help in the selection of the most appropriate application method. As a general rule, targeted applications to control a certain development stage or population level are most effective, whereas shotgun approaches like application of fungicides through irrigation systems could accelerate the development of resistance by exposing a large portion of the fungal population to sub-lethal rates. Particular attention should be given to label recommendations, rates and coverage. Adherence to suggested disease threshold levels is also good resistance management practice.

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- 2.3 The use of cultural practices or growing varieties of crops with a high degree of natural resistance to diseases – requiring fewer or less frequent fungicide applications.
- 2.4 Working with industry bodies such as the CropLife Australia Fungicide Resistance Management Review Group to establish resistance management strategies for minor crops and/or those crops for which no strategies exist. Of particular concern are permitted uses of fungicides, often in minor crops, where repeated use of a limited number of fungicide alternatives occurs. Although not explicitly stated on agricultural use permits, such permitted uses should also incorporate measures to prevent resistance.
- 2.5 In the event of tank mixing products and/or co-formulations, always follow the recommendation from the most recent Fungicide Resistance Management Strategies and apply the most stringent strategy applicable to the pathogen most at risk of developing resistance.
- 2.6 Certain environments are conducive to continuous infection and consistently high disease pressure. Examples of such environments are nurseries, tunnels, glasshouses and other structures of protected cultivation. Because protected cultivation usually requires multiple applications of fungicides at short intervals to control high disease incidence, these are often the origin of resistance to fungicides. Users of fungicides should be particularly mindful of the resistance risk under these conditions. Do not use a fungicide product to which resistance has been confirmed and stop using a product if resistance is suspected. When the fungicide in question no longer gives adequate control, stop using it temporarily and consult the supplier on its current resistance status.
- 2.7 In the absence of an established resistance management strategy for a particular crop/disease situation, it is recommended that the use of fungicides from any given activity group (excluding Group M) be limited to a maximum of one-third of the total number of fungicide applications. The use of consecutive applications of fungicides from the same activity group should also be limited by alternating between products from different activity groups. The use of Group M fungicides is not limited, as these fungicides carry an inherently low risk of fungicide resistance developing.

3. ACTIVITY GROUP LABELLING IN AUSTRALIA

In order to help fungicide users to manage fungicide resistance, all fungicide products sold in Australia are classified according to the chemical activity group of their active constituent. The activity group must be indicated by a letter code on the product label. Australia was the first country to introduce compulsory activity group labelling on products. Since the introduction of activity group labelling in Australia, other countries have adopted activity group classification systems, however caution should be shown if cross-referencing activity groups between Australia and other countries, as there are some differences in classification.

4. CHANGES TO ACTIVITY GROUPS

In 2008, CropLife Australia completely revised Australia's fungicide activity grouping system to bring it into line with the international Fungicide Resistance Action Committee (FRAC) activity group classification system. This was the first major revision of the Australian classification system since its introduction several years ago. Activity group codes have now been changed from letters to numbers (or letter/number combinations). For a complete list of all fungicide active constituents registered in Australia and their old and new activity groups, see the Fungicide Activity Group Table on the CropLife Australia website at www.croplife.org.au.

RESISTANCE RISK

Table 1: Plant pathogens accepted as showing a medium risk of development of resistance to fungicides

FRAC Pathogen	Crop	Disease
<i>Bremia lactucae</i>	Lettuce	Downy mildew
<i>Gibberella fujikuroi</i> *	Rice	Bakanae
<i>Leptosphaera nodorum</i> (<i>Stagonospora nodorum</i>)	Wheat	Leaf spot
<i>Monilinia</i> spp.	Stone and pome fruit	<i>Monilinia</i> rots
<i>Mycosphaerella graminicola</i> (<i>Septoria tritici</i>)	Wheat	Septoria
<i>Mycosphaerella musicola</i>	Banana	Yellow Sigatoka (Leaf Spot)
<i>Peronospora</i> spp.	Various	Downy mildew
<i>Podosphaera leucotricha</i>	Apple	Powdery mildew
<i>Puccinia</i> spp.	Wheat/barley	Rusts
<i>Pyrenophora teres</i>	Barley	Net Blotch
<i>Pyrenophora tritici-repentis</i>	Wheat	Tan spot (yellow spot)
<i>Tapesia</i> spp.	Wheat/barley	Eyespot
<i>Erysiphe necator</i> *	Grapevine	Powdery mildew

* The EPPO Guideline lists these pathogens as high risk and baselines are normally requested

Table 2: Plant pathogens accepted as showing a high risk of development of resistance to fungicides (adapted from EPPO, 2002)

FRAC Pathogen	Crop	Disease
<i>Botryotinia fuckeliana</i> (<i>Botrytis cinerea</i>)	Various, especially grapevine	Grey mould
<i>Erysiphe graminis</i>	Wheat / barley	Powdery mildew
<i>Mycosphaerella fijiensis</i>	Banana	Black sigatoka
<i>Phytophthora infestans</i>	Potato	Late blight
<i>Plasmopara viticola</i>	Grapevine	Downy mildew
<i>Pseudoperonospora cubensis</i> and related	Cucurbits	Downy mildew
<i>Pyricularia oryzae</i>	Rice	Rice blast
<i>Sphaerotheca fuliginea</i> and related	Cucurbits	Powdery mildew
<i>Venturia</i> spp.	Apple, pear	Scab

Table 3: Plant pathogens for which resistance has been confirmed in Australia. Users are advised to at all times adhere to appropriate resistance management strategies.

FRAC Pathogen	Crop	Resistance confirmed against	FRAC Group	Disease
<i>Botrytis cinerea</i>	Strawberries	Iprodione	2	Grey mould
		Strobilurins	11	
		Pyrimethanil	9	
		Fenhexamid	17	
<i>Blumeria graminis</i> f.s.p. <i>hordei</i>	Barley	Tebuconazole	3	Powdery mildew
<i>Podosphaera xanthii</i>	Cucurbits	Buprimate	8	Powdery mildew
		Strobilurins	11	
		Triadimenol	3	
<i>Erysiphe necator</i>	Grapes	Strobilurins	11	Powdery mildew
<i>Venturia inaequalis</i>	Apples	Triazoles	3	Black spot
<i>Plasmopara viticola</i>	Grapes	Phenylamides	4	Downy mildew
<i>Mycosphaerella musicola</i>	Bananas	Strobilurins	11	Yellow sigatoka

Pathogens with high resistance risk:

In some cases, fungicides from additional fungicide activity groups may be available under permit for use in the above crop/pest situations. Details of such permits can be obtained from the Australian regulator's (APVMA) website: (www.apvma.gov.au). In the absence of a resistance management strategy for activity groups of products available under permit, **or in the absence of restrictions contained within the permit**, it is strongly advised that those products (excluding Group M fungicides) be used in alternation with registered products from other fungicide activity groups, which should be used in accordance with the following resistance management strategies.

Pathogens with medium or unlisted resistance risk

In some cases, fungicides from additional fungicide activity groups may be available under permit for use in the above crop/pest situation. Details of such permits can be obtained from the Australian regulator's (APVMA) website: (www.apvma.gov.au). In the absence of a resistance management strategy for activity groups of products available under permit, it is advised that spray programs incorporating those products (excluding Group M fungicides) also incorporate registered products from other fungicide activity groups, which should be used in accordance with the following resistance management strategies.