

Fungicide Resistance Management



Introduction

There has been a steady increase in the occurrence of fungicide resistance since the introduction of systemic fungicides in the early 1970s. Such fungicides frequently have very specific modes of action, unlike many of the older materials.

Resistance is often first recognised when expected levels of disease control in the field are no longer achieved with doses below the label-recommended dose of the fungicide.

Fungicide resistance can arise rapidly and completely so that disease control is totally lost or it can be a more gradual process resulting in partial loss of control. Examples in both categories are known in the UK.

There are many instances of complete failure of control due to resistance to the strobilurin (e.g. azoxystrobin) fungicides and some to the phenylamide (e.g. metalaxyl) group. A more gradual loss of control has been found with the triazole group (e.g. tebuconazole) and dicarboximides (e.g. iprodione).

Resistance to some groups of fungicides has occurred more frequently than to others; likewise some pathogens appear to be more likely than others to become resistant. Factors that affect the development of fungicide resistance include the type of fungicide, its frequency of use, whether alone or in a programme, the target pathogen and the ability of the resistant forms to survive.

It is important to emphasise that most fungicides are still very effective against the target organisms for which they were developed. Poor control may also be caused by a range of other factors, such as poor application or timing, adverse weather and incorrect disease identification. These should always be considered before concluding poor control is caused by resistance.

However, the potential dangers of resistance must be recognised and early stewardship action will enable the industry to gain the maximum benefit from the effective fungicides which are available.

The purpose of this publication is to provide information on fungicide resistance as it affects growers in the UK.

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Strategies against resistance

The risk of pathogens developing resistance to fungicides can be reduced by various means.

1. Where available, make full use of disease-resistant varieties.
2. Use crop rotation to avoid the build-up of soil-borne and trash-borne pathogens.
3. Practice integrated pest management (IPM) to utilise all agronomic measures to reduce the risk of disease occurring, e.g. delayed sowing, barriers, biological controls.
4. Practice good hygiene: clean/disinfect tools and machinery and pay close attention to the disposal of plant debris and elimination of other primary sources of inoculum.
5. Minimise the use of fungicides: use the minimum effective dose, avoid the use of unnecessary prophylactic treatments and particularly avoid repeated applications of fungicides from the same mode of action group.
6. Alternate applications of fungicides from different groups, and use recommended formulated mixtures or tank-mixes designed to help combat resistance. Lists of different popular fungicides approved for use on crops ordered by fungicide mode of action group are available online.
7. Make full use as possible of fungicides with a multi-site mode of action, which are less prone to fungicide resistance problems.
8. In cereals, consider varietal mixtures and other diversification strategies to decrease epidemic development.

Glossary of resistance terms

Adaptability – see Fitness.

Broad spectrum – see Spectrum of activity.

CAA – Carboxylic acid amide.

Chemical family – fungicides with similarities in their chemical structure (see FRAC Mode of Action Groups).

Contact – a fungicide that only works when directly in contact with the disease and is not moved around the plant.

Cross resistance – where pathogens are resistant to different fungicides, within the same mode of action group. Where more than one biochemical or genetic mechanism are known to cause resistance, this is termed Multiple Resistance.

Degradation or enhanced degradation – the normal or increased rate of decomposition of a fungicide mainly in the soil by chemical or biological means. This can lead to disease control failure and give a false impression that resistance is occurring.

DMI – demethylation-inhibiting.

Dose – the amount or rate of a product applied to a unit area e.g. 1.0 kg/ha.

Eradicant – a fungicide that can prevent disease already present in a plant from developing further and therefore causing more damage.

Ergosterol biosynthesis inhibitor (EBI) – an inhibitor of sterol synthesis, which is essential for fungal growth. EBI fungicides include DMIs and in addition, the morpholines and piperidines.

Field resistance – the detection of resistance forms in field samples – see Resistance in practice.

Fitness – relates to the capacity of a pathogen to grow, reproduce and survive in the environment. Some fungicide-resistant forms are less fit than fungicide-sensitive forms and may gradually disappear from the population when the fungicide ceases to be used.

FRAC – Fungicide Resistance Action Committee, an international industry-based committee that issues guidance on anti-resistance strategies for different fungicide groups (www.frac.info).

FRAG-UK – Fungicide Resistance Action Group - UK, an independent group of scientists from academia, industry and the public sector who aim to give an informed and balanced opinion on fungicide resistance issues in the UK.

Fungicide group – classification of fungicides according to their mode of action or chemical structure.

Fungicide mixture – formulated product or tank mix containing two or more fungicides with differing modes of action. The components may be effective against different or the same target organism. In the former case, there is no benefit in terms of a resistance strategy but in the latter the mixture may prevent or delay the selection of resistant strains and could reduce the risk of a complete failure of disease control.

Insensitivity – an old term for resistance. Now used to refer to cases where a fungus is not inherently controlled by a fungicide, for example DMI fungicides do not control *Phytophthora infestans*.

Laboratory resistance – resistance which has been selected in some way in the laboratory, but which has not necessarily been detected in the field (see Resistance in Practice).

MBC – Methyl benzimidazole carbamate.

Mechanism of resistance – the biochemical mechanism by which the target pathogen overcomes the action of the fungicide.

Mode of action – defines how and where the fungicide works. Some fungicides, especially the older ones, affect many physiological processes within the target pathogen (multi-site). Others have very specific activity, perhaps affecting only one physiological process (site specific).

Multi-site fungicide – a fungicide affecting more than one physiological process within the pathogen; have a low resistance risk.

Multi-step shift – the situation where there are various degrees of resistance in fungal populations. Under continual fungicide pressure the population gradually becomes more resistant. When fungicide use is stopped the population may or may not become more sensitive again.

Multiple resistance – resistance caused by more than one mechanism. Multiple resistance often involves fungicides from different mode of action groups but can occur between fungicides which act the same way.

Negatively correlated resistance (or negatively correlated cross resistance) – where a pathogen strain resistant to one group of fungicides, shows greater sensitivity to another group.

One-step shift – the situation where a clearly distinct and highly resistant fungal population arises without intermediate forms. This is usually the case when pathogens become resistant to the strobilurin fungicides.

Pathogen – an organism capable of causing disease, e.g. the pathogen *Botrytis cinerea* causes the disease grey mould.

Population – in this context, the total number of individuals of a particular pathogen in a defined area (e.g. glasshouse, fields, district or country).

Protectant – a fungicide that prevents infection but will not stop disease already present from developing further (see eradicant).

Qil – Quinone inside inhibitor.

Qol – Quinone outside inhibitor.

Resistance – a change in the pathogen which results in decreased sensitivity to a fungicide. N.B. slight changes are not generally obvious in the field and in most cases where disease control failure occurs, the change in sensitivity has been considerable.

Resistance in practice (or practical resistance) – a situation in which reduced sensitivity of a fungal pathogen to a fungicide results in poor disease control in the field and resistance is confirmed by laboratory bioassay (see Laboratory resistance).

Resistance management strategy – the stewarded use of fungicides and other cultural techniques to reduce the risk of fungicide resistance arising. This may involve fungicide mixtures or alternations of different types of fungicide and the use of cultural and biological methods largely aimed at eliminating or reducing the pathogens.

SBI – sterol biosynthesis inhibitor (see DMI).

Sensitivity – the reaction of a pathogen to a particular fungicide. A pathogen may be very sensitive, in which case it should be well controlled, or totally insensitive, in which case it will not be controlled by any concentration of the fungicide.

SDH – succinate dehydrogenase.

Shift – refers to a change in the overall sensitivity of a fungal population to a fungicide. The shift can be in either direction and be by a series of small changes or by one major change.

Site-specific (single site) fungicide – a fungicide affecting a single well-defined biochemical process within the pathogen.

Spectrum of activity – defines the range of pathogens that are sensitive to a fungicide, for instance a fungicide may be broad spectrum and can then be used to control many different pathogens, e.g. strobilurin fungicides, or it may have a narrow spectrum of activity affecting only a few pathogens e.g. cyflufenamid which has activity against powdery mildews *Blumeria* spp.

Systemic – the ability of a fungicide to move within the plant away from the point where it was applied. In most cases systemic fungicides can only move through roots, leaves and stems upwards, only rarely downwards.

Target organism – the pathogen against which a particular fungicide is used.

Translaminar – a fungicide that moves from one side of the leaf to another. Thus when sprayed on the top surface of a leaf the underside will also be protected.

Tolerance – another name for resistance, not now generally accepted.

Further guidance and advice

Advice on resistance management action in a range of crops is available from the website (also includes a list of FRAG-UK committee members): ahdb.org.uk/frag

If you suspect a resistance problem, your local consultant, diagnostic laboratory or agrochemical supplier will be able to advise on an appropriate course of action.

Follow the guidelines on fungicide usage to minimise the risk of resistance issued by FRAG-UK and FRAC.

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