Fungicide Futures

Practical measures to combat fungicide resistance in pathogens of wheat
The fungicide resistance challenge

High wheat yields in the UK over the last 15 years have been supported by high levels of fungicide use. This usage reflects, in part, the low levels of resistance in many popular varieties and the unpredictability of disease pressure. Robust fungicide programmes have put a greater selection pressure on disease pathogens, making the appearance of resistance to fungicides more likely.

Septoria tritici is currently of greatest concern, with significant shifts in sensitivity to strobilurins and azoles in UK populations. Isolates with mutations that confer reduced sensitivity to succinate dehydrogenase inhibitors (SDHIs) are also present across the UK, with increasing frequency each year.

Though good disease control can be achieved by using robust wheat fungicide programmes, it is essential to use comprehensive anti-resistance strategies to slow resistance development, preserve efficacy and maintain the competitiveness of UK wheat.

How fungicide resistance happens

When fungicides are applied, susceptible fungal strains are usually controlled effectively. However, any resistant strains present (through mutation or natural variation) are more likely to survive and reproduce. This process of ‘selection’ makes each subsequent generation more difficult to control. In the absence of any fitness costs, resistant strains may come to dominate the population, causing disease control to fail.

How to manage fungicide resistance

A good fungicide anti-resistance strategy does not need to compromise disease control. In fact, if done well, such strategies should result in robust and sustainable control. Strategies should:

- Exploit all practical, non-chemical control methods to reduce disease risk and slow epidemic development
- Limit the time over which the pathogen population is exposed to the fungicide
- Use effective mixtures and alternate fungicides with different modes of action
- Use the minimum dose required to effectively control target pathogens

Non-chemical control methods

Several modern varieties have improved resistance to septoria and rust. Results from AHDB and industry partners show that such varieties can be managed with fewer fungicide inputs, reducing selection pressure and still giving equivalent outputs to more susceptible varieties.

Appropriate husbandry techniques can be used to reduce disease pressure and allow less intensive fungicide programmes to be used, thus reducing selection pressure. Septoria and rusts are the main drivers of fungicide use in wheat and can be reduced by:

- Avoiding very early sowing, as it can increase septoria pressure early in the season
- Controlling volunteers, as these are an important inoculum source for rusts

Multi-sites

Fungicides that have multi-site modes of action are much less prone to resistance.

The process of mutation and selection, leading to resistance, is very rarely seen with multi-sites outside the laboratory.

Figure 1. Septoria tritici symptoms on a wheat leaf
**Appropriate fungicide use**

Fungicide programmes should be tailored to the risk of disease in the crop, taking account of historic disease pressure, varietal resistance, whether it is a first or subsequent wheat and the sowing date. At some timings, the most appropriate action may be to avoid making an application.

**Fungicide treatment frequency**

- Each application increases the period of exposure of pathogens to fungicides. This can select for resistant strains, even if the pathogen is at a very low level in the crop.
- Applications should only be made in response to the disease risk on a crop-by-crop basis.
- On susceptible varieties, the consequences of applying too few fungicide treatments can be severe. On more resistant varieties or in lower-risk situations, the economic consequences of overtreatment or under treatment are in closer balance. Inputs should always be matched to the risk.
- Pre-T0, T0, T1.5 and T4 spray timings should be avoided, unless there is a clear economic benefit, because these can increase selection for resistance. If a spray is applied at these timings, the use of a multi-site will reduce resistance risk (note: take account of any timing and total dose restrictions).
- Follow statutory limits and never exceed the maximum number of applications for a product or mode of action.

**Fungicide timing**

- Because spray timings have a significant impact on fungicide efficacy, a well-timed spray can avoid the need for higher doses or extra sprays.
- Accurate timing is about applying in a protectant situation, rather than a curative/eradicant situation.
- The efficacy of previous treatments should be monitored and subsequent inputs adjusted accordingly.

**Fungicide dose**

- SDHI resistance in septoria evolves more quickly at higher doses, according to current evidence. Azole resistance is less affected by dose.
- Use the minimum dose of SDHI required for effective disease control for the variety and disease pressure to help slow the spread of resistance.
- When tank-mixing SDHIs and azoles, a high rate of azole relative to the SDHI should be used. This will offer greater protection to the SDHI, without significantly increasing the risk to the azole.

**Fungicide mixtures**

- Mixtures of different modes of action, effective against the target pathogen, should be used to slow fungicide resistance.
- Mixtures should be balanced, such that mixing partners give comparable efficacy, where possible.
- In tank mixes, all components should have an effective mixing partner for the diseases present.
- It should not be assumed that a pre-formulated mixture is balanced for resistance purposes. Although many are, not all are – it depends on the disease target. Product labels often contain relevant guidance.

**Fungicide alternation**

- Alternating fungicides reduces the period of exposure of pathogens to any one mode of action.
- In many circumstances, mixtures may provide a more practical and effective strategy than alternation and may be a legal requirement (check product labels).
- Mixing and alternating can both be practiced – it is not an ‘either/or’.

**Fungicide multi-sites**

- Fungicides that have multi-site modes of action (chlorothalonil, mancozeb and folpet) are at lower risk of resistance and have no recorded instances of resistance in cereal foliar diseases.
- Multi-sites should be used as a cost-effective mixture partner to protect higher risk single site-acting fungicides (e.g. azoles and SDHIs).
- All multi-sites are protectant only, so use must be timed carefully.

**Fungicide programmes**

Resistance management should be considered throughout the spray programme.

**T0:** Consider alternatives to azoles, such as strobilurins and multi-sites, or add a multi-site to protect the azole.

**T1:** Mix azoles with multi-sites and, where disease risk merits it, add an SDHI.

**T2:** Mix azoles with multi-sites and SDHIs for maximum efficacy and resistance management.

**T3:** Add a multi-site to azoles for added septoria control and resistance management.

Additional fungicide sprays should never be a default part of fungicide programmes. If there is a clear economic benefit, multi-sites and other non-azole chemistry should be preferred. However, be aware of timing restrictions on multi-sites.
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**Practical measures to combat fungicide resistance in pathogens of wheat**

<table>
<thead>
<tr>
<th>SDHIs</th>
<th>Azoles</th>
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<tbody>
<tr>
<td><strong>DON’T</strong></td>
<td><strong>AVOID</strong></td>
</tr>
<tr>
<td>Apply more than twice to any cereal crop</td>
<td>Overexpose azoles (use alternative chemistry where possible)</td>
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<tr>
<td>Apply without a mixing partner</td>
<td>Use azoles alone for mildew control</td>
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<tr>
<td>Apply only with a strobilurin as a mixing partner</td>
<td></td>
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<tr>
<td>Applying when disease risk does not merit it</td>
<td>Applying azoles alone without a mixing partner</td>
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<tr>
<th>FRAC Code 7</th>
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<tbody>
<tr>
<td>SDH fungicides include boscalid, benzovindiflupyr, bixafen, fluopyram, fluxapyroxad, isopyrazam and penthiopyrad. They have strong activity against septoria in wheat, moderate-to-strong activity against yellow and brown rust, and low-to-moderate activity against powdery mildew. They are classed as medium-to-high risk for the development of resistance and there is cross-resistance between different SDHIs. Septoria isolates with mutations conferring reduced sensitivity to SDHs have been found across the UK. Field activity remains good but robust anti-resistance measures must be used to slow the further spread of resistance.</td>
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<tr>
<th>FRAC Code 3</th>
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<tr>
<td>Azole fungicides include cyproconazole, difenoconazole, epoxiconazole, flutriafol, metconazole, prochloraz, propiconazole, prothioconazole and tebuconazole. They have low-to-moderate activity against septoria, moderate-to-high activity against yellow and brown rust and low-to-moderate activity against powdery mildew and eyespot. They are classed as medium risk for the development of resistance and there is partial cross-resistance between different azoles. Septoria isolates with multiple mutations conferring reduced sensitivity to azoles are found throughout the UK and there continues to be selection for even less sensitive isolates. Reduced sensitivity in powdery mildew to azoles is also common in the UK. Robust anti-resistance measures must be used to slow the further development of resistance.</td>
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**Building resilient and robust fungicide programmes**

A pyramid of control measures can be used to protect fungicide efficacy from the foundation up.

- **SDHIs**
- **Azoles**
- **Multi-sites**
- **Cultural controls**
- **Varietal resistance**

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**The minimum dose and number of SDHI sprays required for effective septoria control should be used**

**Broad spectrum activity of azoles should be exploited to protect SDHIs**

**Multi-sites can be used to protect other modes of action and add efficacy against septoria**

**Cultural controls (e.g. sowing date, seed rate and crop hygiene) can reduce disease pressure**

**Varietal resistance provides a foundation for disease control**
Know your enemy

Keep up to date with the current resistance status of target diseases, both to ensure optimum control and that appropriate anti-resistance measures are being employed. FRAG-UK provides up-to-date information on the UK situation via its website and more general advice through its publications.

ahdb.org.uk/knowledge-library/frag

What is Fungicide Futures?

Fungicide Futures is a joint initiative between AHDB and the Fungicide Resistance Action Group UK (FRAG).

The initiative combines anti-resistance management information, developed with FRAG, and the power of AHDB’s communications channels. With a focus on practical on-farm action, Fungicide Futures promotes powerful and consistent messages on effective low resistance risk fungicide programmes to growers of cereals and their advisers.

ahdb.org.uk/knowledge-library/fungicide-futures