The integrated management of wheat diseases, covering current challenges around wheat diseases, effects on yield and main disease targets.
Welcome to the seventh Agri-intelligence Insight Report from Agrii

This series of project reports are designed to spotlight the latest research and thinking relating to a number of key agronomic challenges that our agronomists and customers face on farm.

Written by Agrii specialists and populated with findings from our own trials and third party research work, the guides will signpost practical solutions to improve the physical and financial performance of crops.

### 2014/15 Insights

<table>
<thead>
<tr>
<th>Report No.</th>
<th>Subject</th>
<th>Covering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Getting second wheat crops to perform – a management guide</td>
<td>Variety, seed rate, nutrition, seed treatments, fungicides, PGRs</td>
</tr>
<tr>
<td>2</td>
<td>Beating blackgrass – findings from our Stow Longa integrated control experiment</td>
<td>Cultivations, crops, varieties, application, seed treatments, crop protection</td>
</tr>
<tr>
<td>3</td>
<td>Kicking off winter oilseed rape establishment – encouraging a rapid start</td>
<td>Variety &amp; cultivation choice, coping without neonics, starter fertilisers</td>
</tr>
<tr>
<td>4</td>
<td>Future technologies – how innovation in decision support can help</td>
<td>Use of weather station technology, disease &amp; pest forecasting systems, variable seed rates, soil scanning / zoning to include case studies</td>
</tr>
<tr>
<td>5</td>
<td>Micronutrition of crops – why is it important and how should it be targeted?</td>
<td>Review of what each element does, what it is needed for and complimented by our own results</td>
</tr>
<tr>
<td>6</td>
<td>Understanding adjuvant technology – does it deliver?</td>
<td>Why do we need adjuvants? Where are they most likely to deliver a benefit?</td>
</tr>
<tr>
<td>7</td>
<td>Integrated management of wheat diseases</td>
<td>Resistance, the challenges and opportunities. Data from the last few years on cost/ benefit.</td>
</tr>
<tr>
<td>8</td>
<td>A guide to anaerobic digestion – getting the most from feed-in crops</td>
<td>A review of AD and feed-in crops</td>
</tr>
<tr>
<td>9</td>
<td>Cover cropping and what it offers</td>
<td>Understanding what cover crops offer and how to get the most out of them</td>
</tr>
</tbody>
</table>

### THIS MONTH

**Subject:** The integrated management of wheat disease.

**Covering:** Current challenges around wheat disease management, main disease targets & factors affecting severity, responses to fungicides 2012-2014, the integrated approach, product performance & positioning, and finally a view to the future – what measures are Agrii taking to help?
Agrii R&D – Innovations to keep you at the forefront of science & technology

Agriculture moves at a fast pace with challenges and opportunities coming from many different directions.

Agrii’s R&D focuses on potential future innovations as well as the “here and now”. This is to ensure we stay at the cutting edge of science and can help identify solutions for customers using all the tools available. We believe no one else is approaching these challenges like Agrii. Agrii’s stated mission is to deepen the links with scientific institutions to ensure we are working at the forefront of science. Over the last few years we have built strong links with research bodies, offering to be that connection between practical agronomy and basic research.

Every year we invest more than £1 million in R&D to ensure that our skilled Agrii agronomists are always equipped with, and can swiftly communicate, the most up to date intelligence, innovative technology and expertise.

**Agrii R&D facilities include:**

- **4** Technology Centres
- **62,000** Trial plots across the UK: representing all regions and crops
- **460** Replicated trials nationally
- **32** Demonstration iFarms: putting R&D into practice
- **166** Weather stations

+ R&D experts qualified to the highest ORETO standards
+ Collaborations with key industry partners including: ADAS, HGCA, plant breeders, crop protection manufacturers, machinery experts and academic bodies
# Insight into Agrii

## Unrivalled in R&D

Our national R&D programme represents the UK’s leading trials facility and ensures that Agrii agronomists, together with their customers, receive the best intelligence to support sustainable and profitable farming in the UK. 2013/14 trials undertaken include:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Trials</th>
<th>locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety management</td>
<td>206</td>
<td>48</td>
</tr>
<tr>
<td>Drilling dates</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Seed rates</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Plant growth regulation</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Biologicals</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Seed treatments</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Insects/Pests</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Cultivations</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Blackgrass management</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>Ryegrass management</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Brome management</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Annual meadow grass management</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

New agronomy approaches are regularly trialled on our demonstration and working farms. To register your interest visit [www.agrii.co.uk](http://www.agrii.co.uk)
Contents

7 Current & future challenges around wheat disease management
8 Introduction to integrated disease control in wheat
9 Main wheat disease yield effects
9 Wheat disease targets
10 Factors affecting disease development & severity
14 Fungicide responses & cost-effectiveness
15 The integrated approach
16 Fungicide resistance explained
17 Product performance & positioning
22 Summary – suggested management pointers
23 The future – what is Agrii doing to help?
Current and future challenges around wheat disease management

Wheat disease management has never been so challenging. We are at a cross roads on a number of fronts, with some important diseases now resistant to today’s fungicides and question marks over the long term retention of key active ingredients.

Climate change effects are likely to make extreme rain events more likely upscaling the threats posed by some diseases and potentially reducing application opportunities. Finally, with low grain prices, all the above needs to be balanced with the best advice on investment return.

Agrii is investing heavily in finding solutions to these conundrums. These will come from integrating both cultural and chemical control methods into workable solutions – this document is intended to update you on the current situation and give an insight into future work.
Introduction to integrated disease control in wheat

This topic has been talked about for many years. While disease management advice has included integrated measures it has never before been so critical to follow the basic principles. So why have these messages not had the focus?

The primary answer is quite simple – with the efficacy of fungicides high, a strong stream of new products and new formulations, relatively robust grain prices and an ever increasing attainment of good yields on farm – where was the incentive?

The introduction of the variety Riband signalled the start of a new era of high yielding but disease susceptible varieties being taken up by farmers. This variety epitomized the culture which was laid down for years after its arrival. In many ways Riband was a very simple variety to grow – it was highly susceptible to a range of diseases (but particularly Septoria) and the solution was easy – just spray, spray and spray again. No complicated timings, product choices and it worked. This was followed by other disease susceptible varieties such as Consort and Brigadier. Lately we have seen the rise and fall of very high yield potential varieties such as Robigus, Oakley and KWS Kielder.

For plant breeders adding another ‘layer of complication’ by breeding more disease resistance into varieties was another cost. The recommended list trials were (and still are) run using prophylactic fungicide regimes, minimum standards for disease resistance are relatively low and grain prices buoyant so where were the incentives to change?

So why should we re-visit this topic?

1. There has been a long-term erosion of the chemistry used in fungicides to control disease. We have seen a slow but steady decline in the efficacy of triazole fungicides, the demise of the strobilurins (particularly for Septoria) and even the new SDHI chemistry under threat.

2. There has been a number of high profile varieties that have succumbed to a range of diseases (illustrated by the evolution of new races of yellow rust) resulting in incomplete control ‘on farm’ as well as the associated increased growing costs.

3. Farm yields have not increased at the rate they did over the previous twenty years – despite the arrival of new genetics in terms of higher yield potential varieties.

Is the current interest in this topic just a reflection of a bad year in 2014 in terms of disease control?

We have seen high disease years before but the reality is that growers have ‘got out of jail’ by using higher rates of fungicides and these have been cost effective. However this is no longer the case – ever higher rates are being demanded to control disease along with complex formulations of existing chemistry. The new ‘stream of fungicide products’ has slowed to a ‘trickle’ as regulatory and ‘innovation’ issues have arisen.

There is now ‘no silver bullet’ to cure the problem and growers are now subject to more risk than ever – in terms of maximizing their yield potential. The challenge has been enhanced by two mild winters giving rise to earlier sowings and consequential higher disease carry over.
Main wheat disease yield effects

Disease reduces wheat yield and quality in a number of ways:

+ Foliar diseases reduce the green leaf area available for photosynthesis, accelerating senescence of the leaves.
+ Cause the wheat plant to kick in its own defence mechanisms (e.g., phytoalexins), which uses energy depleting yield.
+ Affects the stems and roots, reducing the uptake of water and nutrients necessary for yield building and potentially causing lodging.
+ Reduces specific weight and hence marketable quality.
+ Some species of Fusarium can induce the production of mycotoxins which also impair quality.

Wheat disease targets

Wheat diseases are normally split into the following types based on the part of the plant they affect. They can affect both yield and quality.

+ Root disease
+ Stem based disease
+ Foliar disease
+ Ear disease

<table>
<thead>
<tr>
<th>Area</th>
<th>Disease</th>
<th>Potential yield loss</th>
<th>Risk factors (in addition to variety)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
<td>Take-all</td>
<td>Up to 20%</td>
<td>2nd, 3rd cereal. Poor grassweed control in previous crop. Early drilling.</td>
</tr>
<tr>
<td></td>
<td>Fusarium foot rot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stem base</td>
<td>Eyespot</td>
<td>10 – 30% (greater if lodging).</td>
<td>Trashy seedbeds. Early drilling.</td>
</tr>
<tr>
<td></td>
<td>Sharp eyespot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foliar</td>
<td>Septoria tritici</td>
<td>Can be as high as 90%</td>
<td>Early drilling. Mild winter. Splashy rain in Apr/May/Jun. Warmth.</td>
</tr>
<tr>
<td></td>
<td>Septoria nodorum*</td>
<td>Up to 70%</td>
<td>Mild winters. Cool, damp springs.</td>
</tr>
<tr>
<td></td>
<td>Yellow rust*</td>
<td>Up to 50%; can be up to 90%.</td>
<td>Early sowing. High June / July temps.</td>
</tr>
<tr>
<td></td>
<td>Brown rust</td>
<td>30 – 50%</td>
<td>Warm, dry, but humid. Lush crops.</td>
</tr>
<tr>
<td></td>
<td>Mildew*</td>
<td>Up to 10%</td>
<td>Minimum tillage, warm and wet.</td>
</tr>
<tr>
<td></td>
<td>Tan spot</td>
<td>No figures for the UK – mainly in Europe.</td>
<td></td>
</tr>
<tr>
<td>(plus these foliar diseases can affect the ear)</td>
<td>Microdochium nivale</td>
<td>10 – 20% (can affect leaves too).</td>
<td>Aphid honeydew. Stressed crops.</td>
</tr>
<tr>
<td></td>
<td>Sooty moulds</td>
<td>Mainly quality effects only.</td>
<td></td>
</tr>
</tbody>
</table>
Factors affecting disease development and severity

Many aspects of crop agronomy will interact with both the likelihood of getting disease, the severity with which it attacks the crop, and the impact on yield and quality. The greatest impact is from those factors shown below, although others such as establishment systems, soil types, drainage etc. can play a part too:

1. Weather & Geography:

The following “Risk Maps” taken from the HGCA Wheat Disease Management Guide indicate the Regions at greatest risk from the key foliar diseases.

This variation in risk is largely because of the temperatures and rainfall (timings and amounts) experienced by these differing regions. In order for fungal diseases to grow, reproduce and spread within the plant canopy (for foliar disease) or soil environment (for root / stem base diseases), certain requirements regarding temperature, moisture, and the presence of host plant matter need to be met. Thus disease pressure can vary hugely from year to year, depending on the prevailing weather conditions.
2. Variety Choice:

Choosing the correct variety is the most important decision in any disease management programme. Choice of genetics is, in effect, the first “fungicide application”. The Agrii Advisory List contains additional information about variety disease profiles and their likely stability of resistance to disease in the future. Fortunately growers are now beginning to migrate away from a number of high-risk varieties – though there will still be large acreages of highly disease susceptible wheats. These latter varieties will need high levels of inputs from ‘day one’ – to not do so will increase the risk of poor yields being realized.

**Septoria tritici:**

+ Following very high pressure in 2014, there are now significant acreages of higher Septoria resistant varieties such as Crusoe, Revelation and to a lesser degree Skyfall. The former two varieties have a higher level of resistance to Septoria but they are NOT immune and should disease pressure build then they will need to be managed accordingly.

**Eyespot:**

+ Second wheat varieties with the VPM eyespot resistance (primarily Revelation and Skyfall) should not need an eyespot targeted spray (unless early sown) but varieties with Robigus in their pedigrees (such as Oakley, Kielder, Santiago, Invicta, Leeds, Horatio) should be monitored closely for this disease.

**Brown rust:**

+ It is important that growers recognize the increasing threat for brown rust. This is particularly important for varieties such as Crusoe which is worse than its RL rating suggests based on Agrii data & experience. Brown rust build up is very rapid in susceptible varieties so should be monitored regularly in high risk situations.

**Yellow rust:**

+ Many varieties share similar resistance genes against yellow rust and careful selection of variety “combinations” is important to reduce the spread of this disease between fields. Agrii uses our understanding of Diversification Groups and data taken from the Agrii Tussock plots (established at key sites across the UK) to monitor changes in yellow rust’s considerable capability of overcoming a variety’s resistance to this disease. This may happen rapidly – sometimes in a single season. This particularly applies to varieties which carry major genes for resistance ratings (8 or 9) which can fall dramatically.

### Yellow rust diversification groups (DGs) winter wheat varieties

<table>
<thead>
<tr>
<th>DGI Varieties at low risk from current YR races</th>
<th>DG2a Varieties at moderate risk from current YR races</th>
<th>DG2b Varieties at high risk from current YR races</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWS Trinity</td>
<td>Skyfall</td>
<td>Gallant</td>
</tr>
<tr>
<td>Crusoe</td>
<td>Edgar</td>
<td>Solstice</td>
</tr>
<tr>
<td>Xi19</td>
<td>KWS Lilli</td>
<td>Viscount</td>
</tr>
<tr>
<td>Britannia</td>
<td>Cubanita</td>
<td>Horatio</td>
</tr>
<tr>
<td>Cocoon</td>
<td>Panorama</td>
<td>KWS Kielder</td>
</tr>
<tr>
<td>Zalu</td>
<td>Monterey</td>
<td></td>
</tr>
<tr>
<td>Delphi</td>
<td>Claire</td>
<td></td>
</tr>
<tr>
<td>KWS Croft</td>
<td>Leeds</td>
<td></td>
</tr>
<tr>
<td>Icon</td>
<td>Twister</td>
<td></td>
</tr>
<tr>
<td>RGT Conversion</td>
<td>Reflection</td>
<td></td>
</tr>
<tr>
<td>Invicta</td>
<td>KWS Santiago</td>
<td></td>
</tr>
<tr>
<td>Scout</td>
<td>Conqueror</td>
<td></td>
</tr>
</tbody>
</table>
Factors affecting disease development and severity continued

3. Drilling Date:

As can be seen from the “Risk Factor” (table on page 9), sowing date selection will affect levels of disease that then need to be managed, with early drilling overwhelmingly increasing disease threats in wheat. This is most notable for take-all, eyespot, yellow rust and Septoria tritici. The latter disease is particularly difficult to control these days and early drilling allows the disease to cycle throughout the autumn increasing inoculum pressure on the crop in the spring. The disease assessments below were taken from a trial carried out at AgriFocus (Wiltshire) in 2014, and illustrate the difference in Septoria pressure between crops drilled five weeks apart – EVEN in varieties which have a good resistance rating like Crusoe:

+ Early sowing significantly increases Septoria pressure

4. Nutritional status:

There are numerous scientific papers published on the link between plant nutrition and disease pressure. This is logical. A plant weakened by poor nutrition is more likely to be attacked by disease. This applies both to major and micro nutrients:

Micronutrients – As described in the recent Micronutrition Insight report No.5, these perform important functions in the plant associated with biochemical processes such as chlorophyll synthesis, production of lignin for plant cell walls and are particularly important with regard to flowering biology. Regarding effects on pathogen damage, this can be either by direct toxicity to the pathogen or by promoting Induced Systemic Resistance (ISR).

+ Much evidence linking nutrition & plant health

The published effects of micronutrition on cereal diseases – mechanisms involved

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Effect</th>
<th>Why this is important</th>
<th>Adequate supplies of nutrients therefore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron and Zinc</td>
<td>Maintains integrity of cell membranes and</td>
<td>Leaky membranes release exudates such as carbohydrates and amino acids, creating</td>
<td>Reduce root exudates and therefore infections of <em>F.graminearum</em>, take-all, and <em>Rhizoctonia solani</em></td>
</tr>
<tr>
<td></td>
<td>controls permeability</td>
<td>favourable medium for pathogens to spread</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>Affects lignin synthesis</td>
<td>Associated with physical barriers to penetration by pathogens</td>
<td>Help to suppress disease</td>
</tr>
<tr>
<td>Manganese and Copper</td>
<td>Biosynthesis of lignin and phenolics</td>
<td>Associated with physical barriers to penetration by pathogens</td>
<td>Closely associated with lower levels of take-all and mildew</td>
</tr>
<tr>
<td>Copper</td>
<td>Directly toxic on some diseases</td>
<td>Useful alternative mode of action</td>
<td>Can be used as a fungicide</td>
</tr>
<tr>
<td>Manganese</td>
<td>Directly toxic on some diseases</td>
<td>Plants concentrate Mn at the site of infection and changes it from Mn 2+ to Mn 4+ – increasing direct toxicity</td>
<td>Manganese inhibits production of amino peptidase needed by the pathogen to make amino acids, and inhibits pectin methyl esterase needed to penetrate plant cell walls</td>
</tr>
<tr>
<td>Zinc</td>
<td>Involved in superoxide production in plants</td>
<td>Superoxide is responsible for a cascade of plant defence pathways</td>
<td>Plants more resistant to disease</td>
</tr>
<tr>
<td>Manganese, Copper and Zinc</td>
<td>Cause plant to release calcium from cell</td>
<td>Once released the calcium ions act together with salicylic acid to trigger a SAR</td>
<td>Plants more resistant to disease</td>
</tr>
</tbody>
</table>

Delaying drilling halved Septoria infections levels at AgriFocus in 2013/14, with early drilling challenging even the most robust fungicides regimes on susceptible varieties.

The published effects of micronutrition on cereal diseases – mechanisms involved
Macronutrients – levels of Nitrogen, Sulphur, Phosphate and Potash all have effects to a greater or lesser extent on disease severity.

Nitrogen:
+ High rates of nitrogen encourage lush canopies, encouraging mildew and other foliar diseases with positive correlations with leaf N levels and Septoria well proven. Conversely, nitrogen availability to second wheat crops can help mitigate some of the negative impact of take-all on wheat roots by encouraging root development.

Sulphur:
+ Sulphate reduces rhizosphere pH. Spring top dressings using N&S compounds may help reduce take-all development and spread. Sulphur increases lignification of root cells restricting take-all infection (Skou 1975). Optimising N:S ratio improves plant health and vigour – beneficial effect on uptake of other nutrients.

Phosphate:
+ Promotes root growth. Take-all disease occurs later in soils with adequate phosphate and is less severe. Applications of foliar phosphate have given benefits of up to 1t/ha from improving root development and phosphate uptake.

Potash:
+ Deficiencies can make plants more susceptible to yellow rust and Septoria nodorum.
Fungicide responses and cost-effectiveness

Every season has its own challenges – whether yellow rust in 1989, brown rust in 2007, Microdochium nivale in 2012 – but 2014 will go down in history as the most challenging year for *Septoria tritici*.

In fact according to CropMonitor, 2014 was the highest disease pressure year since 1990 - and probably also since the introduction of semi-dwarf varieties in the 1970’s. The main reason for this was weather related but also an ‘unhealthy’ mix of early drilled, disease susceptible varieties, and a continued erosion in fungicide performance.

So no surprises, when the combines rolled, that responses to fungicide (and PGR) input averaged over 4t/ha – representing a highly cost-effective input with a fungicide cost/ha of £140, even with low grain prices.

**Take-home point**

- Mean response to fungicides in 2014 was + 4t/ha
- Net benefit + £340/ha
The integrated approach – what does it mean and what does the grower need to do to meet its objectives?

Integrated disease management means taking into account the genetics of the variety being grown, its disease resistance spectrum (and associated risks), the planned drilling window, and bringing this together with the most appropriate chemistry to enhance grain yield and physical grain quality.

Variety choice has always been the most important decision a grower makes and yet often this is taken at a relatively superficial level. It is easy to understand why. With yield potential continuing to increase, as apparent on the Recommended List, growers would naturally look to adopt the best yielding variety in the namin group: preferred as historically high yield paid. UK growers have been ‘early adopters’ and this explains the increased yield obtained on farm over the last twenty years. Variety choice was in essence ‘simple’. However not enough attention has been paid to ‘risk management’ of these varieties with little or no reference to the degree of ‘genetic relationship’ between the mix of varieties on farm or the potential threat of new races of disease. Our view is that we need to understand the genetics of varieties in the market and plan for more strategic use of new varieties and stronger genetics in the future.

Growers now face a new and probably the most challenging time for growing wheat in recent history. As world wheat stocks continue to exceed production needs, UK sterling rises in value compared to the Euro and grain prices remain volatile, it is important that growers look to secure the most competitive grain yields in terms of ‘cost per tonne’. To do this growers need to address the agenda of optimizing an integrated disease management strategy.

Implementing an Integrated Wheat Disease Strategy Management programme

<table>
<thead>
<tr>
<th>Assess and understand the risk:</th>
<th>It is worth considering carrying out a ‘risk audit’ with your agronomist whereby each field is reviewed with regard to ‘risk’. This should include: variety, drilling date, rotational position, current fungicidal inputs (including T-1 seed treatment, T0 etc). Make particular note of any ‘extraneous circumstances’ which might increase risk eg locally grown maize which may have implications for fusarium control.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the variety profile on the farm:</td>
<td>In terms of future fungicide use – these could be based upon potential weather events and disease risk.</td>
</tr>
<tr>
<td>Review yield potential aspirations:</td>
<td>It is important to understand the yield potential of the crop under evaluation – what nutrition inputs will be applied (as this will also affect the inherent disease threat) – diseases thrive on crops grown with high levels of nitrogen – but these will also have the highest yield potential.</td>
</tr>
<tr>
<td>Implement a plan to keep ALL disease at bay:</td>
<td>With the highest emphasis on control of Septoria tritici due to the long latent period.</td>
</tr>
</tbody>
</table>
Fungicide resistance explained

Fungal diseases are clever. Of the diseases affecting wheat, eyespot, powdery mildew, foot rot (Microdochium nivale) and Septoria tritici all exhibit some level of resistance to fungicides. Of them all, Septoria is the cleverest yet, managing to mutate in many different ways to overcome the activity of strobilurins, benzimidazoles, and triazole (DMI) fungicides.

What governs the likelihood of resistance? The likelihood of resistance development is governed by the fecundity of the pathogen (speed of reproduction), ability for mutations to occur and site of activity of the fungicide on the disease. Fungicides are classified according to the risk of resistance:

+ Low risk:
  Multi-site fungicides (eg chlorothalonil, folpet, mancozeb) are at very low risk of resistance as the fungus would have to mutate at many sites within the cell in order for the fungicide to lose its activity.

+ Medium risk:
  This includes the triazoles and the SDHIs. Triazole resistance already exists but the decline happened gradually. The SDHIs (Succinate DeHydrogenase Inhibitors) are at medium / high risk from resistance and must always be used in mixture to reduce selection pressure.

+ High risk:
  Fungicides that act on a very specific site in the fungus are at high risk of resistance – such as the strobilurins where first resistant isolates were identified in 2002 and performance fell very dramatically 3 or 4 years after their introduction.

What are the current and future concerns about resistance? Most serious is the decline of the triazoles on Septoria which has happened since the late 1990’s. Until the introduction of second generation SDHIs (succinate dehydrogenase inhibitors), the triazoles were the mainstay of wheat fungicide programmes. Now many different Septoria strains have evolved exhibiting varying levels of resistance to different triazole fungicides. The decline in performance has been gradual and triazoles still offer around 70% activity if applied before Septoria takes hold (ie Protectant), but are down to 30% eradicant activity, as shown by the HGCA data below:

What are the implications of this? Triazoles are still immensely useful, and it is crucial we keep them within our fungicide programmes. They still offer some eradicant control of Septoria (maybe 2 or 3 days versus 7-10 days previously), plus rust and eyespot activity. However crucially they still offer some protection for the highly effective but vulnerable SDHI fungicides. Slightly reduced sensitivity to SDHI fungicides has already been identified in three isolates in the UK, but the strains (which also exhibited triazole resistance) had associated reduced fitness, meaning they competed poorly with other Septoria strains.

![Graphs of Azole activity over time (protectant) and (eradicant).]

**Protectant. Variance accounted for = 43.2%**

**Eradicant. Variance accounted for = 62.4%**

**TAKE-HOME POINT**

+ However it is a warning sign to us all – the integrated approach is essential!
Product performance and positioning

So what can be done to effectively manage disease in the light of resistance issues described above?

Make use of all the tools in the toolbox!

We no longer have the luxury of relying on one fungicide group to deliver the required level of disease control. All of the fungicide groups shown below have some activity on *Septoria tritici* and many have good activity on other key diseases, such as rusts and mildews. Make use of all we have to keep these *Septoria* populations guessing!

Use stacked triazole formulations

We know that different *Septoria* strains are affected to a greater or lesser extent by different triazoles, as shown by the HGCA summary below. It has been confirmed by many research organisations that using repeat doses of the same triazole selects more strongly for a population resistant to that particular triazole. In theory therefore, mixing and matching different triazoles to different situations should reduce the selection pressure and therefore improve overall control. Stacked triazoles formulated with two different active ingredients has indeed been shown to out-perform straight triazoles consistently since their introduction. Interestingly, as resistance has bitten more strongly, the yield benefit between straight and stacked azoles has extended:

- 2010 + 0.4t/ha
- 2012 + 0.6t/ha
- 2014 + 0.8t/ha

The evidence in 2014 is shown below (graphs drawn using data from Agrii trials on the variety Invicta, drilled 26th September, but using HGCA algorithms to create the graph):

**Stacked triazoles showing a great benefit**

**+ Full rate Cortez delivered 18% control**
**+ Full rate stacked azoles delivered 38% control**

**+ Stacked triazoles increase yield advantage from: 0.6t/ha in 2012 to 0.8t/ha in 2014**
**Product performance and positioning continued**

This advantage is due not only to the fact that more than one triazole is being used, but also the formulation is significantly improved over the tankmix. Agrii initially shared the healthy scepticism shown by growers over manufacturer claims of improved formulations sold at a premium over the tankmix, but we have compared the tankmixes with the co-formulated products and have to concour that the claimed benefits are valid and true.

For example, here a tankmix of metconazole + epoxiconazole (applying in fact slightly more active ingredient) was compared with the equivalent Brutus formulation. Similar benefits have been seen with Kestrel and with some adjuvant + fungicide combinations (see Insight Report No. 6).

**The benefit of formulation – Brutus, what about mixing your own?**

<table>
<thead>
<tr>
<th>Disease control</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety = Zebedee. LSD 0.45 t/ha. Trial 7091 – Zebedee, Brown rust</td>
<td>Variety = Zebedee. LSD 0.45 t/ha.</td>
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**Yield**

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| Variety = Zebedee. LSD 0.45 t/ha. | Variety = Zebedee. LSD 0.45 t/ha. |

**TAKE-HOME POINT**

+ Together with better rainfastness, stacked triazoles offer a considerable yield and disease control advantage over single triazoles (+ 0.8t/ha), as evidenced by independent trials data.

**Use the most appropriate SDHI + azole combination**

Over the last 3 years, SDHIs have shown themselves to be essential to effective Septoria tritici control, commonly offering 1 – 2 t/ha yield advantage over triazole + strob comparisons. They can only be applied twice to any cereal crop to minimise selection pressure for resistance.

They are however weaker than triazole + strobos on rust diseases and need support from the strobilurins. There are now 4 SDHI fungicides on the market, all of which have different strengths and weaknesses. Agrii have been trialling them since 2008 and have a good understanding of where they should be positioned.

**Fluxapyroxad (Intrex, Adexar)**

+ Best T2 option for curative Septoria control, with some dose flexibility currently.
+ Intrex most active formulation, performing similarly to Adexar despite having no triazole (HGCA data), and outperforming Adexar when in mix with Brutus or Kestrel.
+ The straight allows most appropriate dose rate selection between SDHI and azole.
+ Consider also use at T1 if no T0 applied or under very high Septoria tritici pressure.
Bixafen (Aviator, Boogie)

- Best T1 option for physiological benefits, but minimal dose flexibility.
- Outperforms Intrex + azole in 2nd wheat, milling wheat, spring wheat.
- Boogie offers wider spectrum of control with added spiroxamine and in situations where these diseases are present outperform Aviator by 0.27t/ha.

Penthiopyrad (Cielex, Felizon, Vertisan)

- Weaker than two above on Septoria, but useful activity on rusts, especially as Cielex as it is formulated with cyproconazole, a very strong triazole against rusts.
- However still outperforms triazole + strob.
- Best used at T1.
- Potential rooting benefits?

Izopyrazam (Seguris, Micaraz)

- The weakest of the new SDHIs on Septoria.
- Some advantage on rusts.
- Light on triazole rate of inclusion.

**TAKE-HOME POINT**

- Include SDHI in all crops at T2, and in Septoria prone situations at T1.

**Trial 14206** Effect of different fungicide treatments on disease incidence and green leaf area at AgriFocus – 10th July 2014 – Invicta

- SDHIs key to disease control

**14206 – Yield AFD Graph**

- Imtrex + Brutus gave + 0.3t/ha more yield than Adexar at commonly used rates
- Boogie > Brutus + Intrex on 2nd wheat by 0.32t/ha
**Product Performance and Positioning continued**

*Use tools for a protectant approach, including multi-sites.*

Adopting a protectant approach to disease management is important and puts you in charge of disease not the other way round. Use an effective T-1 seed treatment such as fluquinconazole which is active on foliar disease, and include a T0 foliar application targeted at Leaf 4. Multi-site chemistry is vital for both resistance management and for the achievement of optimum yield. And we are at the end of the line with this chemistry – no more “multi-site” fungicides will get approved in our view. There are three with wheat approvals on the market: chlorothalonil, folpet and mancozeb, of which the first two are the most important. Again, these have their strengths and weaknesses:

**Multi sites are critical to resistance management**

+ No known resistance  
+ Proven to reduce selection pressure on triazoles  
+ But – Protectant only  
+ Some (CTL) can reduce curative activity of triazoles still further  
+ Different strengths and weaknesses....

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<table>
<thead>
<tr>
<th>Chlorothalonil</th>
<th>Folpet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disease spectrum</strong></td>
<td><strong>Septoria key strength</strong></td>
</tr>
<tr>
<td><strong>Antagonism?</strong></td>
<td>Clear evidence of triazole antagonism, reducing curative activity on Septoria and rusts.</td>
</tr>
<tr>
<td><strong>Resistance management</strong></td>
<td>Good evidence it slows down resistance.</td>
</tr>
<tr>
<td><strong>Tank mixability</strong></td>
<td>Some key incompatibilities eg Atlantis, Helix. No mixes with bixafen where rust is expected or high eradicancy required.</td>
</tr>
</tbody>
</table>

The most critical timing for a multi-site fungicide is at T0 (although they should be used at least once, if not twice more in the programme). T0 reduce disease inoculum, lessening selection pressure and ensuring accurate timing for T1 and T2. Excellent yield responses have been achieved; the best from azole + multi site options which are more effective than multi site only at reducing inoculum.

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+ Reduce inoculum EARLY – Use effective seed treatments (T-1) and a T0 application (average response + 0.4t/Ha but + 0.7t/Ha in 2014).  
+ Reduces inoculum; avoids stretched T1 / T2  
+ Multi-site + azole the most broad spectrum
**Benefit of strobilurins**

Despite the level of resistance of *Septoria tritici* to strobilurins, they are still a useful component in disease management strategies, offering:

+ 30% protectant activity on *Septoria* (NB the best – pyraclostrobin – at full rate).
+ Excellent rust activity – arguably the best...certainly better than any of the SDHIs.
+ Physiological effects, including maximising Nitrogen utilisation with associated boosts to protein levels – critical to milling wheats ESPECIALLY those struggling to deliver protein levels, such as Skyfall.

**TAKE-HOME POINT**

+ Consider adding strobilurins into programmes and / or on rust prone varieties

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**Nitrogen trial Kent – Strob Benefit**

Feed rate (200kg) v. Milling rate (250kg) – from Agrii N calculator

+ Strobe addition to azole or Imtrex improved protein by 1 point.
Summary – suggested management pointers

Taking all of the above into account, discuss with your Agrii agronomist and consider the following approaches to integrated disease control in wheat.

1. Select correct variety & drilling date combination, avoiding drilling susceptible varieties early.

2. Start healthy and feed appropriately, utilising the most appropriate seed treatment (T-1) and ensuring crops do not suffer micro or macro-nutrition deficiency.

3. Make use of the full toolbox of active ingredients and formulations available. Use different modes of action and rotate triazole selection, including prochloraz to maximise efficacy and minimise resistance.

4. Include multi-site fungicides to protect existing chemistry selecting appropriately. If chlorothalonil is preferred take note of data warning of antagonism in curative situations or where rust is a threat and either use folpet (Phoenix /Manitoba) or an adjuvant such as Kantor to overcome the issue.

5. Use an effective T0, targeted at Leaf 4. Adopt a “Prevention better than cure” approach. Select products carefully taking into account likely subsequent product choices using as many different azoles as possible.

6. Use T1 (target Leaf 3) and T2 (target Leaf 1), where possible based around stacked triazoles such as Brutus or Kestrel for the 0.8t/ha benefit they offer; and time accurately.

7. Include SDHI fungicides at T2 and also at T1 in high disease situations / regions (most!). Base around the best formulations. These include Imtrex and Boogie.

8. Consider a T1.5 if disease pressure is particularly high, targeted at Leaf 2. In high disease situations, this has delivered up to 0.9t/ha yield benefit and can help to break the disease cycle.

9. Adhere to timings recommended by your agronomist, and avoid exceeding recommended intervals between sprays. This is particularly important to ensure chemistry is not put under massive curative pressure as that increases resistance risk. As intervals lengthen, poorer disease control will result with proven yield loss.

10. Apply using nozzles and forward speeds appropriate to the disease target.
The future
– what is Agrii doing to help?

With all the challenges outlined above, what is a business like Agrii doing to help?

| Developing a proactive trials programme that is forward thinking. |
| Protecting chemistry – by highlighting the integrated approach and incorporating everything we know. |
| Searching for the best Genetics – by putting development varieties into stressful situations, especially with regard to Septoria, hopefully Agrii can locate varieties for the future which will be more resilient and offer sustainable yield potential. The Agrii Advisory Lists can help provide up to the minute information on variety choice with a “disease resilience” factor for each. |
| Protecting chemistry – by lobbying as hard as we can to defend chemistry and ensure those taking decisions over aspects such as the definition of endocrine disrupters understand the implications. |
| By trialling non triazole fungicide programmes; so we are prepared in the event of a reduced number of triazole options in 2018/19 due to Endocrine Disruptor legislation. |
| By examining other ways to reinforce plant health and help it to withstand disease threats, such as biostimulants. |
| By searching for diagnostic tools to identify the earliest stages at which a wheat plant is infected, thus enabling better fungicide selection. |
| By examining all the disease forecasting systems available to determine how we might better time fungicide applications in the future. |

I hope you have found this document of use and that it will help explain Agrii’s approach to disease management in your crops. Growers need to be better informed about the variety profile they should be growing on the farm. This is a key role for a company such as Agrii. With the high spend on R&D on variety performance (particularly regional) and the very clear understanding of the chemistry available from a range of supplies the business is exceptionally well placed to service this need.
Thank you

Thank you for reading this Agri-intelligence Insight Report. We hope you found it useful.

Please note that the content within this document does not represent advice, which should always be tailored to local situations. Please speak to your adviser for more detailed information on any of the topics covered.

Connect with the Agri-intelligence network

If you would like to learn more about Agrii, we invite you to connect with us in any of the following ways:

+ **Via our agronomy and advisory teams** – we have 300 agronomists throughout the UK who can advise on all aspects of modern crop production, and also seed and nutrition specialists.

+ **At an Agrii iFarm event** – we have 32 locations where, in conjunction with our host farmers, we demonstrate the latest technologies and production techniques. Lively events provide an opportunity to meet other farmers and quiz industry experts.

+ **On AgriiPlus** – a comprehensive information database available to our agronomy customers (more details from your Agrii agronomist).

+ **At www.agrii.co.uk** – for more information, to check your local contacts or to ask us a question. Visit regularly for news and details of our events.

+ **On Twitter** – @AgriiUK – for regular updates.

+ **Sign up for our email newsletters** – eBulletin is a monthly update or eJournal for news and information relevant to your region.

+ **Speak to our Customer Services Team** – with any queries on 0845 6073322

Registered Offices:

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