Contents

Disease control in wheat ................................................................. 2
Fungicide application in autumn sown wheat .............................. 4
Supporting data for wheat ............................................................... 9
Fungicide dose rate ................................................................. 12
Wheat cultivar by fungicide programmes .................................... 13
Septoria tritici blotch ................................................................. 13
New fungicide ................................................................. 19
Phoenix performance ................................................................. 20
Disease control in barley ........................................................... 22
Ramularia ................................................................. 22
Fungicide application in autumn sown barley .............................. 24
Supporting data for autumn sown barley .................................... 27
Fungicide application in spring sown barley .............................. 30
Supporting data for spring sown barley ..................................... 32
Disease resistance to fungicides ................................................ 33
Chemical guide ................................................................. 37

©This publication is copyright to the Foundation for Arable Research and may not be reproduced or copied in any form whatsoever without their written permission.

This Cropping Strategy is intended to provide accurate and adequate information relating to the subject matters contained in it. It has been prepared and made available to all persons and entities strictly on the basis that FAR, its researchers and authors are fully excluded from any liability for damages arising out of any reliance in part or in full upon any of the information for any purpose. No endorsement of named products is intended nor is any criticism of other alternative, but unnamed product.
Introduction

This book summarises recent FAR research results in the area of cereal disease management. Each section begins with a summary of management options that have performed well in independent FAR trials, and is followed by examples of consolidated trial data which form the basis of the management options presented.

This issue of the Cereal Disease Management Cropping Strategy has been revised to consider:

• The recent discovery of strains of Ramularia which are insensitive to SDHIs.
• Recent FAR research results on wheat cultivar resistance to Septoria.
• The introduction of a new active ingredient.

It outlines the disease management options that have provided better economic returns from trials over the last two years, and takes account of recent changes in the resistance of key pathogens to fungicide application. It is important that strategy documents produced prior to the advent of resistance are not used as reference for crops grown now, because of the advent of resistance and newer product availability.

The tactical application of this Cropping Strategy will be updated in FAR Crop Actions.

We hope that you find the information presented in this strategy document both interesting and economically rewarding in the management of your crops.

Rob Craigie

Other Cropping Strategies available:

Issue 1: Nitrogen Application in Wheat (2011)
Issue 2: Nitrogen in Perennial Ryegrass Seed Crops and Canopy Management Strategy for Autumn Sown Oilseed Rape (2011)
Issue 5: Cereal Disease Management (2014) - replace with Issue 8
Issue 6: Closing Date in Perennial Ryegrass (2016) and Closing Date in Italian Ryegrass
Issue 7: Cereal Disease Management (2016) - replace with Issue 8
Disease control in wheat

What’s changed since 2016?

i) Weather conditions

The last two growing seasons have resulted in contrasting disease pressure for wheat crops compared to that observed in 2014 and 2015. This was particularly the case in 2016, where wetter spring conditions encouraged the development of the wet weather disease Septoria tritici blotch (STB), caused by the fungal pathogen Zymoseptoria tritici, and disease in general. The 2017 season experienced intermediate disease pressure, with a wet early spring, followed by dry conditions in November and December.

Over the last three seasons we have provided a guide to the risk level of STB developing in wheat crops in Crop Action. The aim has been to provide information to help growers maximise crop profitability by adjusting their fungicide programmes through the season depending on the disease risk.

Once STB is established in the base of the crop, the key drivers for disease spread are wet weather and high relative humidity. For an infection to occur, spores move by rain splash or wet leaves rubbing against each other in the wind. Danish work suggests that 20 hours with a relative humidity over 85% is a sufficient period for infection to occur. Infection pressure increases in severity as the period of high humidity extends to 48 hours and longer.

- In 2016, initial disease development was reduced by drier conditions in September, however, high rainfall through October and November between GS31 (first node) and GS59 (ear emergence) resulted in high disease pressure conditions, particularly for longer season irrigated crops.
- In 2017, wet conditions through winter and early spring led to high disease pressure in the lead up to GS31; however low rainfall from mid-October to December reduced disease pressure, and levels of disease observed were intermediate compared to the 2016, high disease pressure and 2014-15, low disease pressure seasons. Relative humidity conditions during September, in the lead up to GS31, were similar in both 2016 and 2017, despite lower rainfall in 2016.
- As the season progressed, 2016 was characterised by regular incidences of relative humidity over 85%; this, coupled with rainfall, continued to encourage disease development. While there were isolated instances of high relative humidity in 2017, the lack of rainfall meant disease levels didn’t progress to the same extent as 2016.

ii) FAR trial results

FAR trial results over the last two years saw higher yield responses to controlling disease than in 2014 and 2015. High and intermediate disease pressure conditions in 2016 and 2017 saw yield responses to fungicide of up to 6.5 t/ha and 5.1 t/ha respectively in autumn sown feed wheat CPT trials. During 2016 and 2017, trials were conducted on both disease resistant and susceptible cultivars as well as irrigated and dryland crops.

In the 2016 and 2017 trials, it was not economic to reduce the fungicide programme for wheat cultivars with more resistance to STB. This was not the case in earlier drier seasons. However, in higher disease pressure scenarios, a resistant cultivar will have less yield loss than a more susceptible cultivar if wet weather delays spraying.

In this section of the book we examine how 2016 and 2017 results can help with decision making in the coming seasons but within the constraints of making sure we don’t farm this season’s crop based on last season’s weather patterns.

iii) Fungicide sensitivity and resistance issues – STB control with SDHIs

Monitoring of the STB pathogen population has not revealed any significant changes in the effectiveness of SDHI fungicides for the control of this disease (see fungicide resistance section).
Key fungicide timings for disease management in autumn sown wheat

Summary

Role of an Integrated Disease Management (IDM) approach
Disease pressure, and therefore the need for fungicide, can be affected by a number of factors and agronomic decisions. Before applying any fungicides, consider the points below as they may reduce the need for fungicides and aid with the development of a more Integrated Disease Management (IDM) approach:

- Regional disease prevalence – For example in Otago and Southland (and to a certain extent South Canterbury) leaf rust in wheat is rarely an issue.
- Farm location – Is your cropping enterprise relatively isolated such that you are not surrounded by other cropping enterprises and their associated pathogen inoculum?
- Other integrated disease management factors - Stubble management will affect stubble borne diseases such as STB or tan spot, while control of green bridge volunteers will affect biotrophic pathogens such as rusts, which need a living host.
- The weather conditions before your fungicide application – Prolonged wet weather increases the prevalence of most diseases as it is associated with greater canopy humidity which favours infection.
- Rotation position – Wheat on wheat or barley on barley are higher risk rotations for stubble borne diseases, particularly if the stubble is retained.
- Cultivar resistance – The 2016 and 2017 trials found that robust fungicide programmes were needed to maximise yield and margin over fungicide cost regardless of cultivar resistance to STB. While greater cultivar resistance did not allow a reduction in fungicide rate, yield losses were less compared with more susceptible cultivars, which is an advantage if spraying is delayed by bad weather.

In summary, your fungicide programme should be developed with the goal of generating the highest economic margin for your crop and managing the risk of resistance. As such, the most appropriate fungicide programme in any season, will vary depending on the following factors:

Higher fungicide input required
- More wheat grown in region
- Earlier autumn sowing date
- Stubble borne diseases more difficult to control
- Wet spring months (October and November particularly)
- Irrigation - thicker canopy with longer duration (greater humidity)
- Susceptible cultivar

Lower fungicide input required
- Less intensive wheat production in region
- Later autumn sowing date
- Stripe and leaf rust more easily controlled.
- Drier spring
- Dryland (thinner canopy; shorter duration, lower humidity)
- More resistant cultivar

Once these factors have been taken into account, the crop itself becomes the barometer for action. What growth stage is the crop at and what disease is established in the crop?

On which leaf is the disease present?
It is worth noting that depending on the length of the latent period, the position of disease in the canopy may differ with optimum conditions. For example, STB has a latent period of approximately 250°C days in thermal time; in contrast, the latent period for tan spot is less than 100°C days. With optimum conditions up to flag leaf, STB will be present two leaves behind the newest emerging leaf as it takes 110°C for a leaf to emerge. Tan spot, under optimum conditions, may be present on the leaf below the emerging leaf up to flag leaf. However, this may not mean the leaves above the infection are free of the disease; the disease may be in its latent phase and symptoms cannot yet be seen with the naked eye.

Fungicide application – timing, products and rates

T0 - GS30 (End of tillering/start of stem elongation)
A fungicide application at GS30 for STB control is mainly used as a holding spray until GS32 or as insurance against a delayed GS32 application. It should not be regarded as a routine spray for all wheat crops since later sown crops with no rust issues develop more quickly and the flexibility afforded by this spray is not needed. Whilst a T0 is important for stripe rust control, it is important to moderate use of triazole fungicides due to their declining activity against STB. The aim is to reduce STB exposure to this chemistry where possible.

Where stripe rust is present or early (late March/early April) sowing has encouraged high levels of STB, consider epoxiconazole (e.g. Opus, Stellar, Accuro, Agpro Epoxiconazole, Epoxi 125, Fortify 125) at 25-50% doses for stripe rust control and 100% doses for STB control.

- Stripe rust: Opus 0.25 – 0.50 L/ha
- STB: Opus 1.0 L/ha

In thermal time; in

The best approach is to treat the crop in response to developing disease, so if there is no significant disease pressure at the time, a GS30 application isn’t critical.

T1 - GS31-32 (1st - 2nd node on main stem)
The nodal growth stages GS31-32 traditionally coincide with leaf 3 emergence (the leaf two leaves below the flag). This is the first of the important top three leaves to emerge in the crop canopy and it is critical to keep all three leaves as disease free as possible.

Low disease pressure
Where later sowing or drier weather has reduced disease pressure, consider applying epoxiconazole alone for rusts.

A fungicide application at GS30 for STB control is mainly used as a holding spray until GS32 or as insurance against a delayed GS32 application. It should not be regarded as a routine spray for all wheat crops since later sown crops with no rust issues develop more quickly and the flexibility afforded by this spray is not needed. Whilst a T0 is important for stripe rust control, it is important to moderate use of triazole fungicides due to their declining activity against STB. The aim is to reduce STB exposure to this chemistry where possible.

Where stripe rust is present or early (late March/early April) sowing has encouraged high levels of STB, consider epoxiconazole (e.g. Opus, Stellar, Accuro, Agpro Epoxiconazole, Epoxi 125, Fortify 125) at 25-50% doses for stripe rust control and 100% doses for STB control.

- Stripe rust: Opus 0.25 – 0.50 L/ha
- STB: Opus 1.0 L/ha

In summary, your fungicide programme should be developed with the goal of generating the highest economic margin for your crop and managing the risk of resistance. As such, the most appropriate fungicide programme in any season, will vary depending on the following factors:

Higher fungicide input required
- More wheat grown in region
- Earlier autumn sowing date
- Stubble borne diseases more difficult to control
- Wet spring months (October and November particularly)
- Irrigation - thicker canopy with longer duration (greater humidity)
- Susceptible cultivar

Lower fungicide input required
- Less intensive wheat production in region
- Later autumn sowing date
- Stripe and leaf rust more easily controlled.
- Drier spring
- Dryland (thinner canopy; shorter duration, lower humidity)
- More resistant cultivar
Consider basing applications on at least 75% dose rates of triazole e.g. Opus 0.75 L/ha or Proline 0.6 L/ha. In FAR STB trials, Proline has been more effective towards the 75% end of the 75-100% (0.6 – 0.8 L/ha) dose range than Opus. Note that with Proline the reference is to the highest rate on the label for wheat which is 0.8 L/ha i.e. 75% of the 0.8 L/ha rate.

- **Opus 0.75 – 1.0 L/ha or Proline 0.6 – 0.8 L/ha**
- **Opus 0.75 – 1.0 L/ha or Proline 0.6 – 0.8 L/ha + Phoenix 1.5 L/ha**

You might consider the addition of the multisite fungicide Phoenix® (folpet) as a triazole partner to assist with the control of triazole insensitivity strains of STB. In principle, this is a good anti-resistance strategy, but results with folpet in FAR trials to date have been variable, both in terms of efficacy and economics. More work will be conducted on this in the 2018-19 season. The fungicide Phoenix has a label recommendation for a maximum of two applications up to GS39 and must be mixed with an alternative mode of action fungicide.

**Moderate disease pressure**

Consider mixtures of at least 75-100% triazoles with lower rates of SDHI, 50% dose rate of SDHI for STB protection or with a 50% dose rate of strobilurin for rust control. In these situations, consider Aviator Xpro 0.5 L/ha topped up with at least 0.32 L/ha Proline to ensure a minimum of a 75% dose of prothioconazole. With Adexar at 0.82 L/ha ensure a top up of 0.45 L/ha Opus to give a 75% dose of epoxiconazole.

- **Aviator Xpro 0.5 L/ha + Proline 0.32 L/ha**
- **Adexar 0.62 L/ha + Opus 0.45 L/ha**

**High disease pressure**

Where disease pressure is high as a result of early sowing and/or wet weather, consider topping up the triazole component in order to better compliment the SDHI (e.g. add Proline at 0.25 L/ha to the lower rate label of Aviator or add Opus at 0.25 – 0.15 L/ha to the Adexar depending on whether 1.0 or 1.25 L/ha is used). The reason that this may be required is that the dose rate of the triazole in these pre-formulated mixtures is less than a full label rate for the triazole alone, *Aviator at 0.7 L/ha contains the equivalent of 0.4 L/ha Proline and Adexar at 1.0 L/ha contains approximately 0.5 L/ha Opus.* Note the fungicide Elatus Plus is a solo SDHI product and must be applied in mixture with a triazole.

- **Aviator Xpro 0.7 L/ha + Proline 0.2 L/ha to Aviator Xpro 1.0 L/ha**
- **Adexar 1.0 L/ha + Opus 0.25 L/ha to Adexar 1.25 L/ha + Opus 0.15 L/ha**
- **Elatus Plus 0.75 L/ha + Opus 0.75 L/ha or Proline 0.6 L/ha**

In general, where rusts have been absent and the principal disease is STB, Proline has performed better than Opus, particularly in South Canterbury and Southland.

**T2 - GS39 (Flag leaf emergence on main stem)**

This is an important growth stage for fungicide application in all wheat crops, as the top three leaves have emerged on the main stem. Note that at this growth stage, flag leaves on the tillers are not fully emerged.

It is important to make sure that the time interval between the GS31-32 spray and the flag leaf emergence spray does not exceed four weeks and that flag leaf applications are applied when the flag leaf has emerged on the main stem. Again consider 75-100% dose rates of triazole as the base component for this spray. Consider alternating your triazoles at the different application timings. i.e. if you used Proline at GS31-32, consider Opus at GS38 or vice versa.

In irrigated, or high rainfall scenarios up to flag leaf

Use the higher rates of the SDHI with susceptible cultivars and earlier sown crops. Consider mixing more triazole (as outlined under GS31-32 approach) if the period between the first spray and flag leaf has been punctuated with regular rainfall events.

- **Aviator Xpro 0.7 L/ha + Proline 0.2 L/ha to Aviator Xpro 1.0 L/ha**
- **Adexar 1.0 L/ha + Opus 0.25 L/ha to Adexar 1.25 L/ha + Opus 0.15 L/ha**
- **Elatus Plus 0.75 L/ha + Opus 0.75 L/ha or Proline 0.6 L/ha**

If the weather is drier between GS31-32 and GS39 and the crop is under lower disease pressure, as in 2014 and 2015, then consider SDHI dose rates down to 50% mixed with triazole dose rates of 75-100%.

**In dryland scenarios in Canterbury**

Four years of South Canterbury trials (2014 – 2017) have shown that the use of more expensive fungicide programmes is not always cost effective in dryland situations. The exception was in 2016 where dryland crops behaved more like those grown under irrigation. However, as anti-resistance strategies are based on mixtures, using lower rate mixtures of triazole and SDHI may be more appropriate for disease protection than using triazole only strategies, particularly if triazole alone was used at T1.

- **Aviator Xpro 0.5 L/ha + Proline 0.32 L/ha**
- **Adexar 0.62 L/ha + Opus 0.45 L/ha**

**T3 - GS59–61 (Ear emergence - early flowering)**

In irrigated scenarios, FAR research suggests that higher fungicide rates provide better protection against disease, particularly leaf rust, at GS59-61.

**Where one SDHI application has been applied**

If only one SDHI has been applied and wet weather has favoured STB, and leaf rust is also present, consider similar applications to those outlined for flag leaf.

**Where two SDHI applications have been applied**

- **Do not apply three SDHIs.** Where two SDHIs have been applied and cultivars are susceptible to both leaf rust and STB, consider Prosaro 1.0 L/ha or Opus 0.75 – 1.0 L/ha + Comet 0.4 – 0.6 L/ha, Comet is particularly effective against leaf rust when applied at ear emergence (GS59). Remember that Proline is weaker on leaf rust, hence the use of Prosaro (prothioconazole and tebuconazole), which has been slightly more effective than other mixtures at this timing applied at similar rates. Where STB has been encouraged by wet weather post flag leaf, ensure that Opus rates are at least 0.75 L/ha.
  - **Prosaro 1.0 L/ha**
  - **Opus 0.75 – 1.0 L/ha + Comet 0.4 – 0.6 L/ha**

Where STB and Fusarium sp head infection are the key target diseases, then consider Proline (mixed with tebuconazole e.g. Prosaro for Fusarium sp) as a key ingredient for this spray. Effective control of Fusarium in the head is difficult to achieve, even when the fungicide is applied at the most effective timing (early flowering).

**In dryland scenarios**

The GS59-61 timing is an optional spray, dependent on rainfall from flag leaf up until the end of flowering GS69 (anthers visible up the length of the ear). Consider applying fungicide if higher rainfall occurs in this period. Opus alone (0.25 - 0.5 L/ha) or low rate mixtures such as Amistar (0.25 L/ha) + Opus (0.25 L/ha) have been particularly effective to control rusts. But remember Amistar will not control STB, as this pathogen is resistant to strobilurins in New Zealand.

- **Opus 0.25 – 0.50 L/ha**
- **Opus 0.25 L/ha + Amistar 0.25 L/ha**
T4 - GS69-72 (Post flowering)
Irrigated crops only - optional
For irrigated leaf rust-susceptible wheat crops on soils with good water holding capacity, mixtures based on Opus 0.25 L/ha + Amistar 0.25 L/ha (which have withholding periods of 42 and 35 days respectively) have delivered small but consistent yield benefits when applied following a similar application at ear emergence. However, results were no better than increased rates of Comet/Opus applied at ear emergence when leaf rust was the primary disease. Be extremely mindful of withholding periods when considering late fungicides.

- **Opus 0.25 L/ha + Amistar 0.25 L/ha**

Tan spot scenarios
Where tan spot has been diagnosed in the crop at stem elongation, flag or ear emergence, consider a strategy based on Proline (prothioconazole) mixed with the SDHI bixafen (as the preformulated mixture Aviator) or mixed with the strobilurin Comet (pyraclostrobin). The older triazole fungicide Tilt (propiconazole) is also an option for tan spot control at the GS30 and GS69, but not at the principal GS31-32 and GS39 timings. Tan spot, if present in the region, is most likely to be found first in second and continuous wheat crops.

**Notes:**
- The rates outlined above assume optimum timing of application. Late sprays, where disease pressure is high, may require higher rates.
- Use of rates lower than full label rate are carried out at growers’ risk.
- Be extremely mindful of withholding periods when considering late fungicides.

In some situations and in some seasons (e.g. 2016) dryland sites may be more equivalent to irrigated sites. In dryland situations, monitor rainfall between the key application timings at GS30, 32, 39 and 69 (early stem elongation – end of flowering). Where rainfall is well above the average consider irrigated strategy options as well as dryland options.

**Background supporting research data for fungicide management decisions**

**Appropriate fungicide dose**
Part of FAR’s disease management work since 2013 has been centred on developing a greater understanding of how triazoles and SDHIs perform in relation to different disease pressures. Since the SDHI foliar fungicides should never be used alone to control disease, due to the risk of pathogen resistance, all FAR’s work has been conducted on SDHIs applied in mixture with triazoles. In most cases the SDHIs are supplied already pre-formulated with a triazole, but where they are not, triazole has been added to at least a 75% rate.

High disease pressure in 2016 saw greater yield responses to controlling disease than in previous seasons, with a maximum fungicide response of 5.1 t/ha over the untreated yield (11.16 t/ha) at Irwell. In 2017, the maximum response to fungicide was 4.0 t/ha over the untreated (8.79 t/ha) at Southbridge.

**Triazoles**
A 2012 survey of wheat crops in New Zealand found that the STB pathogen had developed reduced sensitivity to the triazole fungicides. Triazoles include products such as epoxiconazole (e.g. Opus) and prothioconazole (Proline). This reduced sensitivity means that higher rates of fungicide are required to obtain the same level of control as was experienced before the resistance mutation(s) occurred.

At the start of the 2013 season, FAR established a series of trials to assess the rate response of epoxiconazole and prothioconazole. These trials in South Otago and Canterbury established that the optimum dose rate was 75-100%, label rate and that prothioconazole on balance was slightly more effective than epoxiconazole rate for rate. Subsequent trials have found the optimum dose rate has largely remained at 75-100% with the exception of the 2016-17 season, where high disease levels placed additional pressure on fungicide programmes, even at full label rates. A return to moderate disease pressure conditions in the 2017-18 season saw a return to 75-100% optimum rates. The trend for prothioconazole to be superior to epoxiconazole for control of STB has continued, although it is important to note that the reverse is true for leaf rust control.

**Figure 2.** The performance of Opus and Proline against STB applied at GS31 and GS39, disease assessed average GST5-85, trials were conducted across Canterbury and South Otago, 2013-2017. LAA = leaf area affected.
SDHIs

During 2016, the wet October and November encouraged disease spread and placed additional pressure on fungicide programmes. Even with a 100% dose of SDHI mixed with a 75% rate of triazole, STB infection failed to drop below 30% infection of the top three leaves. Where the Oakley crop (susceptible to STB) was left untreated, 70–100% of the top three leaves were infected with STB by GS75-80 (approximately 42 days after the GS39 application). While a 100% dose rate was required for maximising disease control, the most cost effective rate in terms of economics was 75%. In addition, there was no statistical difference in yield between the 75 – 100% rates for Aviator Xpro and 50 – 100% rates for Adexar.

Drier conditions in 2017 saw STB infection levels below 20% on the top three leaves for the cultivar Starfire (intermediate resistance) for all SDHI treatments. Where the crop was left untreated, 50–80% of the top three leaves were infected with STB by GS75-80. Although there were no significant differences in disease control between 50-100% rates, this did not translate to yield. Despite lower disease levels than 2016, at least a 75% dose rate was required for maximising the control of STB. The optimum dose rate in terms of yield response and margin was a 75% dose of SDHI mixed with a 75% rate of triazole for Adexar. While there were no significant yield differences between the 50 – 100% rates for Aviator Xpro, the 100% rate was the most cost effective. The 100% of Aviator Xpro was topped up with 0.03 L/ha Proline, as the full rate of Aviator Xpro contains less than a 75% rate of Proline.

Unlike the 2014 and 2015 seasons, the 2016 and 2017 seasons, despite contrasting disease pressure showed that keeping SDHI rates at 75 – 100% was essential to preserve yields and maximise returns.
Influence of fungicide dose rate on severity of STB infection, yield (t/ha) and margin over fungicide cost (MOFC $/ha) relative to untreated grain (grain price 2016 $300/ha, 2017 $380/ha). Disease assessed GS75-80, 42 days after GS39 fungicide application.

### Disease control in wheat

<table>
<thead>
<tr>
<th>Trt. No.</th>
<th>Yield (t/ha)</th>
<th>MOFC ($/ha)</th>
<th>%LAA STB (Flag to leaf 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65.07</td>
<td>11.16</td>
<td>12.01</td>
</tr>
<tr>
<td>2</td>
<td>61.48</td>
<td>11.25</td>
<td>12.02</td>
</tr>
<tr>
<td>3</td>
<td>59.72</td>
<td>11.24</td>
<td>12.12</td>
</tr>
<tr>
<td>4</td>
<td>56.63</td>
<td>11.35</td>
<td>12.11</td>
</tr>
<tr>
<td>5</td>
<td>54.32</td>
<td>11.41</td>
<td>12.04</td>
</tr>
<tr>
<td>6</td>
<td>52.57</td>
<td>11.48</td>
<td>12.05</td>
</tr>
<tr>
<td>7</td>
<td>50.78</td>
<td>11.54</td>
<td>12.06</td>
</tr>
<tr>
<td>8</td>
<td>48.96</td>
<td>11.60</td>
<td>12.07</td>
</tr>
<tr>
<td>9</td>
<td>47.15</td>
<td>11.66</td>
<td>12.08</td>
</tr>
<tr>
<td>10</td>
<td>45.34</td>
<td>11.72</td>
<td>12.09</td>
</tr>
<tr>
<td>11</td>
<td>43.53</td>
<td>11.78</td>
<td>12.10</td>
</tr>
<tr>
<td>12</td>
<td>41.72</td>
<td>11.84</td>
<td>12.11</td>
</tr>
<tr>
<td>13</td>
<td>39.91</td>
<td>11.90</td>
<td>12.12</td>
</tr>
<tr>
<td>14</td>
<td>38.10</td>
<td>11.96</td>
<td>12.13</td>
</tr>
<tr>
<td>15</td>
<td>36.29</td>
<td>12.02</td>
<td>12.14</td>
</tr>
<tr>
<td>16</td>
<td>34.48</td>
<td>12.08</td>
<td>12.15</td>
</tr>
<tr>
<td>17</td>
<td>32.67</td>
<td>12.14</td>
<td>12.16</td>
</tr>
</tbody>
</table>

**Value of two applications of SDHI**

In 2014/15 trials, three spray programmes were compared. Where an SDHI was applied at GS32 there were no significant differences in yield and margin over fungicide cost compared to a GS32 application of Proline alone. However, there were small differences in disease control in favour of SDHI addition.

At Methven in 2016/17, under high disease pressure conditions, there was no significant yield advantage to applying two SDHIs under irrigation compared with a programme with one SDHI. However, the additional 0.3 t/ha gained with the second SDHI application was enough to make it more cost effective.

Similar results were found at Chertsey in 2017/18. Where moderate disease pressure limited STB progression, there was no significant yield advantage to applying two SDHIs over a programme with a single SDHI. The additional 0.4 – 0.5 t/ha yield gain, while not significant, was enough to make two SDHIs more cost effective for the cultivars Excede and Inferno. As in the 2014/15 trials, there were small differences in disease control in favour of SDHI application in both the 2016/17 and 2017/18 seasons.
Dryland

In 2016, the dryland trial behaved more like an irrigated scenario, with the highest yields achieved with the four spray programme. However, the cost of chemicals meant there were minimal differences in margin over fungicide cost (MOFC) between the four spray and two spray programmes.

In 2017, all fungicide programmes lost between $143 and $361/ha at Chertsey. Losses were also generated for most programmes at St Andrews, regardless of cultivar, where drought conditions limited both yield and yield response to fungicide. In South Otago, the highest yields and margins were achieved with the least expensive fungicide programme for Waikani and Inferno.

**Cultivar Resistance and its interaction with irrigation**

The economic impact of STB varies from year to year and between cultivars, creating challenges for farmers to effectively control disease in a given field in a given season. Previous FAR trials in 2014/15 found cultivar genetic resistance to STB gave greater rate flexibility when making decisions on what fungicide programme and dose to apply.

In the 2016/17 and 2017/18 seasons nil fungicide replicates were added to irrigated CPT trials at Chertsey, Methven and Temuka. Yield response was greater for more susceptible cultivars compared to more resistant cultivars. Yield loss ranged from 1.8 t/ha for the moderately resistant cultivar Reflection, to 5.1 t/ha for the moderately susceptible cultivar Conqueror. Both STB and leaf rust were observed in these trials.

Results from irrigated cultivar by fungicide trials in 2016/17 found the highest yields and greatest margins were achieved with a four spray programme, regardless of cultivar resistance. However the differences in margins between, for example, one spray and four sprays was smaller with the more resistant cultivar, indicating that delayed sprays (due to bad weather) would have less significant impact on crop profitability than the same scenarios in susceptible cultivars. This suggests that under high disease pressure conditions where high rainfall and relative humidity are prevalent from stem elongation to ear emergence (and under irrigation), a robust fungicide programme is required, even if the cultivar is more resistant to STB. However, it also suggests that while a robust programme is required, a more resistant cultivar may still offer greater flexibility if fungicide timings are not optimal due to lack of spray windows, as the potential for yield loss is lower for more resistant cultivars. Under dryland conditions, for all cultivars, while a four spray programme had higher yields, a less intensive two spray programme was more cost effective without causing significant yield loss.

Under moderate disease pressure conditions in 2017/18, a three spray programme produced the highest net returns under irrigated and dryland conditions: Chertsey 2016/17. (grain price $300/ha). Disease assessed on top three leaves (%LAA), GS75-80, 21/12/2016.

Table 2. Yield and margin over fungicide cost (MOFC) for autumn sown wheat under different STB resistance ratings: Excede, Inferno, Starfire, and Adexar, at St Andrews, Methven, and Temuka 2016/17 and 2017/18 seasons. Diseased assessed on top three leaves (%LAA), GS75-80, 21/12/2016.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>MOFC ($/ha)</th>
<th>Yield t/ha</th>
<th>LSD</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excede</td>
<td>995</td>
<td>6.9</td>
<td>0</td>
<td>68.5</td>
</tr>
<tr>
<td>Starfire</td>
<td>68.1</td>
<td>8.7</td>
<td>446</td>
<td>35.8</td>
</tr>
<tr>
<td>Inferno</td>
<td>64.0</td>
<td>8.9</td>
<td>403</td>
<td>35.8</td>
</tr>
<tr>
<td>Adexar</td>
<td>98.1</td>
<td>7.2</td>
<td>7.2</td>
<td>58.5</td>
</tr>
<tr>
<td>Excede</td>
<td>42.5</td>
<td>10.3</td>
<td>634</td>
<td>42.5</td>
</tr>
<tr>
<td>Starfire</td>
<td>45.3</td>
<td>10.0</td>
<td>673</td>
<td>45.3</td>
</tr>
<tr>
<td>Inferno</td>
<td>45.3</td>
<td>9.5</td>
<td>552</td>
<td>45.3</td>
</tr>
<tr>
<td>Adexar</td>
<td>98.1</td>
<td>11.4</td>
<td>983</td>
<td>98.1</td>
</tr>
<tr>
<td>Excede</td>
<td>34.8</td>
<td>11.0</td>
<td>864</td>
<td>34.8</td>
</tr>
<tr>
<td>Starfire</td>
<td>36.8</td>
<td>11.0</td>
<td>864</td>
<td>36.8</td>
</tr>
<tr>
<td>Inferno</td>
<td>36.8</td>
<td>11.0</td>
<td>864</td>
<td>36.8</td>
</tr>
<tr>
<td>Adexar</td>
<td>22.5</td>
<td>11.4</td>
<td>983</td>
<td>22.5</td>
</tr>
<tr>
<td>Excede</td>
<td>22.5</td>
<td>11.4</td>
<td>983</td>
<td>22.5</td>
</tr>
<tr>
<td>Starfire</td>
<td>17.3</td>
<td>11.5</td>
<td>985</td>
<td>17.3</td>
</tr>
<tr>
<td>Inferno</td>
<td>17.3</td>
<td>11.5</td>
<td>985</td>
<td>17.3</td>
</tr>
<tr>
<td>Adexar</td>
<td>98.1</td>
<td>11.4</td>
<td>983</td>
<td>98.1</td>
</tr>
</tbody>
</table>

*Starfire was replaced by Wakanui in Year 2 due to Starfire's increased susceptibility following the 2016/17 season. It is now rated intermediate resistant to STB.*
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>GS30-31</th>
<th>GS32</th>
<th>GS39</th>
<th>GS65</th>
<th>%LAA by STB</th>
<th>Yield t/ha</th>
<th>MOFC ($/ha)</th>
<th>%LAA by STB</th>
<th>Yield t/ha</th>
<th>MOFC ($/ha)</th>
<th>%LAA by STB</th>
<th>Yield t/ha</th>
<th>MOFC ($/ha)</th>
<th>%LAA by STB</th>
<th>Yield t/ha</th>
<th>MOFC ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excede</strong></td>
<td><strong>Untreated</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>19.4</td>
<td>9.0</td>
<td>0</td>
<td>17.5</td>
<td>7.1</td>
<td>0</td>
<td>24.5</td>
<td>4.6</td>
<td>0</td>
<td>35.3</td>
<td>8.4</td>
</tr>
<tr>
<td><strong>Excede</strong></td>
<td>-</td>
<td>Prosaro 0.6 + Phoenix 1.0</td>
<td>Adexar 0.62 + Opus 0.25</td>
<td>Opus 0.25 + Amistar 0.25</td>
<td>1.2</td>
<td>9.1</td>
<td>-44</td>
<td>2.9</td>
<td>7.5</td>
<td>-25</td>
<td>14.8</td>
<td>4.5</td>
<td>-208</td>
<td>7.8</td>
<td>9.6</td>
<td>347</td>
</tr>
<tr>
<td><strong>Excede</strong></td>
<td>-</td>
<td>Proline 0.6</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>1.1</td>
<td>10.0</td>
<td>283</td>
<td>1.8</td>
<td>7.5</td>
<td>-73</td>
<td>10.2</td>
<td>4.7</td>
<td>-214</td>
<td>2.3</td>
<td>10.2</td>
<td>421</td>
</tr>
<tr>
<td><strong>Excede</strong></td>
<td>-</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>-</td>
<td>0.8</td>
<td>9.9</td>
<td>283</td>
<td>2.6</td>
<td>7.7</td>
<td>32</td>
<td>4.9</td>
<td>4.8</td>
<td>-127</td>
<td>0.6</td>
<td>10.3</td>
<td>506</td>
</tr>
<tr>
<td><strong>Excede</strong></td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>1.2</td>
<td>9.4</td>
<td>43</td>
<td>1.6</td>
<td>7.8</td>
<td>11</td>
<td>3.4</td>
<td>4.9</td>
<td>-167</td>
<td>0.9</td>
<td>10.6</td>
<td>539</td>
<td></td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td><strong>Untreated</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>1.7</td>
<td>9.4</td>
<td>0</td>
<td>10.2</td>
<td>8.2</td>
<td>0</td>
<td>19.5</td>
<td>5.0</td>
<td>0</td>
<td>35.3</td>
<td>9.2</td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td>-</td>
<td>Prosaro 0.6 + Phoenix 1.0</td>
<td>Adexar 0.62 + Opus 0.25</td>
<td>Opus 0.25 + Amistar 0.25</td>
<td>0.03</td>
<td>10.2</td>
<td>146</td>
<td>2.6</td>
<td>8.4</td>
<td>-119</td>
<td>11.5</td>
<td>4.9</td>
<td>-221</td>
<td>2.3</td>
<td>10.3</td>
<td>242</td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td>-</td>
<td>Proline 0.6</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.03</td>
<td>9.7</td>
<td>-67</td>
<td>0.8</td>
<td>8.7</td>
<td>-69</td>
<td>6.9</td>
<td>5.1</td>
<td>-193</td>
<td>3.4</td>
<td>10.6</td>
<td>275</td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td>-</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>-</td>
<td>0.1</td>
<td>9.5</td>
<td>-81</td>
<td>1.8</td>
<td>8.6</td>
<td>-58</td>
<td>1.9</td>
<td>5.1</td>
<td>-172</td>
<td>0.6</td>
<td>10.7</td>
<td>357</td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td>-</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.0</td>
<td>9.7</td>
<td>-40</td>
<td>1.3</td>
<td>8.6</td>
<td>-155</td>
<td>2.5</td>
<td>5.3</td>
<td>-160</td>
<td>1.1</td>
<td>10.6</td>
<td>240</td>
</tr>
<tr>
<td><strong>Wakanui</strong></td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.0</td>
<td>9.4</td>
<td>-235</td>
<td>0.5</td>
<td>8.8</td>
<td>-99</td>
<td>1.4</td>
<td>5.4</td>
<td>-166</td>
<td>0.4</td>
<td>10.7</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td><strong>Untreated</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.1</td>
<td>9.1</td>
<td>0</td>
<td>4.9</td>
<td>8.3</td>
<td>0</td>
<td>15.6</td>
<td>4.8</td>
<td>0</td>
<td>23.1</td>
<td>9.3</td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td>-</td>
<td>Prosaro 0.6 + Phoenix 1.0</td>
<td>Adexar 0.62 + Opus 0.25</td>
<td>Opus 0.25 + Amistar 0.25</td>
<td>0.1</td>
<td>10.0</td>
<td>233</td>
<td>0.8</td>
<td>8.6</td>
<td>-53</td>
<td>9.0</td>
<td>4.4</td>
<td>-316</td>
<td>1.0</td>
<td>10.2</td>
<td>172</td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td>-</td>
<td>Proline 0.6</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.03</td>
<td>9.2</td>
<td>-63</td>
<td>0.5</td>
<td>8.5</td>
<td>-154</td>
<td>8.4</td>
<td>5.0</td>
<td>-178</td>
<td>1.8</td>
<td>10.3</td>
<td>177</td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td>-</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>-</td>
<td>0.10</td>
<td>9.7</td>
<td>158</td>
<td>0.3</td>
<td>8.6</td>
<td>-116</td>
<td>3.3</td>
<td>4.8</td>
<td>-207</td>
<td>2.2</td>
<td>10.2</td>
<td>154</td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td>-</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.03</td>
<td>9.4</td>
<td>1</td>
<td>0.4</td>
<td>8.6</td>
<td>-179</td>
<td>2.3</td>
<td>4.8</td>
<td>-281</td>
<td>0.8</td>
<td>10.8</td>
<td>314</td>
</tr>
<tr>
<td><strong>Inferno</strong></td>
<td>Opus 1.0</td>
<td>Aviator Xpro 1.0</td>
<td>Adexar 1.0 + Opus 0.25</td>
<td>Opus 0.75 + Comet 0.4</td>
<td>0.03</td>
<td>9.4</td>
<td>-72</td>
<td>0.1</td>
<td>8.5</td>
<td>-229</td>
<td>1.7</td>
<td>4.7</td>
<td>-361</td>
<td>0.6</td>
<td>10.2</td>
<td>50</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.4</td>
<td>9.6</td>
<td>2.9</td>
<td>8.2</td>
<td>8.0</td>
<td>4.9</td>
<td>6.7</td>
<td>10.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LSD</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.8</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>2.0</td>
<td>0.6</td>
<td>2.1</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Wakanui has been rated intermediate resistance to STB for the 2018 season.*
Table 4. Yield response to fungicide for irrigated wheat – 2 year mean of 6 irrigated CPT trials, Chertsey, Methven and Temuka 2016/17 and 2017/18. Trials infected with STB and leaf rust.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Fungicide</th>
<th>Nil Fungicide</th>
<th>Yield Loss</th>
<th>STB rating</th>
<th>LR rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection</td>
<td>13.7</td>
<td>11.9</td>
<td>1.8</td>
<td>MR</td>
<td>MR</td>
</tr>
<tr>
<td>Empress</td>
<td>12.5</td>
<td>10.3</td>
<td>2.3</td>
<td>MRR</td>
<td>MRMS</td>
</tr>
<tr>
<td>Ignite</td>
<td>13.9</td>
<td>11.3</td>
<td>2.6</td>
<td>MR</td>
<td>MS</td>
</tr>
<tr>
<td>Inferno</td>
<td>13.0</td>
<td>10.1</td>
<td>2.9</td>
<td>MRR</td>
<td>MR</td>
</tr>
<tr>
<td>Ruapuna</td>
<td>13.3</td>
<td>9.6</td>
<td>3.7</td>
<td>MS</td>
<td>MS</td>
</tr>
<tr>
<td>Graham</td>
<td>14.2</td>
<td>10.4</td>
<td>3.8</td>
<td>MR</td>
<td>MRMS</td>
</tr>
<tr>
<td>Claire</td>
<td>13.1</td>
<td>8.7</td>
<td>4.5</td>
<td>MS</td>
<td>MRMS</td>
</tr>
<tr>
<td>CW7223</td>
<td>13.5</td>
<td>9.0</td>
<td>4.5</td>
<td>MRMS</td>
<td>(MRR)</td>
</tr>
<tr>
<td>Torch</td>
<td>13.5</td>
<td>9.0</td>
<td>4.6</td>
<td>MRMS</td>
<td>MS</td>
</tr>
<tr>
<td>Wakanui</td>
<td>13.4</td>
<td>8.7</td>
<td>4.7</td>
<td>MR</td>
<td>MS</td>
</tr>
<tr>
<td>Excede</td>
<td>12.6</td>
<td>7.8</td>
<td>4.8</td>
<td>MSS</td>
<td>MRMS</td>
</tr>
<tr>
<td>Starfire</td>
<td>13.2</td>
<td>7.9</td>
<td>5.4</td>
<td>MRMS</td>
<td>MS</td>
</tr>
<tr>
<td>Gator</td>
<td>13.2</td>
<td>7.6</td>
<td>5.7</td>
<td>MS</td>
<td>MSS</td>
</tr>
<tr>
<td>Conqueror</td>
<td>13.3</td>
<td>7.5</td>
<td>5.8</td>
<td>MS</td>
<td>S</td>
</tr>
<tr>
<td>Mean</td>
<td>13.3</td>
<td>9.3</td>
<td>4.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STB Latent Period and Progression

Septoria tritici blotch has a latent period of approximately 250°C days in thermal time. This is the time it takes from a STB spore landing on a leaf to visible symptoms showing. With optimum conditions up to flag leaf, STB will be present two leaves behind the newest emerging leaf as it takes approximately 110-120°C days for a leaf to emerge.

This was seen in FAR’s cultivar x fungicide programme trials at Chertsey in 2016. The trial was sown using the cultivars Excede (mostly susceptible), Starfire (moderately resistant) and Inferno (mostly resistant). At GS33 (leaf 2 emergence on the main stem), STB was present two leaves behind on leaf 4 in untreated Excede plants. Low and very low levels of STB were observed on leaf 4 in untreated Starfire and Inferno plots respectively. Further down the plant, leaf 5 had senesced and was covered in the characteristic black fungal pycnidia of STB in untreated Excede. Leaf 5 in untreated Starfire plots has partially senesced and is still green in untreated Inferno plots. This shows how greater genetic resistance can influence STB development, even when sown early and weather conditions have been conducive to disease. It is important to note that while genetic resistance affected STB development earlier in the season, by GS75-80, high disease pressure conditions in this trial meant STB developed to reach high levels on the top 3 leaves, regardless of cultivar.

New SDHI Elatus Plus – compared with Adexar and Aviator Xpro

Figure 6. Septoria tritici blotch (STB) on leaf 4 of April sown wheat at GS33. The plant on the left is the mostly susceptible (MSS) cultivar Excede, the middle plant is the moderately resistant (MR) cultivar Starfire and the plant on the right is the mostly resistant (MRR) cultivar Inferno. All of these plants were untreated with fungicide.

Figure 7. Influence of Elatus Plus (active ingredient benzovindiflupyr) applied in mixture with Opus (epoxiconazole) (L/ha) against STB applied at GS31 and GS39 at Irwell 2016-17 and Southbridge 2017-18 – 2 trial mean.
The coded fungicide F15/01 reported in the last Strategy has now been commercialised as a new SDHI fungicide Elatus Plus (active ingredient benzovindiflupyr). In 2016/17 and 2017/18 trials, Elatus Plus achieved similar levels of STB control and yields compared to Adexar and Aviator Xpro at equivalent rates of SDHI. All SDHI products were applied in mixture with a 75% rate of triazole.

A new coded product, F17/01, trialled for the first time in 2017, was significantly more effective on STB than other treatments trialled. F17/01 is a coded product to look out for in 2018 trials.

Phoenix

The 2016 Cereal Disease Management Strategy reported on two FAR trials using the multisite fungicide Phoenix (active ingredient folpet). Additional STB control was observed in the susceptible cultivar Savannah with two applications of Phoenix + Opus compared with Opus alone, however the yield increases were not statistically significant. Phoenix has been assessed in a further five trials over 2016 and 2017 seasons with similar results. At a high yielding dryland trial site at Clinton, when Phoenix was added to the programme twice (GS32 and GS39) there was a non-significant increase in STB control and yield. Similar results were found at a dryland trial at St Andrews in 2016 where Phoenix was added to the programme once at GS32. At an irrigated trial at Lauriston, in 2016, again there was an indication of extra STB control but no yield increase. Two irrigated trials at Wakanui in 2016 and Southbridge in 2017 also showed non-significant additional STB control but the yield results were not reliable in these trials due to lodging and take-all.

### Table 5. Influence of Phoenix on the severity of STB infection (% leaf area affected – LAA) for the intermediate resistant cultivar Wakanui at Clinton, South Otago, 2016.

<table>
<thead>
<tr>
<th>GS32</th>
<th>GS39</th>
<th>GS65</th>
<th>Yield</th>
<th>% LAA by STB 19 December 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.9</td>
<td>15.5</td>
<td>55.9</td>
<td>98.1</td>
<td></td>
</tr>
<tr>
<td>13.3</td>
<td>3.7</td>
<td>29.9</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>13.5</td>
<td>4.1</td>
<td>31.0</td>
<td>83.0</td>
<td></td>
</tr>
<tr>
<td>14.1</td>
<td>2.6</td>
<td>22.9</td>
<td>84.0</td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td>4.7</td>
<td>82.6</td>
<td>34.5</td>
<td>14.5</td>
</tr>
<tr>
<td>LSD</td>
<td>0.9</td>
<td>4.4</td>
<td>11.8</td>
<td>15.6</td>
</tr>
</tbody>
</table>

*Wakanui has been rated intermediate resistance to STB for the 2018 season.*

### Table 6. Influence of Phoenix on the severity of STB infection (% leaf area affected – LAA) for the moderately resistant cultivar Wakanui at St Andrews, 2016.

<table>
<thead>
<tr>
<th>GS32</th>
<th>GS39</th>
<th>GS65</th>
<th>Yield</th>
<th>% LAA by STB 31 December 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.2</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.1</td>
<td>34.5</td>
<td>75.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.4</td>
<td>26.4</td>
<td>47.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>56.3</td>
<td>73.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.4</td>
<td>42.8</td>
<td>68.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td>3.3</td>
<td>27.0</td>
<td>27.0</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>0.9</td>
<td>27.1</td>
<td>38.6</td>
<td></td>
</tr>
</tbody>
</table>

The rapid loss of strobilurin chemistry due to resistance in the STB pathogen, the reduced efficacy of triazole chemistry and the unavailability of chlorothalonil to control STB means there is widespread use of SDHI chemistry for STB control. This increases the risk of resistance developing to this chemical group. Incorporating Phoenix into a spray programme introduces another mode of action which has multisite activity and could reduce the risk of resistance developing. A number of independent overseas fungicide specialists believe that adding Phoenix to a triazole has value as an anti-resistance strategy. In the five most reliable FAR trials conducted over the last four years, the trends in yield data and disease control have been positive, although non-significant, which adds weight to the economic argument.
What has changed in barley disease management since 2016?

- Ramularia has been the main disease present in recent FAR autumn sown barley trials.
- Ramularia together with leaf rust have been the main diseases present in recent FAR spring sown trials.
- Ramularia is resistant to the strobilurins and has recently become less sensitive to the SDHI fungicides.
- The new multisite fungicide Phoenix® has shown good control of Ramularia when used in a mix with Proline, but currently does not have a registration for control of this disease.

Ramularia life cycle

Ramularia leaf spot is caused by the fungus Ramularia collo-cygni. It grows from infected seed and moves systemically as the plant grows. Airborne spores from barley volunteers, grasses and crop debris can also infect plants. Infected crops do not display visible symptoms initially. Senescing leaves may show signs of infection early in the season, but the main damage occurs on the top leaves after flowering. Later in the season, rows of white spores can be seen with a hand lens on the undersides of affected leaves. Stressed crops, including those exposed to high light levels, waterlogging and rainfall after flowering, are thought to be more likely to show symptoms. However, even stress associated with flowering may be sufficient to initiate symptoms.

Early symptoms comprise small brown pepper spots on the upper leaves. These develop quickly into typical Ramularia lesions. Mature Ramularia lesions can be distinguished from other foliar symptoms by applying the ‘5Rs’: ringed with yellow margin of chlorosis, rectangular shape, restricted by the leaf veins, reddish-brown colouration and right through the leaf.

Ramularia is often mistaken for other diseases, such as the spot form of net blotch and physiological spotting. Net blotch lesions are not rectangular or restricted by leaf veins. Physiological leaf spots, caused by oxidative stress, show as superficial browning on upper leaf surfaces, while the undersides remain unaffected. These physiological spots cause less yield loss but can trigger the appearance of Ramularia.

Figure 8. Ramularia leaf spot in barley. Photograph courtesy of Ian Harvey PLANTwise.

Figure 9. Life cycle of Ramularia (Ramularia collo-cygni). Illustration courtesy of Ian Harvey, PLANTwise.
Disease susceptible scenarios
Generally autumn sown barley tends to be more susceptible to diseases than spring sown barley. This is due to the longer growing season and the tendency for wet weather diseases such as scald (Rhynchosporium) to build up over winter. FAR research trials have found that under these conditions, autumn sown barley benefits from at least two foliar fungicide applications.

Therefore, consider basing an autumn sown barley strategy on at least two spray applications from the start of stem elongation GS30-31, even if Systiva seed treatment has been used.

Seed treatment – Systiva based on the SDHI fungicide fluxapyroxad
Systiva seed treatment trials have shown an economic advantage in one irrigated trial but not in two dryland trials (one of the dryland trials had very low disease pressure and no response to fungicide). Limited data show that foliar fungicide programmes should not be reduced through the use of Systiva. However, if Systiva has been used, remember it counts toward the two SDHI applications allowed per season, thus limiting you to one SDHI based foliar fungicide application in-crop. If SDHI seed treatment has been used, FAR would envisage GS39 to GS59 as the optimum timing window to add a foliar SDHI to the mix, due to the activity of these fungicides against leaf rust.

T0 - GS29 (Late tillering)
Four out of five recent FAR trials did not justify a fungicide at late tillering (Table 9). However, when high scald pressure is present early in the spring, consider applying a lower cost “holding” spray prior to the two sprays at GS30-31 and GS39-49 timings. Options would include Proline 0.2 L/ha + Protek 0.5 L/ha. Do not omit the other two sprays if the T0 (pre-GS30) is applied. This holding spray has tended to be most important in dryland crops on lighter soils where early leaf loss is relatively more important (since there is less green leaf retention later in the season). The two most likely scenarios for needing an early tillering spray are where barley is grown following barley or where barley is sown early.

T1 - GS30-GS31 (pseudo stem erect - first node)
In 2017-18 FAR trials a Proline + Phoenix mix provided the highest margin over fungicide cost. This mix can be used for efficacy against Ramularia and scald.

Phoenix (multi-site protectant) and Ramularia control: In 2017-18 FAR trials Phoenix (active ingredient folpet) mixed with Proline has given superior control of Ramularia and higher yields compared with triazole plus SDHI treatments. Phoenix could also assist in controlling Ramularia strains with reduced sensitivity to the SDHIs. The fungicide Phoenix has a label recommendation for control of scald only in barley, with a maximum of two applications up to GS39. A change to the label is currently being sought to add Ramularia. Once the new label claim is approved, growers may consider:

- Proline 0.4 L/ha + Phoenix 1.5 L/ha
- Proline 0.4 L/ha + Acanto 0.25 L/ha + Phoenix 1.5 L/ha
- Proline 0.4 L/ha + Seguris Flexi 0.3 L/ha + Phoenix 1.5 L/ha
- Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
- Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

In lower disease pressure scenarios, such as a dry spring or more disease resistant cultivars, the lower rate in the range may be more appropriate. Since the dose rate of the triazole in these pre-formulated mixes of Aviator Xpro 0.5 L/ha or Adexar 0.63 L/ha is less than half the label rate for the triazole, consider topping up the triazole component in order to better complement Phoenix and the SDHI (e.g. add Proline at 0.1 L/ha to the lower rate of Aviator Xpro or add Opus at 0.2 L/ha to the Adexar).

T2 - GS39 (flag leaf fully emerged)
The T2 timing has previously been described as a spray window from GS39 to GS49. However, if Phoenix is used (after label approval), the latest timing for this spray is GS39. At GS39 consider using Proline + Phoenix for Ramularia and scald control, respectively.

- Proline 0.4 L/ha + Phoenix 1.5 L/ha
- Proline + Phoenix is less effective against leaf rust. If rust is present or the cultivar has a susceptibility to rust consider:
  - Proline 0.4 L/ha + Seguris Flexi 0.3 – 0.6 L/ha + Phoenix 1.5 L/ha
  - Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
  - Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

In FAR trials, the T2 spray has generally been applied at the GS49 end of the GS39-49 spray window. If the spray is applied at GS39 we do not know if the mix will have the persistence needed against leaf rust and where a rate range is given, the higher rate may be of value. Use the higher rates of SDHI if there has been higher disease pressure. Consider mixing more triazole to Aviator Xpro or Adexar (as outlined under the T1 approach) if the period between T1 and T2 has had regular rainfall events.

Key fungicide timings for disease management strategies in autumn sown barley

Summary

Disease susceptible scenarios
Generally autumn sown barley tends to be more susceptible to diseases than spring sown barley. This is due to the longer growing season and the tendency for wet weather diseases such as scald (Rhynchosporium) to build up over winter. FAR research trials have found that under these conditions, autumn sown barley benefits from at least two foliar fungicide applications.

Therefore, consider basing an autumn sown barley strategy on at least two spray applications from the start of stem elongation GS30-31, even if Systiva seed treatment has been used.

Seed treatment – Systiva based on the SDHI fungicide fluxapyroxad
Systiva seed treatment trials have shown an economic advantage in one irrigated trial but not in two dryland trials (one of the dryland trials had very low disease pressure and no response to fungicide). Limited data show that foliar fungicide programmes should not be reduced through the use of Systiva. However, if Systiva has been used, remember it counts toward the two SDHI applications allowed per season, thus limiting you to one SDHI based foliar fungicide application in-crop. If SDHI seed treatment has been used, FAR would envisage GS39 to GS59 as the optimum timing window to add a foliar SDHI to the mix, due to the activity of these fungicides against leaf rust.

T0 - GS29 (Late tillering)
Four out of five recent FAR trials did not justify a fungicide at late tillering (Table 9). However, when high scald pressure is present early in the spring, consider applying a lower cost “holding” spray prior to the two sprays at GS30-31 and GS39-49 timings. Options would include Proline 0.2 L/ha + Protek 0.5 L/ha. Do not omit the other two sprays if the T0 (pre-GS30) is applied. This holding spray has tended to be most important in dryland crops on lighter soils where early leaf loss is relatively more important (since there is less green leaf retention later in the season). The two most likely scenarios for needing an early tillering spray are where barley is grown following barley or where barley is sown early.

T1 - GS30-GS31 (pseudo stem erect - first node)
In 2017-18 FAR trials Phoenix (active ingredient folpet) mixed with Proline has given superior control of Ramularia and higher yields compared with triazole plus SDHI treatments. Phoenix could also assist in controlling Ramularia strains with reduced sensitivity to the SDHIs. The fungicide Phoenix has a label recommendation for control of scald only in barley, with a maximum of two applications up to GS39. A change to the label is currently being sought to add Ramularia. Once the new label claim is approved, growers may consider:

- Proline 0.4 L/ha + Phoenix 1.5 L/ha
- Proline 0.4 L/ha + Acanto 0.25 L/ha + Phoenix 1.5 L/ha
- Proline 0.4 L/ha + Seguris Flexi 0.3 L/ha + Phoenix 1.5 L/ha
- Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
- Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

In lower disease pressure scenarios, such as a dry spring or more disease resistant cultivars, the lower rate in the range may be more appropriate. Since the dose rate of the triazole in these pre-formulated mixes of Aviator Xpro 0.5 L/ha or Adexar 0.63 L/ha is less than half the label rate for the triazole, consider topping up the triazole component in order to better complement Phoenix and the SDHI (e.g. add Proline at 0.1 L/ha to the lower rate of Aviator Xpro or add Opus at 0.2 L/ha to the Adexar).

T2 - GS39 (flag leaf fully emerged)
The T2 timing has previously been described as a spray window from GS39 to GS49. However, if Phoenix is used (after label approval), the latest timing for this spray is GS39. At GS39 consider using Proline + Phoenix for Ramularia and scald control, respectively.

- Proline 0.4 L/ha + Phoenix 1.5 L/ha
- Proline + Phoenix is less effective against leaf rust. If rust is present or the cultivar has a susceptibility to rust consider:
  - Proline 0.4 L/ha + Seguris Flexi 0.3 – 0.6 L/ha + Phoenix 1.5 L/ha
  - Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
  - Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

In FAR trials, the T2 spray has generally been applied at the GS49 end of the GS39-49 spray window. If the spray is applied at GS39 we do not know if the mix will have the persistence needed against leaf rust and where a rate range is given, the higher rate may be of value. Use the higher rates of SDHI if there has been higher disease pressure. Consider mixing more triazole to Aviator Xpro or Adexar (as outlined under the T1 approach) if the period between T1 and T2 has had regular rainfall events.

Key fungicide timings for disease management strategies in autumn sown barley
When is a T3 – GS59 spray necessary?

In four out of six recent FAR trials, crops did not show a yield response to a T3 fungicide following Proline 0.4 L/ha + Seguris Flexi 0.3 at T2. However, the T2 spray in these trials was generally applied at the GS49 end of the GS39-49 window. When the T2 spray is targeted at GS39 (if Phoenix is in the mix) it may not persist long enough against leaf rust. Do not apply more than two SDHI sprays on a barley crop. Consider:

- Proline 0.2 L/ha + Seguris Flexi 0.3 L/ha
- Proline 0.2 L/ha + Acanto 0.25 L/ha

Notes:
The above rates assume optimum timing of application. Late sprays where disease is at high pressure may require higher rates.

In some situations and in some seasons dryland sites may be more equivalent to irrigated sites. In dryland situations monitor rainfall between the key application timings at GS30, 39-49 and 59 (early stem elongation – ear emergence). If rainfall is well above the average consider irrigated strategy options as well as dryland options.
What role, if any, do SDHI fungicides now have in disease management programmes for autumn sown barley? Although not common in FAR autumn sown barley trials, leaf rust is a disease that Proline + Phoenix mixes are less effective against; SDHI fungicides can strengthen their control, especially in cultivars without good rust resistance.

**Value of T0 and T3 sprays in autumn sown barley**

Four out of five FAR trials over the last four seasons had no yield response to a T0 spray (Table 9). There was also minimal response to a T3 (GS59) spray following Proline 0.4 L/ha + Seguris Flexi 0.3 L/ha at T2. When Ramularia is the main disease it could be expected that there would be a greater yield response to this spray combination, particularly if the SDHIs are compromised. Possibly the crop was far enough advanced in these trials that when Ramularia progressed there was no benefit from keeping the canopy green for a longer duration. In FAR trials, the T2 spray has generally been applied at the GS49 end of the GS39-49 spray window. If the spray is applied at GS39, because Phoenix is in the mix, we do not know if the mix will have the persistence needed against leaf rust. This will be tested in 2018-19 trials.

**Table 9. Yield response (t/ha) to T1 + T2 fungicide sprays and yield response to either an additional T0 (Proline 0.2 L/ha + Protek 0.5 L/ha) or T3 (Proline 0.2 L/ha + Seguris Flexi 0.3 L/ha) fungicide application in addition to the T1 + T2 applications.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Season</th>
<th>Cultivar</th>
<th>Additional T0 response</th>
<th>T1 + T2</th>
<th>Additional T3 response</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geraldine</td>
<td>2017</td>
<td>Cassia</td>
<td>0.7</td>
<td>0.2</td>
<td>Ramularia</td>
<td></td>
</tr>
<tr>
<td>Southbridge</td>
<td>2017</td>
<td>776</td>
<td>0.4</td>
<td>0.9</td>
<td>0</td>
<td>Ramularia</td>
</tr>
<tr>
<td>Temuka</td>
<td>2015</td>
<td>Padura</td>
<td>0.5</td>
<td>0.34</td>
<td>Ramularia</td>
<td></td>
</tr>
<tr>
<td>Methven</td>
<td>2015</td>
<td>Sanette</td>
<td>0.88</td>
<td>0</td>
<td>Scald</td>
<td></td>
</tr>
<tr>
<td>Temuka</td>
<td>2014</td>
<td>Cassia</td>
<td>1.05</td>
<td>0</td>
<td>Ramularia</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>0.08</td>
<td>0.76</td>
<td>0.09</td>
<td></td>
</tr>
</tbody>
</table>
Comparison to autumn sown barley:
Optimum fungicide timings in spring sown barley have generally mirrored those observed in FAR trials on autumn sown barley. However, four key differences have been observed:

• Spring sowing naturally reduces disease pressure, allowing lower rates of fungicide to be employed.
• Later sown crops (October) develop much more quickly, with a short grain fill period reducing the need for fungicide persistence.
• Leaf rust was more prevalent in spring sown trials and this is reflected in the suggested spray programmes.
• Where dryland crops are sown later, particularly on the east coast of New Zealand (e.g. Hawkes Bay), fungicides produce relatively small gains in profitability and therefore fungicide cost needs to be tailored accordingly.

Therefore, for spring sown barley crops, consider two spray programmes starting at the start of stem elongation GS30 or as the rows close over at GS23-30.

Spring barley

T1 - GS23-GS30 - Row closure
A Proline + Phoenix mix has good efficacy against Ramularia and scald, respectively.

Phoenix (multi-site protectant) and Ramularia control: In 2017-18 FAR trials Phoenix (active ingredient folpet) added to Proline has given superior control of Ramularia and high yields compared with treatments that include a SDHI. Phoenix could also assist in controllingRamularia strains with reduced sensitivity to the SDHIs. This mix would benefit from a partner with activity against leaf rust. The fungicide Phoenix has a label recommendation for control of scald only in barley, with a maximum of two applications up to GS39. A change to the label is being sought to add Ramularia.

This mix is less effective against leaf rust. As most barley cultivars are susceptible to rust, consider adding a strobilurin or SDHI to the mix. Therefore, for irrigated crops or early sown dryland crops consider:

• Proline 0.2 L/ha + Seguris Flexi 0.3 L/ha + Phoenix 1.5 L/ha
• Proline 0.2 L/ha + Acanto 0.25 L/ha + Phoenix 1.5 L/ha
• Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
• Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

For dryland crops, where disease pressure has been historically low, consider:

• Proline 0.2 L/ha + Protek 0.5 for scald or Proline 0.2 + Phoenix 1.5 if scald and Ramularia are the expected weaknesses

T2 - GS39 - flag leaf fully emerged (T2)
The T2 timing has previously been described as a spray window from GS39 to GS49. However, if Phoenix is used, the latest timing for this spray is GS39.

For irrigated crops or early sown disease prone dryland crops consider:

• Proline 0.2 L/ha + Seguris Flexi 0.3 L/ha + Phoenix 1.5 L/ha
• Proline 0.2 L/ha + Acanto 0.25 L/ha + Phoenix 1.5 L/ha
• Aviator Xpro 0.5 – 0.7 L/ha + Phoenix 1.5 L/ha
• Adexar 0.63 – 1.0 L/ha + Phoenix 1.5 L/ha

The SDHI option Seguris Flexi would be more effective if the key target diseases were leaf rust and Ramularia, whilst the SDHI option based on Aviator Xpro or Adexar would be more effective on scald, Ramularia and leaf rust. Good leaf rust resistance and/or very dry conditions may reduce the value of adding a strobilurin or SDHI with the Proline and Phoenix.

Currently Phoenix can be added to the mix up to GS39 (see T1 notes).

If Phoenix is not used, the later GS49 timing has the advantage of applying fungicide to the flag leaf sheath, which is un-emerged at GS39. However this benefit has to be considered against ensuring that the gap between the two sprays (T1 and T2) does not exceed four weeks.

Dryland crops with lower disease pressure
Trials in Manawatu and Hawkes Bay over three years (and drier inland parts of Southland in previous FAR trials) have shown lower cost fungicide programmes to be more cost effective. In the Manawatu and Hawkes Bay trials there has been no increase in yield from adding other fungicides to a two spray Proline programme in dryland situations.

Notes:
The above rates assume optimum timing of application. Late sprays where disease is at high pressure may require higher rates.

In some situations and in some seasons dryland sites may be more equivalent to irrigated sites. In dryland situations monitor rainfall between the key application timings at GS23, 33 and 49 (late tillering – awn emergence). Where rainfall is well above the average, consider irrigated strategy options as well as dryland options.
Background supporting data 2017-18

The following table shows the yield and margin over fungicide cost from 15 fungicide treatments in an irrigated trial of cultivar Sanette at Methven in 2017-18. Ramularia and leaf rust were the main diseases in the trial. The highest yielding and margin over fungicide cost treatments both had Phoenix in the mix with either Proline alone or Proline and Seguris Flexi. Proline + Seguris Flexi + Phoenix was the only treatment that yielded significantly higher than Proline alone. While Phoenix is registered for barley, it currently has no label recommendation for Ramularia control or applications after GS39. Neither the triazole Proline 0.2 L/ha nor the SDHI Seguris Flexi at a half rate of 0.3 L/ha appeared to contribute to controlling Ramularia in this trial. Seguris Flexi gave good control of leaf rust. When Phoenix was added to Proline, good control of Ramularia was obtained (this was also observed in the autumn sown barley trials), but no additional control of leaf rust. In this trial, increasing the rate of Adexar above 0.62 L/ha and Aviator above 0.35 L/ha did not increase the yield, even though leaf rust control was improved. In contrast in a 2016 trial at Chertsey, with leaf rust as the main disease, increasing the rates of Adexar to 1.25 L/ha and Aviator to 1 L/ha increased the yield by 1.0 t/ha and 1.4 t/ha respectively. In this trial Proline 0.2 L/ha + Seguris Flexi 0.3 L/ha had the highest equal margin over fungicide cost with Aviator 1.0 L/ha.

In FAR trials the T2 spray has generally been applied at the GS49 end of the GS39-49 spray window. If the spray is applied at GS39 (if Phoenix is in the mix) we do not know if the mix will have the persistence needed against leaf rust. This will be tested in 2018-19 trials.

Table 10. Influence of fungicide on leaf area affected by Ramularia and leaf rust (%), yield (t/ha) and margin over fungicide cost relative to the untreated (MOFC $/ha, grain price $380/t) in irrigated spring sown barley (Sanette) – at Methven in 2017-18.

<table>
<thead>
<tr>
<th>Trt. No.</th>
<th>GS31</th>
<th>GS39-49</th>
<th>Ramularia (% Leaf area affected, mean leaf 2 and leaf 3)</th>
<th>Leaf Rust (% Leaf area affected, mean leaf 2 and leaf 3)</th>
<th>Yield (t/ha)</th>
<th>MOFC ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nil</td>
<td>Nil</td>
<td>11.2</td>
<td>22.6</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Proline 0.2</td>
<td>Proline 0.2</td>
<td>8.5</td>
<td>9.0</td>
<td>9.2</td>
<td>267</td>
</tr>
<tr>
<td>3</td>
<td>Proline 0.2</td>
<td>S.F. 0.3</td>
<td>9.2</td>
<td>2.0</td>
<td>9.6</td>
<td>409</td>
</tr>
<tr>
<td>4</td>
<td>Proline 0.2 + S.F. 0.3</td>
<td>Proline 0.2 + S.F. 0.3</td>
<td>8.3</td>
<td>1.3</td>
<td>9.3</td>
<td>277</td>
</tr>
<tr>
<td>5</td>
<td>Proline 0.4 + S.F. 0.3</td>
<td>Proline 0.4 + S.F. 0.3</td>
<td>10.1</td>
<td>4.0</td>
<td>9.5</td>
<td>272</td>
</tr>
<tr>
<td>6</td>
<td>Proline 0.2 + Acanto 0.25</td>
<td>Proline 0.2 + Acanto 0.25</td>
<td>11.7</td>
<td>4.4</td>
<td>9.7</td>
<td>420</td>
</tr>
<tr>
<td>7</td>
<td>Proline 0.2 + Phoenix 1.5</td>
<td>Proline 0.2 + Phoenix 1.5</td>
<td>1.6</td>
<td>7.1</td>
<td>9.9</td>
<td>501</td>
</tr>
<tr>
<td>8</td>
<td>Proline 0.2 + S.F. 0.3 + Phoenix 1.5</td>
<td>Proline 0.2 + S.F. 0.3 + Phoenix 1.5</td>
<td>2.3</td>
<td>1.1</td>
<td>10.2</td>
<td>529</td>
</tr>
<tr>
<td>9</td>
<td>Aviator Xpro 1.0</td>
<td>Aviator Xpro 1.0</td>
<td>6.3</td>
<td>0.8</td>
<td>9.6</td>
<td>290</td>
</tr>
<tr>
<td>10</td>
<td>Aviator Xpro 0.7</td>
<td>Aviator Xpro 0.7</td>
<td>10.2</td>
<td>3.8</td>
<td>9.7</td>
<td>375</td>
</tr>
<tr>
<td>11</td>
<td>Aviator Xpro 0.35</td>
<td>Aviator Xpro 0.35</td>
<td>9.8</td>
<td>5.9</td>
<td>9.3</td>
<td>302</td>
</tr>
<tr>
<td>12</td>
<td>Adexar 1.25</td>
<td>Adexar 1.25</td>
<td>8.5</td>
<td>3.1</td>
<td>9.8</td>
<td>348</td>
</tr>
<tr>
<td>13</td>
<td>Adexar 0.94</td>
<td>Adexar 0.94</td>
<td>8.1</td>
<td>3.4</td>
<td>9.8</td>
<td>400</td>
</tr>
<tr>
<td>14</td>
<td>Adexar 0.62</td>
<td>Adexar 0.62</td>
<td>11.1</td>
<td>8.6</td>
<td>9.7</td>
<td>401</td>
</tr>
<tr>
<td>15</td>
<td>Aviator Xpro 0.35</td>
<td>Proline 0.2 + S.F. 0.3</td>
<td>9.0</td>
<td>2.7</td>
<td>9.5</td>
<td>329</td>
</tr>
</tbody>
</table>

| Mean | 4.0 | 5.3 | 9.6 |
| LSD (P<0.05) | 4.8 | 5.9 | 0.8 |
| CV% | 5.5 |

*Seguris Flexi (S.F.) alone is an experimental treatment only in order to assess sensitivity of Ramularia to SDHIs. SDHI fungicides should always be mixed with a fungicide with a different mode of action effective against the target disease. Note: Phoenix does not currently have a label claim for Ramularia.

What is the current situation with fungicide resistance?

Investigating fungicide resistance has become an increasingly important aspect of FAR’s work in the cropping sector. Since 2014 FAR have been co-funding a programme at Plant & Food Research that is monitoring any changes in the STB population that may reduce the effectiveness of SDHI and triazole fungicides against this disease. From 1 July 2018 a FAR led programme supported by the MPI Sustainable Farming Fund, has been setup to monitor Ramularia resistance.

Key points on fungicide resistance

- Monitoring of the New Zealand Ramularia population has detected isolates with reduced sensitivity to the SDHIs in lab studies. Field performance of the SDHIs against Ramularia has reduced. Further, interim results of isolates collected in the 2017 season indicate the proportion of insensitive isolates has increased to more than 80% of the pathogen population.
- Monitoring of the New Zealand Zymoseptoria pathogen population from 2014 to 2017 has not revealed reduced activity in the SDHIs (Seguris Flexi, Adexar, Aviator and Elatus Plus) against this disease. This is not the case in Europe, where SDHI resistance is evident in the Zymoseptoria pathogen population.
- Of the three fungicide modes of action we use regularly for cereal disease control; • Strobilurins e.g. Amistar are at the highest risk of pathogen resistance development. Septoria tritici biotch (STB) in wheat and Ramularia and powdery mildew in barley are already resistant to strobilurins in New Zealand, so strobilurin fungicides will be ineffective on these diseases.
- SDHI fungicides e.g. Aviator Xpro, are at moderate-high risk of resistance development. So far in New Zealand Ramularia is less sensitive to these products. In Europe, Ramularia, net blotch and Zymoseptoria pathogens are developing resistance to the SDHIs.
- Triazoles are at low-moderate risk of pathogen resistance development. Resistance to the triazoles develops slowly over a number of years with multiple mutations. The Zymoseptoria pathogen is showing a shift in sensitivity to triazoles e.g. epoxiconazole (e.g. Opus) in New Zealand.

Overall, FAR trial work still shows the more effective triazoles have reasonable activity (75-90% control) against STB, but that prothioconazole is superior to epoxiconazole.

- Not all pathogens present the same risk of developing successful resistance mutations to fungicide groups. For example the mutation which renders the STB pathogen resistant to strobilurins is lethal to cereal rust pathogens, meaning that strobilurins such as Amistar and Comet are still very effective against rust pathogens.

SDHI testing in New Zealand

Ramularia

Leaves infected with Ramularia were collected from barley crops throughout New Zealand in 2016. Laboratory tests carried out by Plant & Food Research in spring 2017 identified Ramularia isolates sampled from Canterbury, Southland and Otago with reduced sensitivity to the SDHI fungicides. The presence of three mutations which impact the performance of the SDHI protein of the Ramularia pathogen. Isolates with these mutations required more than 0.5 ppm bixafen to inhibit growth by 50%, compared with less than 0.005 ppm bixafen to control the wild-type isolates. This means that the isolates were 100 x less sensitive than the wild type i.e. they had a resistance factor of 100. A similar result would be expected with other SDHI fungicides, as they are cross resistant.

As this publication goes to print, microplate assays of Ramularia isolates collected from crops in Canterbury, Manawatu and Southland in 2017-18 are nearly complete. Interim results indicate that there has been a further shift with more than 80% of isolates collected insensitive to SDHI fungicides.

Another mutation, C-897S, was also found, and is associated with a low-to-moderate reduction in sensitivity to SDHI fungicides.

32 Key fungicide timings for disease management strategies in spring sown barley
Results from fungicide trials in barley crops in 2017 support the laboratory findings that the SDHIs are not as effective against the Ramularia population as they used to be.

**Triazole testing in New Zealand**

Changes in sensitivity of Zymoseptoria to triazole fungicides is a gradual, stepwise process. A shift in sensitivity of isolates collected in 2017 to prothioconazole was recently observed, with a change in average EC₅₀ value from 0.021 to 0.036 µg mL⁻¹. Figure 13 illustrates the shift in EC₅₀ values between 2016 and 2017. Due to the differences in activity of each azole chemistry, continuing to utilise a diverse selection of triazoles in the field is important to manage resistance development in this pathogen. Gene sequencing of STB isolates showing higher than usual prothioconazole EC₅₀ values (>0.1 µg mL⁻¹) is underway, to determine if there have been changes in the STB mutations present in the New Zealand population.

**Field performance of triazoles**

A trial was run at Methven in 2016 to compare the efficacy of a range of triazole fungicides on STB. This trial is experimental only as it includes 4 applications of azole products only. There were two main diseases in the trial, STB and leaf rust. Triazole performance against STB was similar to previous seasons. The Proline 0.8 L/ha x 4 applications programme gave 92% control of STB and the highest yield increase over the nil fungicide treatment of 4.4 t/ha, Opus 1.0 L/ha gave 85% control and a 4.1 t/ha yield increase and Folicur 0.44 L/ha performed poorly against STB with only 33% control. Bolide 1.25 L/ha (mix of epoxiconazole and the group 3 fungicide prochloraz) gave similar control to Opus and Proline. In earlier trials either mixing or alternating Proline and Opus, gave a similar margin to Opus alone, and would be regarded as better resistance management than repeating the same triazole.

**Figure 13.** Comparison of percentage frequency distribution of EC₅₀ (µg mL⁻¹) values of Zymoseptoria tritici field isolates tested from 2015–2017 against prothioconazole. EC₅₀ is the concentration of fungicide that inhibits growth of the isolate by 50%.

**Figure 14.** STB infection levels (GS75) and subsequent yield response from triazole only programmes – cv Starfire, Methven, 2016. Multiple applications of triazoles alone were used in this trial for experimental purposes only.
Case for alternating and mixing triazole fungicides
FAR research trials have shown margin advantages to mixing and alternating triazoles when less expensive generic triazoles, such as epoxiconazole, are used, compared with using solely prothioconazole. This has been noted when epoxiconazole has been alternated or mixed with prothioconazole, in terms of giving similar disease control to a higher number of prothioconazole sprays, but with reduced cost.

Ramularia
Laboratory tests carried out by Plant & Food Research in spring 2017 show that Ramularia is sensitive to, and well controlled by, prothioconazole. So, at present, this fungicide remains a key ingredient for barley disease management strategies.

What can growers do to protect fungicides?

Integrated Disease Management
• Use all the tools in the toolbox to control disease, not just fungicides.
• Look to grow more disease resistant cultivars.
• Where appropriate, sow more resistant cultivars in the early sowing windows (when disease pressure is typically higher) and less resistant cultivars later.
• Consider stubble management and controlling the green bridge between crops and grazing pre GS30.

Clearly, the best way to avoid fungicide resistance is not to use fungicides! However in an Integrated Disease Management (IDM) approach, when a cultivar’s genetic resistance breaks down or is incomplete, it is imperative that growers have other ways of controlling the disease, such as fungicides. At present, few, if any, cereal cultivars offer complete resistance to all the principal diseases. Minimising the number of fungicide applications of a particular mode of action in any one growing season and mixing fungicides of different modes of action active against the disease are the principal means of reducing the selection pressure and preventing resistance development.

Key points on anti-resistance measures when using fungicides
• Minimise the number of fungicide applications in a season (a maximum of two strobilurins and two SDHIs in a season) and use these active ingredients in mixtures with triazole fungicides (different mode of action) at effective rates.
• Disease management decisions on fungicide rate should be based on effective control of the target pathogen. The application rate should not be seen as the core resistance management consideration, and should never prejudice effective control of the pathogen. In many cases, the full label rate is the most appropriate rate for control, however, if the grower has adopted a more resistant cultivar or disease pressure is less severe, then it may be appropriate to apply a lower rate of the fungicide as long as effective control of the pathogen is achieved, since it will not increase resistance risk.
• Triazoles used alone are best reserved for less important spray timings and situations where disease pressure is low. Consider mixing the multisite (controls the pathogen at more than one site of activity) protectant Phoenix to the triazole where STB is the main disease.
• Depending on the products used, there are advantages in margin over chemical cost from both mixing or alternating triazole fungicides, even though they are from the same family of fungicides.
• With dryland crops, particularly where leaf rust or Ramularia are not considered a risk, later fungicide sprays could be omitted rather than using lower rates.

Chemical guide

<table>
<thead>
<tr>
<th>Chemical trademarks</th>
<th>Label rate for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Barley (L/ha)</td>
</tr>
<tr>
<td>Acuro 125 SC is a registered trademark of Adria Crop Protection</td>
<td>0.5</td>
</tr>
<tr>
<td>Adexar is a registered trademark of BASF (NZ) Ltd</td>
<td>1.0</td>
</tr>
<tr>
<td>AgPro Epoxiconazole is a registered trademark of AGPRO NZ Ltd</td>
<td>1.25</td>
</tr>
<tr>
<td>AgPro Thiazole is a registered trademark of AGPRO NZ Ltd</td>
<td>1.0</td>
</tr>
<tr>
<td>Amistar is a registered trademark of Syngenta Crop Protection</td>
<td>0.4 – 0.8</td>
</tr>
<tr>
<td>Aviator Xpro is a registered trademark of Bayer Crop Science</td>
<td>0.70 – 1.0</td>
</tr>
<tr>
<td>Bolide is a registered trademark of Adama New Zealand</td>
<td>2.0</td>
</tr>
<tr>
<td>Comet is a registered trademark of BASF (NZ) Ltd</td>
<td>0.8</td>
</tr>
<tr>
<td>Elatus Plus is a registered trademark of Syngenta Crop Protection</td>
<td>0.75</td>
</tr>
<tr>
<td>Epirix 125 is a registered trademark of AgriSource Ltd</td>
<td>1.0</td>
</tr>
<tr>
<td>Folicur is a registered trademark of Bayer Crop Science</td>
<td>0.44</td>
</tr>
<tr>
<td>Fortify 125 is a registered trademark of Ravensdown Fertiliser Co-Operative Ltd</td>
<td>1.0</td>
</tr>
<tr>
<td>Kestrel is a registered trademark of Bayer Crop Science</td>
<td>1.0</td>
</tr>
<tr>
<td>Opus is a registered trademark of BASF (NZ) Ltd</td>
<td>1.0</td>
</tr>
<tr>
<td>Pilot is a registered trademark of Orion Agriscience</td>
<td>0.4 – 0.8</td>
</tr>
<tr>
<td>Phoenix is a registered trademark of Adama New Zealand</td>
<td>1.5</td>
</tr>
<tr>
<td>Proline is a registered trademark of Bayer Crop Science</td>
<td>0.4 – 0.8</td>
</tr>
<tr>
<td>Prosaro is a registered trademark of Bayer Crop Science</td>
<td>1.0</td>
</tr>
<tr>
<td>Protek is a registered trademark of Lonza NZ Ltd</td>
<td>0.3 – 0.5</td>
</tr>
<tr>
<td>Seguris Flexi is a registered trademark of Syngenta Crop Protection</td>
<td>0.8</td>
</tr>
<tr>
<td>Stellar is a registered trademark of Adama New Zealand</td>
<td>1.0</td>
</tr>
<tr>
<td>Systiva is a registered trademark of BASF (NZ) Ltd</td>
<td>0.75 – 1.25 l/t seed</td>
</tr>
<tr>
<td>Tilt EC is a registered trademark of Syngenta Crop Protection</td>
<td>0.5</td>
</tr>
<tr>
<td>Vitallis is a registered trademark of Adria Crop Protection</td>
<td>0.4 – 0.8</td>
</tr>
</tbody>
</table>