EYESPOT FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

SOUTHERN
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Knowing the risk prior to sowing is the key to eyespot management

KEY POINTS

- **TEST.** Know the eyespot inoculum levels in your paddocks. Determine the levels using a pre-sowing PREDICTA® B soil test. Cereal residues must be included in the sample even if residues are scattered and fragmentary
- **INSPECT.** After head emergence, check for eye-like lesions (Figure 1) low on stems, particularly where stems have lodged. Peel back leaf sheaths to see lesions clearly. Do not rely on lodging alone as an indicator of eyespot presence
- **VARIETY CHOICE.** Select more resistant cereal types and varieties to help reduce yield losses and lodging. To decrease lodging risk, avoid varieties with weak stem strength
- **ROTATION.** A grass-free break from cereals will reduce inoculum, but if levels are high it will take more than a one-year break to reduce inoculum to a low level
- **PADDOCK MANAGEMENT.** Early sown crops are most at risk from eyespot, but do not delay sowing to reduce that risk. High humidity at the base of the plants increases the risk of infection. This means that factors such as bulky early crop growth, weeds and large stubble loads can contribute to higher infection rates and increased yield loss
- **FUNGICIDES.** Where inoculum levels are medium or high, apply prior to canopy closure. Correct timing and method of application are critical for best efficacy and reliability

PHOTO: MARGARET EVANS, SARDI

FIGURE 1 The eye-shaped lesions of eyespot on the base of cereal stems.

Summary

Eyespot caused by *Oculimacula yallundae* is a stubble-borne fungal disease of cereals that occurs in areas with prolonged cool and damp conditions early in the growing season. The eye-like lesions (Figure 1) caused by eyespot weaken plant stems and lodging often occurs as a result, with consequent harvest difficulties.

Eyespot is most common in South Australia (Figure 2) and can cause yield losses of 20 to 40 per cent in susceptible wheat varieties. Lesions alone can cause yield losses (Figure 3), but losses will be greatest where lodging occurs. In addition to lodging, eyespot can cause tiller death, whiteheads and reduced grain size.

To manage eyespot effectively, it is critical that paddocks with high levels of inoculum are identified prior to sowing a susceptible crop. A PREDICTA® B soil test can be used for this purpose or all cereal crops can be monitored for eyespot lesions visually.

In paddocks with high levels of eyespot inoculum, a break from cereals should be considered or a more resistant cereal type or variety used in combination with a fungicide applied prior to canopy closure.

Symptoms

The most obvious paddock symptom of eyespot is lodging where stems fall in all directions (Figures 4 and 5). Patches of lodging can be small or

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very large and may occur at any time from head emergence through to grain maturity. Lodging can be caused by other issues such as wind or insect damage. To confirm that lodging is due to eyespot, inspect the point of breakage for an eye-shaped lesion. As lodging does not always occur, even where eyespot is present at levels that cause yield loss, paddocks that have an eyespot problem can remain undetected for many years. For more details on eyespot symptoms, see Box 1.

Seasonal conditions

Spore production is favoured by lower temperatures (less than about 20°C) and rain is required to splash the spores onto plant bases. Infection of leaf sheaths by the spores requires an extended period of high humidity (a minimum of two to three days) at the plant bases.

Eyespot expression will be worst where crops establish early and there are rainfall events of about three millimetres per day or more over several days during early to mid-tillering. Multiple infection events can occur in one season. These events result from spores produced on infested stubble, not from spores produced by lesions on the current crop. The earlier the infection occurs, the higher the yield losses are likely to be.

Factors that encourage high humidity at plant bases, for example high stubble loads, narrow row widths and weeds, may result in higher than expected infection rates under low rainfall conditions. Waterlogging, including flooding (most likely in low-lying areas of paddocks), will also exacerbate eyespot issues. Drying winds can reduce humidity at the base of the plants and may reduce the risk of infection, particularly in young crops.

Life cycle

The eyespot fungus can survive in plant residues for three years or longer. When conditions are favourable, millions of spores (conidia) can be produced on infested stubble. These spores are spread short distances by rain-splash during autumn and winter and cause lesions low on stems or even below the soil surface (Figure 7).

Spores germinate and infect outer leaf sheaths when moisture levels remain high for extended periods. The fungus moves through successive leaf sheaths and then the stem, destroying structural and water and nutrient-carrying tissue as it does so. After infection, it can take six to eight weeks before lesions are visible on stems. By then, it will be too late to implement management strategies to avoid yield losses.

Airborne spores (ascospores) are also produced, but in much lower numbers. These spores do not contribute significantly to yield loss but they can spread over long distances, which helps to explain the disease's distribution.

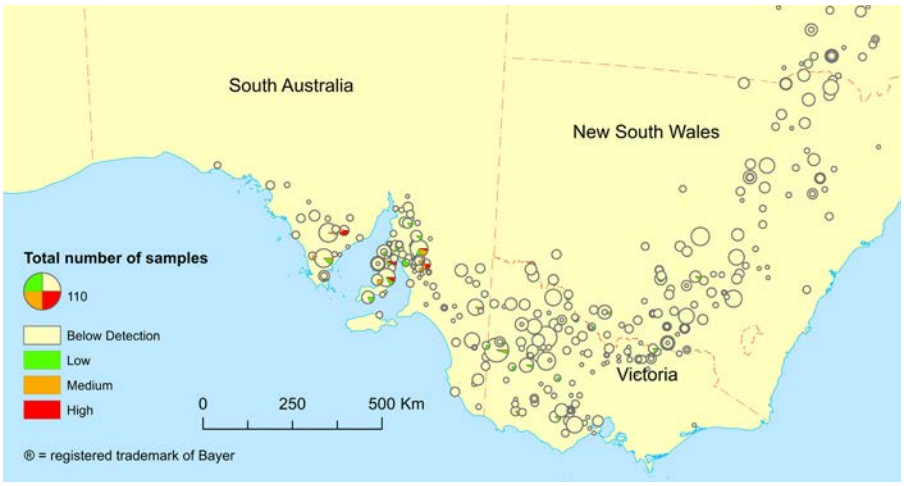
BOX 1: IDENTIFYING EYESPOT

Eyespot takes its name from the eye-shaped lesions (Figure 1) that develop on stem bases. After infection, lesions develop very slowly and are not easy to see until stem elongation. Lesions weaken stems, which often lodge at the mid-point of the lesions (Figures 1 and 6). Individual stems or areas of crop, large or small, may lodge (Figures 4 and 5). Affected stems usually fall randomly but can fall in one direction if there is a strong wind event. Sharp eyespot caused by *Rhizoctonia cerealis* also produces lesions similar to those of true eyespot, so correct identification of the disease is important.

To see eyespot lesions clearly, collect plants after stem elongation/head emergence, targeting paddock areas that are low-lying or where lodging is visible. Strip back the leaf sheaths to examine the stem bases. Leaf sheaths can be discoloured and difficult to remove if there is significant eyespot expression.

Lesions can be described as elliptical, lens or eye-shaped, and will have a border ranging from honey to dark brown, with a lighter centre. As the lesion matures, the lighter centre will develop black spots commonly called 'charcoal' or 'scurf' and the stem and inside of the leaf sheaths may appear to be affected with sooty mould. Fungal hyphae are very dense in these black spots, forming structures that will produce spores during the next season.

A single eyespot lesion can surround the entire stem and be up to four centimetres. Multiple lesions can also be present on a stem and where these multiple lesions coalesce, the typical eye-shaped lesion can be obscured, leading to a general discolouration of stems (Figure 6). This symptom is common where significant waterlogging or flooding occurs; for example, in high-rainfall zones or in seasons where there is unusually high rainfall early in the season.



SOURCE: SARDI, PREDICTA® B

FIGURE 2 Distribution of eyespot (2017-2019 information as provided by the PREDICTA® B service). Note that South Australia has the most paddocks affected by eyespot and that the eyespot population densities are also highest in SA. Although eyespot DNA has been detected at low levels in some Western Australian paddocks, no symptom expression has been identified.

BOX 2: ASSESSING EYESPOT INOCULUM LEVELS

SOIL SAMPLING

PREDICTA® B is a DNA-based soil test that detects inoculum levels for many cereal pathogens, including the eyespot pathogen.

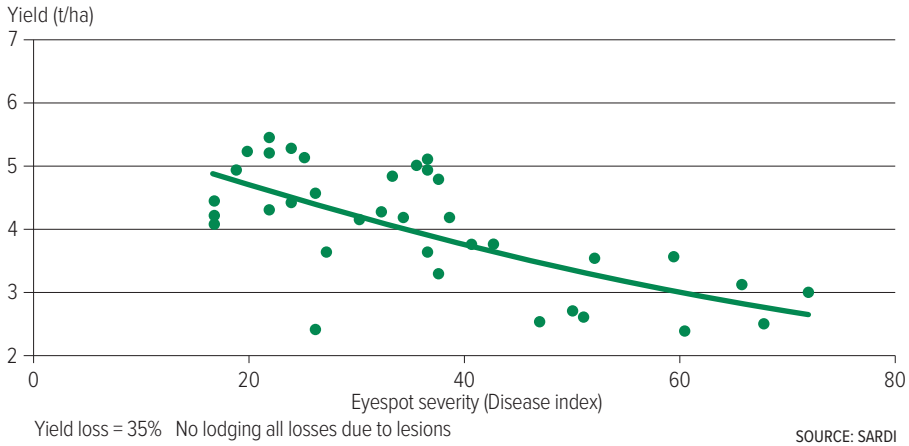
- It is commercially available to growers from accredited agronomists through the South Australian Research and Development Institute (SARDI).
- The test identifies the levels of soil-borne pathogens prior to sowing using a dedicated sampling strategy – scroll down to the sampling section at https://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b. Do not use the sampling strategy for assessing soil nutrients.
- Soil cores should target rows from the previous winter cereal crop and any stubble fragments must be retained.
- Stubble pieces from previous cereal crops must be added to the soil sample to ensure eyespot inoculum is detected if it is present. This may mean searching for small fragments of stubble to add to the sample.

STEM LESION ASSESSMENT

Check cereal crops for eyespot lesions on stem bases between head emergence and the end of grain fill. Stems can be collected later than this, but seeing the lesions will be more difficult as the stems lose their green colour. If the stems are collected after harvest, weather damage may obscure symptoms.

Walk (or drive if the sample is taken after harvest) in a large 'W' pattern, collecting five stems at each of 10 locations. Separate the stems into healthy and diseased piles. Count the number of diseased stems. As a rule of thumb, if around 10 or more stems have eyespot lesions, the next susceptible cereal crop will be at risk of yield loss.

FIGURE 3 Effects of eyespot lesions on yield of the bread wheat cultivar Mace$^{\phi}$ (susceptible) at Tarlee in Mid North South Australia, 2014. Trial characteristics – no lodging; high levels of eyespot inoculum; early sown; high plant density; high nitrogen application at sowing.



Yield loss = 35% No lodging all losses due to lesions

SOURCE: SARDI

TABLE 1 Effects of varietal resistance on yield loss at Tarlee in Mid North South Australia, 2016. Susceptibility to eyespot – Mace$^{\phi}$ susceptible (S); Trojan$^{\phi}$ moderately susceptible (MS). Trial characteristics – a very wet season; lodging occurred in both varieties; high levels of eyespot inoculum; early sown; high plant density; high nitrogen application at sowing.

	Untreated yield (t/ha)	Yield losses	
		%	t/ha
Mace$^{\phi}$ (S)	3.81	23	1.13
Trojan$^{\phi}$ (MS)	6.00	7	0.43

SOURCE: SARDI

Management

1. Identify paddocks with high inoculum levels.
2. Minimise losses when cereals are grown.
3. Reduce eyespot inoculum.

1 Identifying paddocks with high inoculum levels

Pre-sowing paddock assessment

Eyespot does not move readily between paddocks, so it is a paddock-by-paddock, not a locality-wide, disease. It is critical that paddocks with eyespot inoculum present are identified before sowing susceptible cereals. A pre-sowing PREDICTA® B soil test can be used to quantify eyespot inoculum levels directly. Alternatively, systematic visual inspections of cereal stem bases (symptoms on oats can be difficult to detect) can be used to assess the likely risk for the next cereal crop.

As eyespot is quite unevenly distributed in paddocks and is closely associated with stubble (Figure 8), it is critical that sampling is undertaken correctly to identify paddocks with high inoculum levels. For more information on assessing eyespot inoculum levels, see Box 2.

2 Minimising losses when cereals are grown

Cereal type and variety choice

Internationally, disease-resistant varieties are the most economic and reliable control for eyespot. There are no major eyespot resistance genes in current Australian cereal varieties, although some commercial varieties exhibit limited but useful levels of resistance to eyespot.

Barley, durum wheat and long season bread wheat varieties are generally rated as moderately susceptible (MS). Most main season wheat varieties are susceptible, with some being MS. Current levels of resistance in commercial bread wheat varieties reduce yield losses due to eyespot (Table 1) and limited trial data suggest that varietal resistance also plays a role in improving fungicide efficacy where disease pressure is high. Information on variety resistance can be found in the latest South Australian Cereal Variety Disease Guide.

Avoid varieties with poor straw strength as this trait makes lodging more likely, even in varieties with better eyespot resistance.

PHOTO: MARGARET EVANS, SARDI

FIGURE 4 Stems that lodge due to eyespot fall in all directions and layer themselves in such a way that harvest is difficult. Note that some stems do not lodge.

PHOTO: RANDALL WILKSCH

FIGURE 5 Typical lodging patterns seen at harvest.

Fungicides

In-crop fungicide application is needed for eyespot management. Applying fungicide to seed, fertiliser or as a liquid stream in-furrow is not effective with current chemistries. Fungicide application must occur before canopy closure as it is critical that the fungicide reaches the lower stems where infection occurs.

The recommended timing of fungicide application for eyespot management is at early stem elongation (GS30/31) – before canopy closure. Application at tillering (when herbicides are applied) can be very effective, but results can be inconsistent. If there are more infection events after the tillering fungicide application has reached the end of its effectiveness, there can still be significant yield loss. If weather conditions suitable for eyespot infection do occur in that period, it may mean a second application at GS30/31 will be needed.

Do not reduce the recommended application rate as this may result in ineffective rates reaching the stem base due to interception by leaves, stubble, weeds, and so on. Set the spray boom height to target the plant base, use a high water rate, lower than normal speed during application and ensure spray nozzles and pressures are correct for maximum efficacy of application.

The use of fungicides for eyespot management should be considered together with fungicide applications for other diseases such as septoria tritici blotch, powdery mildew and rusts. Regardless of the disease, the same fungicide should not be used twice in the same season and every effort should be taken to use fungicide mixtures and/or rotate fungicides from different classes. Consideration should also be taken where some loss of efficacy of a fungicide class has already been reported to have occurred, so that selection for that resistance is reduced.

Until 2018 no fungicides were registered for eyespot management in cereals in Australia. Aviator® Xpro® at 500 millilitres per hectare (Bayer) is now registered for that purpose. This registration is a direct result of GRDC-invested research.

Stubble

High stubble loads can provide a very humid environment at the base of new crop plants and if the stubble is heavily infested, this may favour infection with eyespot. Even in low rainfall years, such situations may result in an unexpectedly high incidence of eyespot lesions on stems.

Nitrogen application

Nitrogen application will not increase the amount of eyespot directly but can increase plant growth and lead to the high humidity that favours eyespot infection.

Seeding rates and row widths

High seeding rates and narrow row widths tend to create a denser canopy earlier in the season. This may slightly increase the risk of infection by eyespot and reduce fungicide penetration to the base of the cereal plants, so reducing fungicide efficacy.

Time of sowing

Early sowing can increase the risk of eyespot, but the reduced yield associated with delayed sowing may be greater than the loss from eyespot. Consider the following strategies to reduce the risk of yield loss in early sown crops: use a more resistant cereal type (for example, barley) or variety (for example, Trojan); ensure fungicide application is undertaken in a timely manner. Also consider sowing the worst affected paddocks later than usual.

Weed management

High weed numbers (for example, where herbicide resistance is a problem) increase humidity at the base of the crop, therefore increasing the risk of infection by eyespot. The presence of weeds may also make it more difficult to get good spray penetration to the base of the cereal plants, so reducing fungicide efficacy.

Harvest

Lodging due to eyespot causes stems to fall in all directions, reducing harvest speed and efficiency. Consider placing badly lodged paddocks last in the harvest order to ensure crops without this problem are harvested in a timely manner, without weather damage.

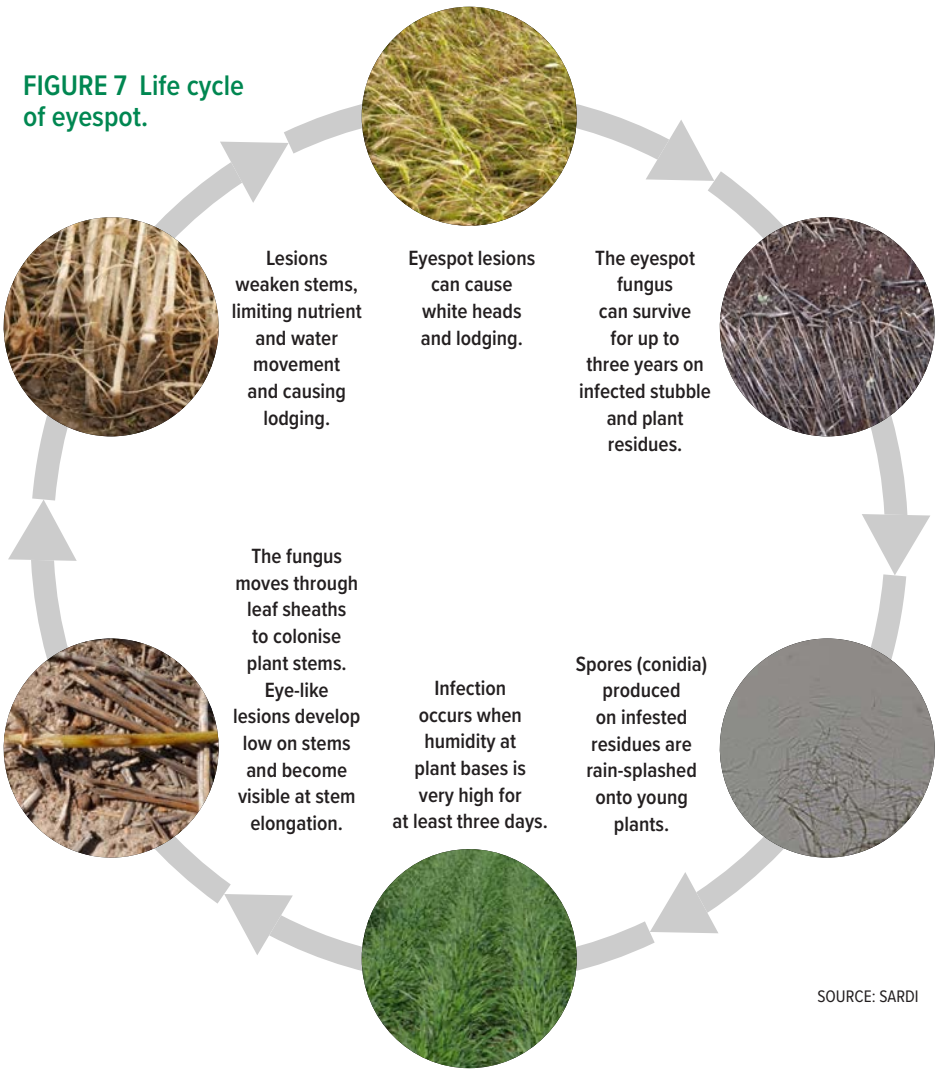
3 Reducing eyespot inoculum

Rotation

The level of eyespot inoculum will be reduced with each grass-free year out of cereal. The rate at which reduction occurs will depend on the rainfall during the break from cereal. If inoculum levels are high, it can take at least a two-year break from cereal to reduce the inoculum to a low level. PREDICTA® B testing is the only accurate way to assess the eyespot risk after a break and prior to sowing a cereal.

The effectiveness of different break types at reducing inoculum is unknown at present, but the range in effectiveness will likely be limited. Select the break that best suits the management and economics for the paddock under consideration.

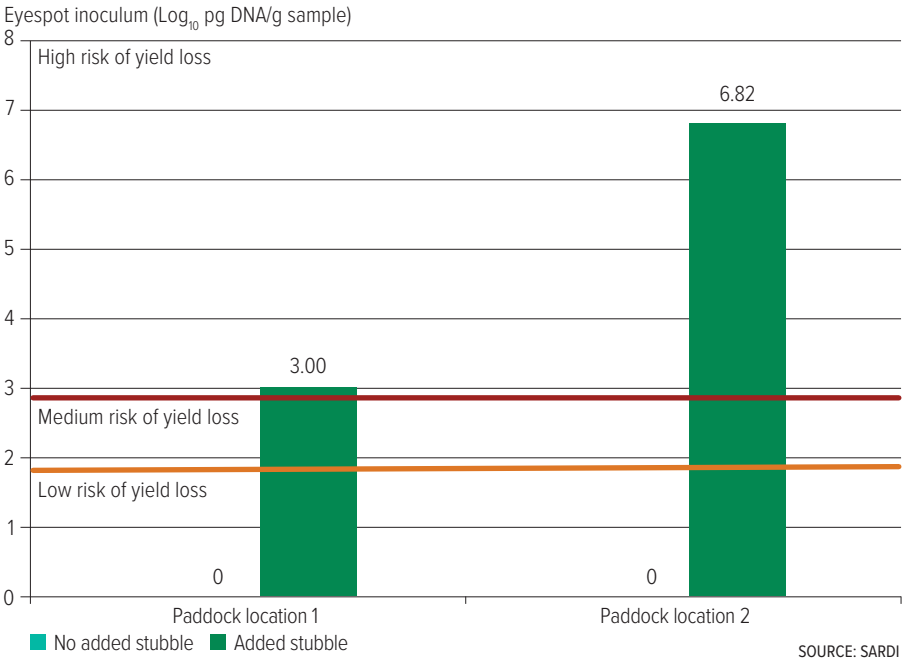
FIGURE 7 Life cycle of eyespot.



SOURCE: SARDI

PHOTO: MARGARET EVANS, SARDI

FIGURE 6 Multiple eyespot lesions that have coalesced, leading to a general discolouration of stem bases. Note the 'folding' on the middle stem due to weakening of the stem wall – this leads to the characteristic eyespot-caused lodging patterns.



SOURCE: SARDI

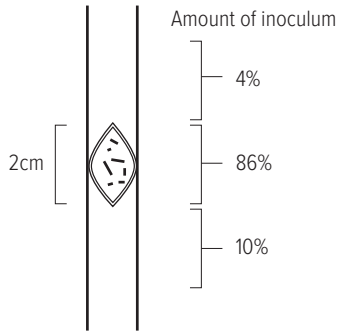
FIGURE 8 Using the correct soil sampling protocol is critical to determine the risk of yield loss from eyespot. This is clearly demonstrated in results from PREDICTA® B samples taken in the same paddock to assess eyespot risk levels at two locations approximately 500m apart. Without stubble it appears there is no eyespot inoculum detected (0 DNA detected). With added stubble, it is clear eyespot inoculum is present – at a low (paddock location 1) or high (paddock location 2) risk level. Also note the variability in eyespot inoculum between the two paddock locations.

Stubble management

Burning, working or burying infested stubble will reduce but not eliminate eyespot inoculum. These operations may assist in managing eyespot at a low level as part of a medium to long-term management strategy. This is due to the following characteristics of eyespot:

1. Many eyespot lesions are protected from burning as they are close to or at the base of stems or are below the soil surface.
2. Eyespot lesions produce millions of spores and even a small amount of inoculum will quickly build to a point where crop damage occurs.
3. The DNA of this pathogen is mainly associated with the lesions but is also present for at least 2cm below the lesion (Figure 9).

If the decision is made to burn or work stubble, including discing it, this should be done immediately before a break from cereal as this will ensure the greatest breakdown of inoculum. Before burning or working infested stubble, consider the implications for nutrient loss, erosion and degradation of soil structure.



SOURCE: MARGARET EVANS, SARDI

FIGURE 9 Eyespot DNA distribution in infected stubble of a susceptible bread wheat.

FREQUENTLY ASKED QUESTIONS

Is there any variety resistance to eyespot?

Yes, but it is limited. Barley, durum wheat and long season bread wheat varieties are usually moderately susceptible or better, with only occasional varieties rating as susceptible. Most main season winter wheat varieties are susceptible, with some being moderately susceptible. Avoid varieties with poor straw strength as this trait makes lodging more likely even in varieties with better eyespot resistance. Information on variety resistance can be found in the latest South Australian *Cereal Variety Disease Guide*.

Can I use a fungicide for eyespot management?

Yes, use an in-crop spray application for eyespot management. Fungicide application must occur before canopy closure (early stem elongation – GS30/31) as it is critical that the fungicide reaches the lesions on the lower stems. Applying a fungicide at tillering can also be effective but yield improvements can be unpredictable if infection events occur between tillering and canopy closure.

Will sowing on the inter-row reduce yield loss due to eyespot?

No. The spores of this disease are spread by rain splash and the distance they move is sufficient to infect plants sown on the inter-row.

Will burning or cultivating remove eyespot?

Burning, working or burying infested stubble will reduce but not eliminate eyespot. These operations may assist in managing eyespot at a low level as part of a medium to long-term management strategy, particularly if undertaken at the start of a break from cereal. Before burning or working infested stubble, consider the implications for nutrient loss, erosion and degradation of soil structure.

Where do I take PREDICTA® B soil cores if no old cereal rows are visible?

Follow the recommended sampling protocol but take the samples at random. In these circumstances it is critical that cereal residues are added to the sample even if the pieces of stubble are very small. On the sample bag, record the fact you did not sample on-row (and whether added stubble).

USEFUL RESOURCES

Cereal variety disease guide – SARDI

Managing eyespot in winter wheat – Department of Environment, Food and Rural Affairs (UK)

Eyespot – Cereal Disease Encyclopedia – Agriculture and Horticulture Development Board (UK)

GRDC PROJECT CODE

DAS00139 – Improved disease management in SA field crops through surveillance, diagnostics and epidemiology knowledge

DAS1807-005BLX – Managing eyespot in intensive cereal, stubble retention farming systems in SA

DAS00109 – National Variety Trial

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