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WHEAT

SECTION 10

PLANT GROWTH REGULATORS AND CANOPY MANAGEMENT

WHAT IS CANOPY MANAGEMENT? | KEY CEREAL GROWTH STAGES FOR
DISEASE CONTROL AND CANOPY MANAGEMENT

SECTION 10

Plant growth regulators and canopy management

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10.1 What is canopy management?

Canopy management deals with the green surface area of the crop canopy in order to optimise crop yield and inputs. It is based on the premise that the crop's canopy size and duration determine its photosynthetic capacity and therefore its overall grain productivity.

Adopting canopy management principles and avoiding excessively vegetative crops may enable growers to achieve a better match of canopy size with yield potential as defined by the available water. Other than sowing date, plant population is a starting point for the grower to influence the size and duration of the crop canopy.¹

The concept of canopy management was primarily developed in Europe and New Zealand—both distinct production environments from those typically found in most grain-producing regions of Australia and especially the southern grains region.

Canopy management includes a range of crop-management tools for crop growth and development, to maintain canopy size and duration and thereby optimise photosynthetic capacity and grain production. One of the main tools for growers to manage the crop canopy is the rate and timing of applied fertiliser nitrogen (N).

The main difference between canopy management and previous N-topdressing research is that all or part of the N input is tactically delayed until later in the growing season. This delay tends to reduce early crop canopy size but the canopy is maintained for longer, as measured by green leaf retention, during the grain-filling period.²

10.1.1 Canopy management in a nutshell

Select a target head density for your environment; 350–400 heads/m² should be sufficient to achieve optimum yield, even for yield potential of 4–5t/ha.

Adjust canopy management based on paddock nutrition, history and seeding time to achieve target head density.

Established plant populations for wheat between 75 and 250 plants/m² would cover most scenarios:

- Use the lower end of range (75–100 plants/m²) for earlier sowings–high fertility and/or environments with low yield potential and low rainfall.
- Use the higher end of the range (150–250 plants/m²) for later sowings, lower fertility situations and/or higher rainfall regions.

During stem elongation (Zadoks growth stages GS30–39), provide the crop with

¹ N Poole (2005) Cereal growth stages. GRDC, <http://www.grdc.com.au/uploads/documents/GRDC%20Cereal%20Growth%20Stages%20Guide1.pdf>

² G McMullen (2009) Canopy management in the northern grains region—the research view. Northern Grower Alliance, Consultants Corner, Australian Grain, July 2009, <http://www.nga.org.au/results-and-publications/download/31/australian-grain-articles/general-1/canopy-management-tactical-nitrogen-in-winter-cereals-july-2009-.pdf>

i More information

[GRDC: Advancing the management of crop canopies](#)

[GRDC/Grassroots Agronomy: Assessing canopy management in CTF systems](#)

[GRDC Ground Cover: New tool lifts canopy management potential](#)

[GRDC: Disease management and crop canopies](#)

[NSW DPI: Durum wheat and barley canopy management](#)

necessary nutrition (particularly N at GS30–33 pseudostem erect–third node), matched to water supply and fungicides to:

- maximise potential grain size and grain number per head;
- maximise transpiration efficiency;
- ensure complete radiation interception from when the flag leaf has emerged (GS39); and
- keep the canopy green for as long as possible following anthesis.

Keeping tiller numbers just high enough to achieve potential yield will help to preserve water for filling grain and increase the proportion of water-soluble carbohydrates (WSC).

The timing of the applied N during the GS30–33 window can be adjusted to take account of target head number. Earlier applications in the window (GS30) can be employed where tiller numbers and soil N seem deficient for the desired head number. Conversely, where tiller numbers are high and crops are still regarded as too thick, N can be delayed further until the second or third node (GS32–33), which will result in fewer tillers surviving to produce a head.³

10.2 Key cereal growth stages for disease control and canopy management

10.2.1 Why is growth stage important in making fungicide decisions?

Five to 10 years ago, it was common to make decisions on fungicide applications for stripe rust based on thresholds of infection; these thresholds varied from 1% to 5% plants infected. However, growers and advisers found that, in the paddock, it was difficult to calculate whether this disease threshold had been reached, not least because of the sporadic nature of the initial foci of the disease. In addition, by the time growers realised that the threshold had been reached and carried out the spray operation, the crops were badly infected. When crops that are badly infected with stripe rust are treated with fungicides, the control is poor, because fungicides work better as protectants than as curatives.

Trials on stripe rust control (GRDC project SFS00006-2002–04) quickly established that foliar fungicide applications based on growth stages and applied between second node (GS32) and flag-leaf emergence (GS39), or at both stages, gave good control of the disease. These timings based on growth stage also gave growers the opportunity to plan disease management strategies for susceptible cultivars.⁴

10.2.2 Why do these growth-stage timings work for stripe rust control?

The primary reason for these timings working is that the growth stages between GS32 and GS39 coincide with the emergence of the top three leaves of the crop canopy in wheat, meaning that fungicides are applied to leaves shortly after they have emerged and before tissue becomes heavily infected. However, it is also important to note that foliar fungicide applied at first or second node (GS31–32) does not protect the flag leaf or the leaf beneath it (flag-1), because they have not emerged at this early stem-elongation growth stage. Equally, a foliar fungicide applied at flag leaf (GS39) may

³ N Poole, J Hunt (2014) Advancing the management of crop canopies. GRDC, <http://www.grdc.com.au/CanopyManagementGuide>

⁴ N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC Update Papers, 7 Sept. 2011, <http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/09/Cereal-growth-stages-and-decision-making-for-fungicide-timing>

protect the flag leaf but may be too late to protect flag-2, which emerged 2–3 weeks earlier.⁵

Yield loss to disease at different growth stages of disease onset

Although the use of growth-stage timings for fungicide applications can ensure that the top three leaves of the plant are adequately protected, the growth stage of disease onset dictates the level of economic response to a fungicide.

For the construction of the RustMan model, a simple relationship (derived from trial results) linked expected yield losses to the onset of stripe rust infection at particular growth stages (Table 1). This chart (although complicated by the presence of adult plant resistance, APR) remains a useful guide to potential yield loss with susceptible cultivars at different growth stages. It is based on the premise that yield loss to stripe rust is dependent on:

- the extent of stripe rust by early grain development
- the temperature during grainfill

Responses in Table 1 assume average temperatures; if hotter, the yield loss (due to disease) is less than expected.

Table 1: Expected yield losses (%) from stripe rust based on different growth stages of disease onset

Source: ICAN Cereal Foliar Disease Workshops for Advisers (G. Murray, July 2004)

Disease onset		Stripe rust reaction			
		Susceptible	Moderately susceptible	Moderately resistant	Resistant
GS31	First node	85	75	55	25
GS39	Flag leaf	75	45	15	5
GS45	Booting	65	25	7	2
GS49	1st awns	50	10	3	1
GS55	Mid-heading	40	5	2	0
GS65	Mid-flower	12	2	1	0

The complication with APR in Table 1 is that some cultivars such as Gregory^D (rated as resistant (R) to stripe rust) may display infection at GS30 but have never recorded losses as great as 25% with the current pathotypes. This is because APR switches on, ensuring that the disease does not develop in the resistant cultivar. Indeed, it is unlikely that a cultivar could be rated as resistant if it were subject to yield losses of 25% from an early infection. Hence, although the table is a useful guide to losses at particular growth stages for more susceptible cultivars, it is not useful for resistant cultivars.

Nonetheless, the data illustrate that the earlier the disease infects the crop, irrespective of variety resistance rating, the greater the expected loss.⁶

Influence of disease onset on optimum timings of fungicide spray for very susceptible cultivars

The time of disease onset of stripe rust not only influences the expected return from foliar fungicides, it also influences the timing of fungicide applications in order to achieve the greatest return.

What difference does it make to fungicide strategy if stripe rust infects the crop at GS32 (second node) v. GS39 (flag-leaf emergence on the main stem)?

⁵ N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC Update Papers, 7 Sept. 2011, <http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/09/Cereal-growth-stages-and-decision-making-for-fungicide-timing>

⁶ N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC Update Papers, 7 Sept. 2011, <http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/09/Cereal-growth-stages-and-decision-making-for-fungicide-timing>

This scenario was presented during research in Young, New South Wales, in 2004 with the very susceptible cultivar H45⁽¹⁾ (GRDC project SFS0006). Stripe rust arrived in the district at the beginning of October. One research trial had been established in early July, another in early June. The early-sown trial was infected at flag-leaf emergence (GS39, Figure 1), whereas the later sown trial was infected at second node (GS32). So, if one unit of fungicide were available, in this case Folicur[®] at 145 mL/ha, what would be the best use?

1. Spray both crops at flag leaf (GS39), this being the most cost-effective timing in most fungicide trials?
2. Split the fungicide between two timings, the first applied at GS32 and the other at GS39?
3. Treat the two crops with a different strategy?



Figure 1: Flag leaf. (Photo: Foundation of Arable Research)

The scenario and results are summarised as follows. For the July-sown crop

- yield potential 5 t/ha
- disease onset GS32 (second node)
- disease onset 1 October
- significant advantage to spraying twice
- 2.51 t/ha response to fungicide (52% loss)

For the June-sown crop

- yield potential 6 t/ha
- disease onset GS39 (flag leaf)
- disease onset 1 October
- no advantage to spraying twice
- 2.01 t/ha response to fungicide (34% loss)

Therefore, where stripe rust infection occurred at second node (GS32), the two-spray program was optimal, but with a later, flag-leaf infection, there was no advantage to applying fungicide twice. It is arguable that because fungicides are insurance inputs, the more consistent program of the two trials (in terms of disease control and yield response) was fungicide applied at both stages: second node (GS32) and flag leaf (GS39).

Would the result be the same if a cultivar had a low level of APR rather than a very susceptible rating for stripe rust?

Cultivar Wyalkatchem⁽¹⁾ is rated susceptible for stripe rust resistance but is acknowledged as having a low level of APR. In order to examine the interaction between cultivar resistance and environment, this cultivar (in 2008 and 2009) and Derrimut⁽¹⁾ (in

2010), with moderately susceptible rating to stripe rust, were sown at two sowing dates in the long-season, southern Victorian, high-rainfall zone at Inverleigh.

The questions to be answered were:

- Would later sowing exhibit greater disease resistance than earlier sowing, acknowledging that later sowings develop later in the season in a climate that is usually warming and therefore less conducive to stripe rust infection and fungicide response? Might it also encourage greater APR if the switches for APR genes were linked to temperature, a feature of APR expression in some cultivars?
- Alternatively, would stripe rust onset be the same for all crops in the district, later sown crops being infected at earlier growth stages and therefore giving greater response to fungicide?

Three years of data (2008–2010) revealed that Wyalkatchem⁽¹⁾ and Derrimut⁽¹⁾ had greater responses to fungicides when sown later (June) as opposed to early sowing (May), despite lower yield potential (Figure 2). During the 3 years, stripe rust infection was observed to arrive in the district. This resulted in the earlier sowings first showing infection at more advanced growth stages (relative to the later sowings), which was then less damaging to yield than experienced with later sowings. By contrast, later sowings first showed infection at a similar calendar date, but at earlier growth stages. The results illustrated that later June sowings of these susceptible cultivars gave greater response to fungicide application, because stripe rust infection occurred at earlier growth stages than for the earlier May sowings.

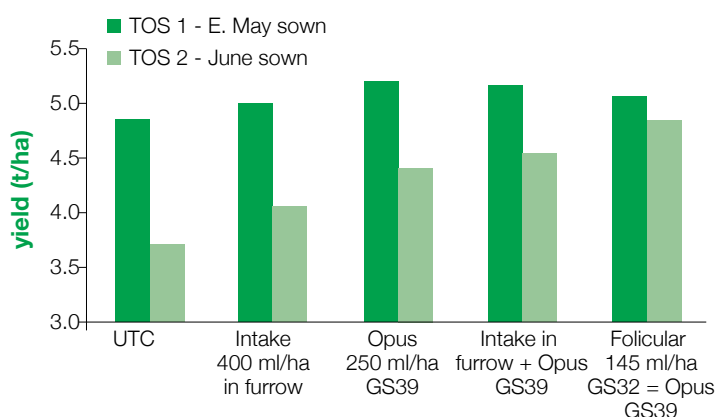
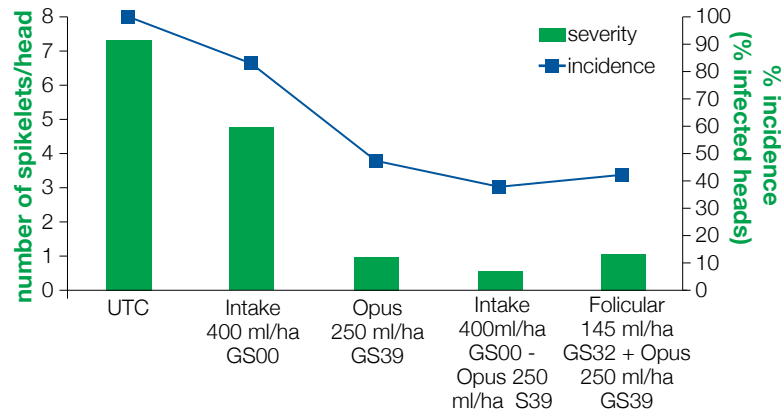


Figure 2: Influence of sowing date on yield response to fungicide application for stripe rust control in Wyalkatchem⁽¹⁾ and Derrimut⁽¹⁾, for two sowing dates at Inverleigh, southern Victoria, 2008–2010 (3-year yield mean).

The trial also indicated that although none of the fungicide treatments directly applied fungicide to the head, treatments that were effective in reducing stripe rust in the foliage were also effective in reducing head infection (Figure 3). In addition, earlier May sowings suffered later build-up of stripe rust infection and consequently had less head infection.⁷

⁷ N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC Update Papers, 7 Sept. 2011, <http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/09/Cereal-growth-stages-and-decision-making-for-fungicide-timing>



fungicide treatment
LSD (5%) severity - spikelets incidence - 35%

Figure 3: Influence of fungicide treatment for control of disease in the foliage and its subsequent effect on infection in the head, June-sown Derrimut⁽¹⁾, at Inverleigh, southern Victoria, 2010. ⁸

To hear Nick Poole discuss canopy management, visit: [GRDC Driving Agronomy – Disease management and crop canopies](#).

For more information on registered plant growth regulators, visit [Australian Pesticides and Veterinary Medicines Authority](#).

⁸ N Poole (2011) Cereal growth stages and decision making for fungicide timing. GRDC Update Papers, 7 Sept. 2011, <http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/09/Cereal-growth-stages-and-decision-making-for-fungicide-timing>