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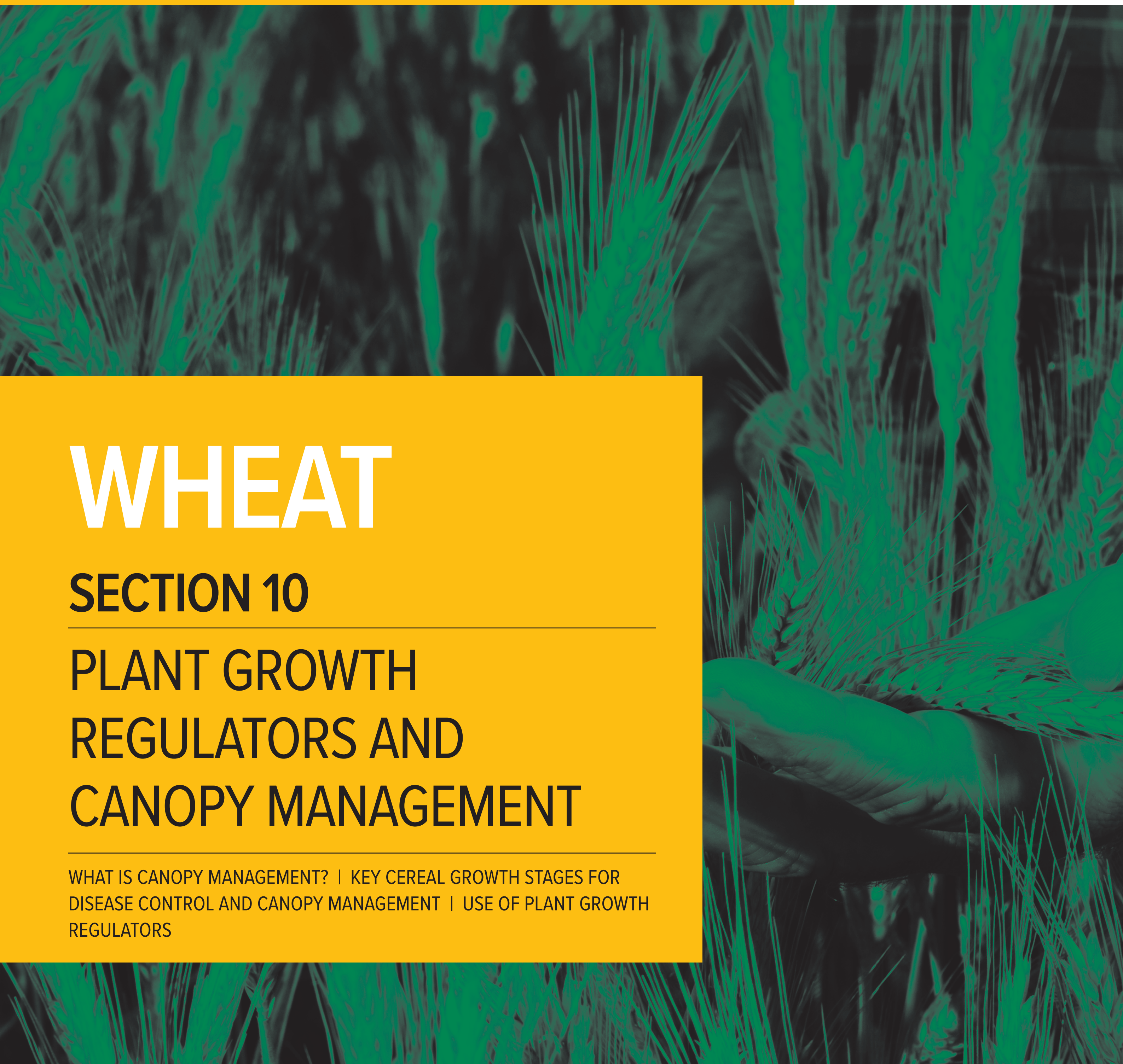
GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



WHEAT

SECTION 10

PLANT GROWTH REGULATORS AND CANOPY MANAGEMENT

SECTION 10

Plant growth regulators and canopy management

10.1 What is canopy management?

Much of the research on topdressing nitrogen (N) in northern New South Wales (NSW) has focused on the role of in-crop N to respond to seasons in which yield potentials have increased significantly due to above-average rainfall conditions.

In these situations, research has shown that positive responses can be achieved, especially when good rainfall is received after N application (*Australian Grain* July/August 2007). Recently, though, there has been significant interest in the role of 'canopy management' principles for crop production in the northern grains region. [1]

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 ensure a better match of canopy size with yield potential as defined by the water available. Other than sowing date, plant population is the first point at which the grower can influence the size and duration of the crop canopy. [2]

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 northern 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 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.

Can it work under Australian conditions—especially in the shorter growing season of northern NSW? Results from southern regions have been encouraging, especially in areas with high yield potential and therefore higher N inputs, but further research was required to test and validate the principles in northern NSW. [3]

More information

http://www.grdc.com.au/Resources/Publications/2014/01/Advancing-the-management-of-crop-canopies

1 G McMullen (2009) Canopy management in the northern grains region—the research view. 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

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

3 G McMullen (2009) Canopy management in the northern grains region—the research view. 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

10.1.1 Canopy management in a nutshell

1. Select a target head density for your environment (350 to 400 heads per square metre should be sufficient to achieve optimum yield even for yield potential of 7 tonnes per hectare).
2. Adjust canopy management based on paddock nutrition, history and seeding time to achieve target head density.
3. Established plant populations for wheat of between 80 and 200 plants/m^2 would cover most scenarios.
4. Lower end of range (80–100 plants/m^2) – earlier sowings/high fertility and or low yield potential low-rainfall environments.
5. Higher end of the range (150–200 plants/m^2) – later sowings, lower fertility situations and or higher rainfall regions.
6. During stem elongation (GS30–39), provide the crop with necessary nutrition (particularly N at GS30–33 pseudo stem 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 number just high enough to achieve potential yield will help preserve water for filling grain and increase the proportion of WSCs.

The timing of the applied N during GS30–33 window can be adjusted to take account of target head number; earlier applications in the window (GS30) and can be employed where tiller numbers and soil nitrogen seems deficient for 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 less tillers surviving to produce a head.[4]

10.1.2 Research on the Liverpool Plains

Since 2006, trials have been conducted by a collaborative research group including NSW DPI, Northern Grower Alliance (NGA), AgVance Farming, and Nick Poole from the Foundation for Arable Research (FAR), New Zealand. This work, funded by GRDC, has focused on the effect of delayed applications of N in high-yielding crops on the Liverpool Plains.

To test whether canopy management principles did improve crop performance in northern wheat crops, trials were established under overhead irrigation systems to supplement water supply at the critical growth stages when urea was applied to the soil surface. Nitrogen was applied at three times through the season in various combinations: at sowing, into the seedbed (SB), during early stem elongation (GS31), or after flag leaf emergence (GS39). Details of the research sites and treatments are presented in Tables 1 and 2.

4 GRDC (2014), Advancing the management of crop canopies. http://www.grdc.com.au/CanopyManagementGuide

Table 1: Nitrogen timings for canopy management trials

Treatment	At sowing (SB)	Stem elongation (GS31)	Flag leaf emergence (GS39)
No N	–	–	–
Single applications	100%	–	–
	–	100%	–
	–	–	100%
Split applications	50%	50%	–
	–	50%	50%
	50%	–	50%

Table 2: Overview of canopy management trials

	2006	2007	2008
Location	Caroona	Caroona	Spring Ridge
Sowing Date	27 June	14 July	29 May, 3 July
Variety	Ventura⚖	Ventura⚖	EGA Gregory⚖, Ventura⚖
Starting nitrate-N (0–90cm)	25 kg N/ha	74 kg N/ha	78 kg N/ha
Previous crop	2005 sorghum	2006 sorghum	2007 sorghum
Total N applied	110 kg N/ha	140 kg N/ha	160 kg N/ha
In-crop rainfall	234 mm (123 mm irr.)	285 mm (150 mm irr.)	450 mm (incl. irr)

Further research by NSW Department of Primary Industries (DPI) and NGA also assessed the role of different N fertilisers and measured the losses of N due to volatilisation. [5]

Results

From 2006 and 2007, the response to tactically delaying N until later in the growing season was relatively consistent for main- to late-sown, short-season crops (cv. Ventura ⚖). In both years, delaying or splitting fertiliser N did not result in significant grain yield increases compared with SB N. However, grain yield was maintained when N was split between SB and GS31. Delaying all N until after GS31 or splitting with GS39 applications resulted in lower grain yields but higher grain protein.

In 2008, the responses when all N was delayed were much the same as in 2006 and 2007, with no advantage in delayed N (Table 3). However, there was a 12% increase in grain yield when applied N was split between SB and GS31. Over the 3 years, with late June or July sowings, there has been an average 0.3 t/ha benefit to splitting N between SB and GS31 over the standard SB treatment (yield-neutral in 2006, +0.2 t/ha in 2007, and +0.7 t/ha in 2008).

5 G McMullen (2009) Canopy management in the northern grains region—the research view. 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

Table 3: Influence of nitrogen timing on grain yield for main-sown wheat cv. Ventura from 2006 to 2008

Nitrogen timing	Yield (t/ha)	Protein (%)	Screenings (%)
2006			
Nil	1.6	8.9	7.8
100% SB	3.7	11.8	7.7
100% GS31	3.3	12.5	6.6
100% GS39	2.3	14.2	5.3
50% SB + 50% GS31	3.7	11.7	7.3
50% GS31 + 50% GS39	3.3	13.0	6.6
50% SB + 50% GS39	3.5	12.1	5.7
l.s.d. (P = 0.05)	0.2	0.3	0.8
2007			
Nil	2.6	11.8	3.8
100% SB	3.5	12.5	4.4
100% GS31	3.4	13.3	4.4
100% GS39	2.9	14.4	3.5
50% SB + 50% GS31	3.7	13.0	4.1
50% GS31 + 50% GS39	3.2	13.7	3.6
50% SB + 50% GS39	3.6	13.4	3.3
l.s.d. (P = 0.05)	0.2	0.3	0.7
2008			
Nil	2.2	13.5	9.8
100% SB	4.7	13.4	8.5
100% GS31	4.4	14.4	8.9
100% GS39	3.4	15.1	9.9
50% SB + 50% GS31	5.4	13.5	9.0
50% GS31 + 50% GS45	4.3	15.0	8.8
50% SB + 50% GS45	4.8	13.6	9.6
l.s.d. (P = 0.05)	0.4	0.5	0.5

The results from the main sowing time in 2008 were encouraging, but one of the key questions after 2006 and 2007 was: what would the response be in early-sown, long-season crops? In 2008, EGA Gregory⦷ was sown on 29 May to assess these responses. The magnitude of the response was surprising.

As in previous years, the site was strongly responsive to N; in fact, canopy size as measured by crop dry matter showed a 3-fold reduction by delaying N until GS31 (Figure 1). After flag leaf emergence and at flowering, the canopy of the delayed treatments was still significantly smaller than with SB applied N. However, by crop maturity, the delayed N treatments, except when all N was applied after GS39, had reached higher peak dry matter levels than the SB N treatment.

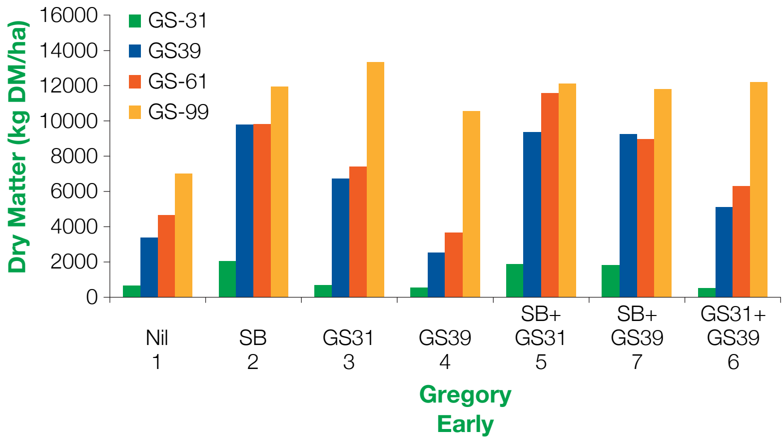


Figure 1: Effect of delayed nitrogen on crop dry matter (kg DM/ha) of early-sown wheat cv EGA Gregory⦶ in 2008.

These large differences in canopy size translated into very strong grain yield and protein responses (Figure 2). For the longer season EGA Gregory⦶, all delayed N treatments resulted in significantly higher grain yields than the SB applied N.

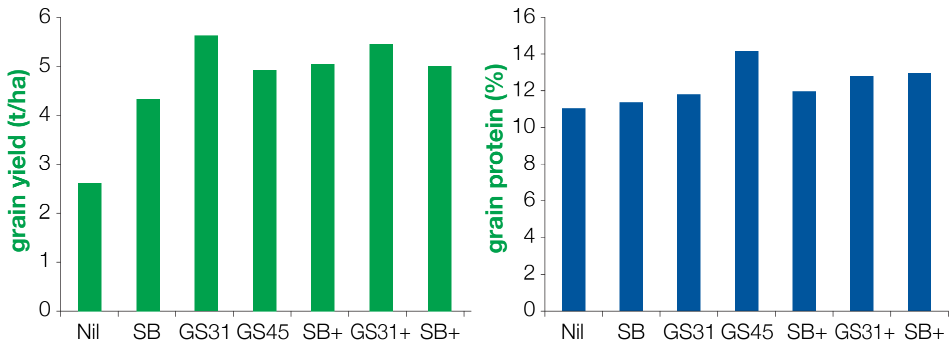


Figure 2: Effect of delayed nitrogen on grain yield and protein of early-sown wheat cv EGA Gregory ⦶ in 2008.

The highest yield was found when all N was delayed until GS31, with >1 t/ha extra yield, a result that appeared linked to the crop canopy staying greener for longer during grain-fill (Figure 3). This increase in yield was accompanied by increased grain protein for all delayed treatments, the greatest of which was when all N was applied after flag leaf emergence at booting (GS45).

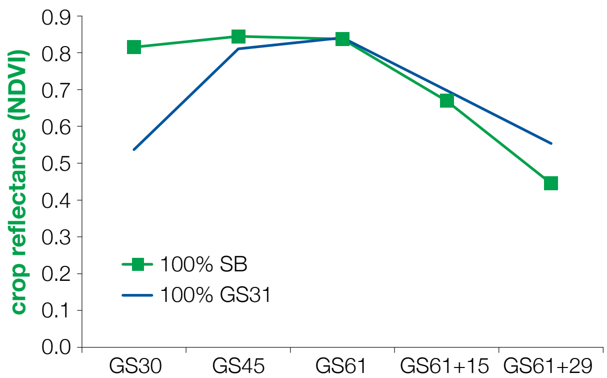


Figure 3: Effect of delayed nitrogen on crop reflectance (NDVI) of early-sown wheat cv EGA Gregory⦶ in 2008.

Nitrogen volatilisation

The risk of N volatilisation remains a significant concern when applying in-crop N; particularly in northern NSW, where lower rainfall incidence compared with southern regions and the presence of soil carbonates significantly increase the risk of N loss. Despite the risk factors being well understood, there is little quantitative information on the effect of soil properties, different N fertilisers and, most importantly, field conditions on potential losses of N. The NSW DPI and NGA have been conducting laboratory-based comparisons of the effect of differing soil properties and N fertilisers on the potential losses of N due to volatilisation.

The laboratory-based work has verified that the presence of calcium carbonates at the soil surface significantly increases the potential losses of N, while some N-fertiliser products can reduce the potential losses (e.g. urea ammonium nitrate liquid, liquid ammonium nitrate, and urea treated with a urease inhibitor—GreenUrea®) (Figure 4). Field-based estimates of volatilised N are to commence in the coming spring under a GRDC funded project. [6]

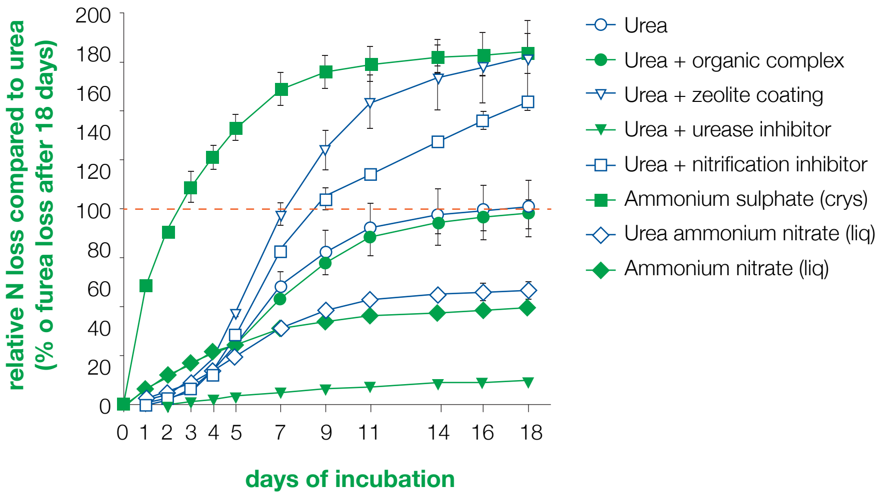


Figure 4: Cumulative volatilisation loss of nitrogen applied as fertiliser to the surface of an alkaline soil containing 7% CaCO3.

For more information, see *Section 5. Nutrition and fertiliser*.

Summary

Results from 3 years of supplementary-irrigated research have provided important pointers for the use of canopy management principles in northern NSW. Tactically delaying N is a management system that allows flexibility to respond to seasonal conditions and manage climate variability. Research has shown that N fertiliser could be delayed until stem elongation (GS31) without yield loss and usually with increased grain protein when conditions are suitable. This means that growers are able to apply a portion of the expected N requirement and then assess yield potential, as influenced by soil water and seasonal forecasts, later in the season and respond accordingly. To date, the best results with this approach have been seen in early-sown, long-season varieties with high yield potential that are very N-responsive with high N fertiliser inputs.

Further research in 2009 again showed impressive responses and examined the use of tactically delayed N in durum crops to improve yield and protein. The research group is also looking at using crop reflectance to assist in making N fertiliser decisions. So

[6] G McMullen (2009) Canopy management in the northern grains region—the research view, 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

far, crop reflectance (measured as normalised difference vegetation index, NDVI) at key growth stages has shown strong relationships to crop structure and yield. [7]

10.1.3 The commercial view

Based on the results of three years of trials carried out by AgVance Farming, NSW DPI and NGA with input from Nick Poole (FAR, New Zealand), it was concluded that delaying all N until GS30–31 had a detrimental effect on main-season wheat plantings.

Yield was maximised in the treatments where all N was applied early (SB), or split 50–50 (between SB and GS30–31). NSW DPI/NGA demonstrated in one recent season that this may be different for longer season varieties, but this remains to be proven over a number of years.

Generally, a full profile of moisture receives sufficient N at the start to provide the entire crop requirement to the predicted yield level. If yield potential is higher due to favourable seasonal conditions, there is generally an opportunity to apply small amounts of N later to increase yield but usually this is not necessary.

In a lower moisture profile situation, N can be applied at a rate less than the target yield-level requirement and topped up before rainfall, as opportunities present. This requires careful planning and preparation by the grower, in order to take advantage of impending rainfall, sometimes in short time-frames.

The 50–50 split application of N extends the period that N can be applied through the season without a 'cliff face' drop in yield if the N is not applied at precisely GS30–31. Effectively, it improves the margin of error available to the grower if rainfall does not occur at GS30–31.

More information

http://www.grdc.com.au/ApplyingPA

Where growers are set up for, and using, precision agriculture, a 70–30 application can be used when there is a full soil moisture profile and a 50–50 application where soil moisture is likely to be limiting. This is where a proportion of the predicted N requirement is held back until after NDVI imaging has taken place and N is applied based on NDVI results. This also requires a high level of organisation and planning.

Limitations of tactical nitrogen application

The main limitation to tactical N application in the north is the ability to reliably apply N before a rain event, to enable roots to access soluble N in the root-zone.

An analysis of rainfall events comparing Clare (South Australia) and Wagga Wagga (southern NSW) with Quirindi (North West Slopes of NSW) showed that Quirindi had only 30% of the opportunities to apply N that the southern locations had, and that the predictability of rainfall events >3 days before rain was very unreliable.

Predicted rain fronts may pass without yielding anything; therefore, dependably applying N throughout the season is risky. This becomes increasingly difficult further north and west of the Liverpool Plains to locations such as Moree and Walgett.

Foliar N application is gaining popularity; however, this is only suitable for relatively low rates of N addition. Where higher N input is required, an efficient system to apply N into the wet soil profile, after a rainfall event, needs to be devised.

As technologies such as NDVI imaging and paddock management in zones become prevalent, the addition of N later in the crop cycle will become more relevant and will force the development of equipment to make such a system work.

While traditional views of canopy management are based on southern experiences, northern region growers and agronomists are developing guidelines for the northern cropping zone. Based on sound trials and paddock experience, the aim of improving the economic outcome at the end of the season through manipulation of the most costly input is taking shape. Adoption of these techniques throughout the northern

[7] G McMullen (2009) Canopy management in the northern grains region—the research view. 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

More information

http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Varieties-and-agronomy-for-maximising-irrigated-wheat-yields-in-the-northern-region

cropping zone would be further aided by development of efficient, in-soil N-application equipment. [8]

10.1.4 Irrigated wheat in north-eastern Australia

Growers of irrigated cotton in north-eastern Australia have recently grown record areas of irrigated wheat (Figure 5) (notably in 2008) in response to increased grain prices, but wheat yields in the region have been severely constrained by lodging. Irrigated experiments were conducted at Gatton in 2009 and 2011 to assess the ability of canopy-management techniques of delayed N application and low plant populations to decrease lodging risk in the northern region. High leaf area index at the end of tillering was associated with increased lodging. Maximum yields for irrigated experiments were generally achieved when soil + fertiliser N at sowing was <100 kg/ha, with low-N treatments having less lodging and yield increases of up to 1 t/ha compared with high N treatments (Figure 6). Increasing plant density to >100 plants/m^2 increased lodging and decreased yield in high-N treatments. The highest yielding treatments had the least lodging, a harvest index of 0.45, and <450 tillers/m^2 at the end of tillering. Therefore, canopy-management techniques can be used to increase yields and decrease lodging in irrigated wheat in the northern region, but the techniques will be different from those used for irrigated wheat growing in southern Australia. The responses observed may have been reliant on irrigation during tillering to ensure that low levels of N were fully available to the crop. Further study is needed to determine the importance of early-season irrigation in maintaining yield on low-N paddocks.[9]

Figure 5: Wheat under irrigation.

[8] P McKenzie (2009) Canopy management in the northern grains region—the commercial view. 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

[9] A Peake, K Bell, N Poole, J Lawrence (2012) Nitrogen stress during tillering decreases lodging risk and increases yield of irrigated bread-wheat (*Triticum aestivum*) in north-eastern Australia. Australian Agronomy Conference 2012, Australian Society of Agronomy/The Regional Institute Ltd, http://www.regional.org.au/au/asa/2012/crop-development/8120_peakeas.htm#TopOfPage

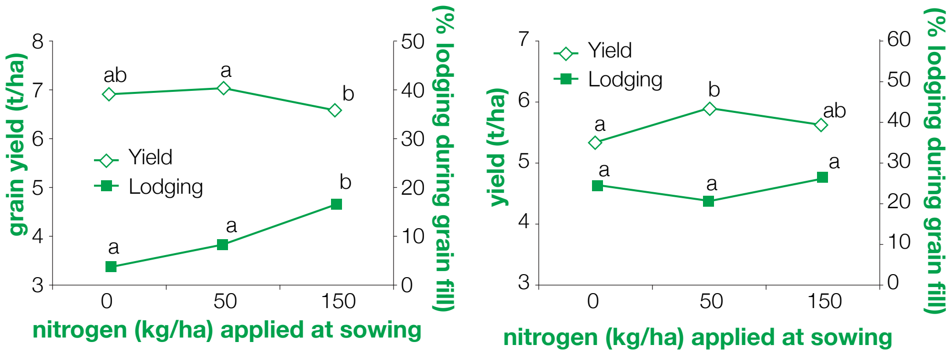


Figure 6: Yield and average lodging during grain-fill across three nitrogen regimes for (a) Kennedy and (b) EGA Gregory in 2011. Means on the same response curve with different letters are significantly different (P < 0.05).

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 would have been common to make decisions on fungicide applications for stripe rust based on thresholds of infection; these thresholds varied from 1 to 5% plants infected. A problem soon became apparent to growers and advisers 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, since 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 timings gave good control of the disease. These growth-stage-based timings also gave growers the opportunity to plan disease management strategies for susceptible cultivars. [10]

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), since they have not emerged at this early stem-elongation growth stage. Equally, a foliar fungicide applied at flag leaf (GS39) may protect the flag leaf but may be too late to protect flag-2, which emerged 2–3 weeks earlier. [11]

Yield loss to disease at different growth stages of disease onset

Although growth-stage timings of fungicide applications can ensure that the top three leaves of the plant are adequately protected, the growth stage of disease onset dictates

10 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

11 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

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 4). This simple chart (whilst complicated by the presence of adult plant resistance, APR) remains a useful guide to potential yield loss with susceptible cultivars at different growth stages.

Table 4: Expected yield losses (%) based on different growth stages of disease onset (stripe rust)

Disease onset		Stripe rust reaction			
Growth Stage		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

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

This guide to yield loss is based on the premise that yield loss to stripe rust is dependent on:

1. The extent of stripe rust by early grain development
2. The temperature during grain-fill (responses in the table assume average temperatures; if hotter, the yield loss (due to disease) is less than expected)

The complication with APR in Table 4 is that some cultivars, such as Gregory⫯ (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, since APR in the plant 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. For this reason, the table is a useful guide for losses at particular growth stages for more susceptible cultivars, but not the resistant ones.

Otherwise, the data illustrate that the earlier the disease infects the crop, irrespective of variety resistance rating, the greater the expected loss. [12]

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

The time of disease onset (stripe rust) not only influences the expected return from foliar fungicides, it also influences the timing of fungicide applications in order to create 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)?

This scenario presented during research work in Young, NSW, with the very susceptible cultivar H45⫯ in 2004 (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), while the later sown trial was infected at second node (GS32). So if one unit of fungicide were available, in this case 145 mL/ha of Folicur®, what would be the best use?

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

12 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

Figure 7: Flag leaf. (Photo: Foundation of Arable Research)

Figure 7 presents the results. The first panel shows:

- July-sown crop
- 5 t/ha yield potential
- Disease onset GS32 (second node)
- Disease onset 1 October
- Significant advantage to spraying twice
- 2.51 t/ha response to fungicide (52% loss)

The second panel shows:

- June-sown crop
- 6 t/ha yield potential
- Disease onset GS39 (flag leaf)
- Disease onset 1 October
- No advantage to spraying twice
- 2.01 t/ha response to fungicide (34% loss)

The answer to the question posed was that 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 since 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 second node stage GS32 and at flag-leaf stage GS39.

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

Cultivar Wyalkatchem⫚ 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 (2008 and 2009) and Derrimut ⫚ (2010; moderately susceptible rating to stripe rust) were sown at two sowing dates in the long-season, southern Victorian, high rainfall zone.

The questions to be answered were:

- Would later sowing exhibit greater disease resistance than earlier sowings, 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? or
- 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 generated at Inverleigh in southern Victoria from 2008 to 2010 revealed that Wyalkatchem⊕/Derrimut⊕ gave greater responses to fungicides when sown later (June) as opposed to early sowing (May), despite lower yield potential (Figure 8). During the 3 years, stripe rust infection was noted to arrive in the district (and trial) at similar times of the year. 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, as stripe rust infection occurred at earlier growth stages relative to the earlier May sowings.

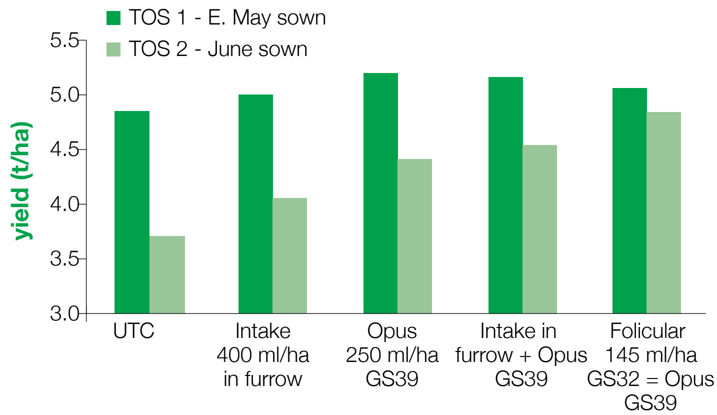


Figure 8: Influence of sowing date on fungicide response to stripe rust control in Wyalkatchem⊕, Inverleigh, southern Victoria 2008–2010 (3-year yield mean).

The trial work also indicated that although none of the fungicide treatments directly applied fungicide to the head, treatments that were effective at reducing stripe rust in the foliage were also effective at reducing head infection (Figure 9). In addition, earlier May sowings suffered later build-up of stripe rust infection and consequently had less head infection. [13]

[13] 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

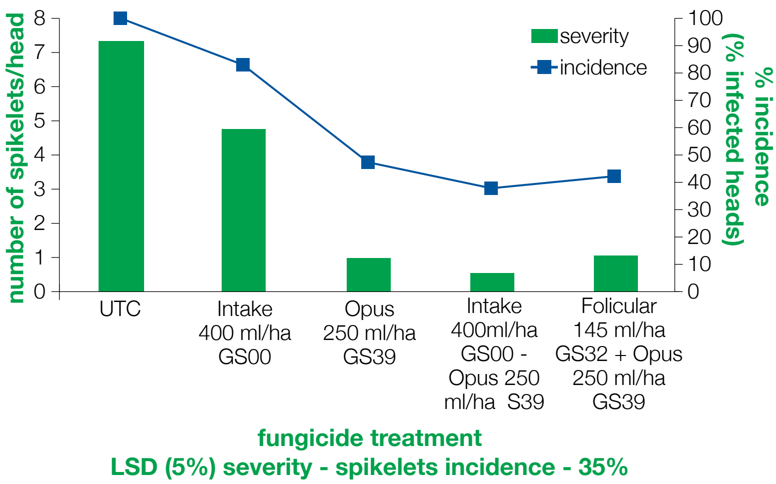


Figure 9: Influence of fungicide treatment for control of disease in the foliage and its subsequent effect on infection in the head, June-sown Derrimut⊕, Inverleigh, southern Victoria, 2010. [14]

To hear Nick Poole discuss canopy management, visit http://www.grdc.com.au/Media-Centre/GRDC-Podcasts/Driving-Agronomy-Podcasts/2009/07/Disease-management-and-crop-canopies.

10.3 Use of plant growth regulators

Plant growth regulators (PGR) may be used to minimise crop lodging and maximise yield, particularly in high-N situations. A combination of two PGRs increased yield by 16% when applied at GS31 (Table 5). This experiment was configured with 30-cm row spacing sown into a 2-m flat bed.

Approximately 150 seedlings emerged and the site was irrigated via flood furrow. 180 kg/ha N was applied at sowing and the site had less than 30 kg/ha residual soil nitrate/ 90 cm soil. Despite the fact that no lodging was observed in this experiment, a significant positive effect on yield was achieved using the products in this experiment when applied at the booting stage of crop growth. This trend has been consistent through several experiments conducted using these products and mixtures. [15]

Table 5: Comparison of plant growth regulators, timing, rate, and mixtures, ACRI Narrabri, 2011—wheat cv. EGA Gregory⊕

Treatment	Application timing (Zadoks growth stage)	Yield (t/ha)	
1. Untreated check		5.8	bc
2. Product X @ 50 g a.i./ha	GS31	6.0	ab
3. Product X @ 100 g a.i./ha	GS31	6.1	ab
4. Product X @ 50 g a.i./ha + Cycocel 750 A @ 756.6 g a.i./ha	GS31	6.9	a
5. Product X @ 50 g a.i./ha	GS37	5.4	bc
6. Product X @ 100 g a.i./ha	GS37	5.0	c
7. Product X @ 50 g a.i./ha + Cycocel 750 A @ 756.6 g a.i./ha	GS37	5.7	bc
l.s.d. ($P = 0.05$)		0.8	

Means followed by same letter are not significantly different ($P > 0.05$)

For more information on registered plant growth regulators, visit www.apvma.gov.au

14 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.

15 B Griffiths, L Bailey, C Guppy, N Hulugalle, C Birchall (2013) Managing resources and risk for 8-tonne cereal-crops. GRDC Update Papers 5 March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Managing-resources-and-risk-for-8-tonne-cereal-crops