CANOPY MANAGEMENT

FACT SHEET

GRDC Grains Research & Development Corporation

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Cereal canopy management more than delayed nitrogen

Understanding and applying the principles of canopy management, allows decisions on the most profitable use of inputs and the most appropriate target yield to be made.

Applying nitrogen (N) or fungicide at stem elongation increases the opportunity to match input costs to the potential yield for that season. While seeding applications may still be required for healthy establishment, crop models help support decisions on application timing. Models such as APSIM and Yield Prophet® simulate growth stage and season.

However, canopy management is not about a delayed N strategy but starts at seeding by determining the correct plant establishment for the chosen seeding date and row spacing. This must also take into account available soil moisture and nutrients (Figure 1).

FIGURE 1 Factors under grower control that influence canopy density, size and duration

Larger/thicker canopies		Smaller/thinner canopies
Higher seed rates	⟷	Lower seed rates
More nitrogen	⟷	Less nitrogen
Earlier nitrogen	⟷	Later nitrogen (longer duration)
Early sowing	⟷	Later sowing
First wheats		Second wheats
Irrigated		Dryland
Longer season cultivars		Short season cultivars
Higher GAI	⟷	**Lower GAI**

GAI = Green area index (amount of green surface area)
Assuming water is not a variable under the growers control, it is the first four statements over which the grower has most control, and in principal the means by which growers can practice canopy management.

KEY MESSAGES

- **Canopy management starts at seeding: sowing date, variety, plant population and row spacing are fundamental. It is more than purely delaying nitrogen.**
- **Correct identification of the key growth stages for input application is essential, particularly during early stem elongation when the key leaves of the crop canopy emerge.**
- **Knowledge of soil moisture status and soil nitrogen reserve and supply need to be taken into account in order to match canopy size to environment.**
- **Crop models can help integrate crop development, environmental conditions and nutrient status in order to make better canopy management decisions.**

Successful canopy management also relies on the correct identification of key growth stages particularly those that occur during stem elongation.

While N inputs can boost canopy growth and ultimately yield, lush crops can be more susceptible to foliar disease that can reduce yield and in addition may not be well matched to seasonal soil water supply.

Canopy management is about producing the most appropriate amount of crop biomass for that growing season to optimise grain yield and input use. It is not just about crop canopy size it is also about canopy duration in a particular environment.

While N timing and rate are key components of successful canopy management, it is essential that they are considered in conjunction with the inter-related factors of:

- soil moisture;
- soil nitrogen reserves;
- seeding date; and
- seed rate and variety.

To practice canopy management it is important to understand the principal interactions between plant growth stages, available water and nutrients, and disease pressure. These interactions are complex but tools from simple visual indicators through to crop models can assist.

SETTING UP THE CANOPY

Research has shown that extra tillers produced by more plants per unit area are more strongly correlated to yield, than extra shoots stimulated by increased nitrogen at seeding.

Boosting tiller numbers with seeding nitrogen results in greater tiller loss between stem elongation and grain fill. This specifically occurs in two situations: low rainfall, short environments and when soil moisture is limited. In these situations moisture and nutrient resources are used prior to stem elongation to produce biomass, which fails to contribute to grain yield. Indeed by diverting these resources to unsuccessful tillers limits the potential of surviving tillers.

Therefore, identifying the correct population for a particular sowing date, soil nitrogen reserve and region, is the basis for setting up the crop canopy.

Soil moisture status

Under Australian conditions soil moisture has been identified as the biggest driver of the cereal crop canopy, both in terms of size and duration. Therefore, an understanding of how much water a soil can hold, and how much water a soil is holding at seeding and stem elongation is central to canopy management (see Useful resources).

The start of stem elongation (GS30) is the pivotal point for managing the canopy with inputs, as from this point canopy expansion is rapid and soil nitrogen and water reserves can be quickly used.

If soil moisture is limited at the start of stem elongation the ability to manipulate the crop canopy with nitrogen is limited, in many cases the best canopy management is not to apply inputs such as nitrogen and fungicides.

By setting up a smaller crop canopy, modelling demonstrates that limited stored soil moisture can be reserved for use at grain fill, rather than being depleted by excessive early growth. However, in higher rainfall regions and in a good season setting-up a small canopy may result in actual yield falling below potential.

Calculating potential yield and then plotting actual rainfall against decile readings for the region provides a broad picture of whether there will be sufficient soil moisture to consider additional nitrogen inputs at stem elongation.

The decision support tool Yield Prophet® and the Sirius Wheat Calculator (developed in New Zealand) offer simple tools to record and assess multiple options about the relationship between growing plants and the environment including available water and nutrients.

Soil nitrogen

It is important to have an understanding of soil N reserves to the depth of the rooting zone.

Generally, 40 to 50 kilograms of N per hectare of soil available N is required to feed a crop to stem elongation (GS30). Higher soil nitrogen reserves provide much more flexibility in managing the canopy with tactical nitrogen applied during stem elongation. Figure 5 details some broad scenarios for the use of in-crop N for canopy management based on soil N reserves.

Timing of deep-soil tests is important. Deep-soil nitrogen tests carried out in summer, several months before seeding may reveal less soil nitrogen than tests carried out after the autumn rain, when greater mineralisation will have occurred.

Providing soil moisture has not been limited or the crop has not been subject to waterlogging over winter, crop appearance at GS30–31 gives a reasonable indication of nitrogen reserves and the justification for nitrogen application at this stage.

However, it is difficult to use visual appearance unless you have a benchmark; this has lead to the concept of the N rich strip (Figure 2).

A useful guide that requires no sophisticated equipment is to apply an excess of nitrogen at sowing, for example 50 to 100kg N/ha, to a small area of the paddock, approximately 2 metres by 10m.

During winter and spring by comparing crop vigour (tiller number) and greenness in these small N-rich areas with the rest of the crop, an indication of N supply can be obtained (Figure 2). The advantage of using the plant rather than depending totally on a soil test is that the plant is directly registering soil N supply, rather than soil nitrogen reserve which crop roots may not always be able to access.

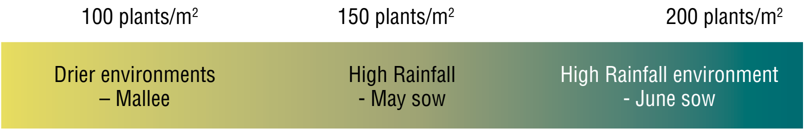
This visual difference can be quantified by using crop sensors that measure the light reflectance from the crop canopy. By measuring the reflectance at the red and near infrared wavelengths, it is possible to quantify canopy greenness using a number of vegetative indices, the most common of which is termed the Normalised Difference Vegetative Index (NDVI). This index gives an indication of both biomass present and the greenness of that biomass. This canopy sensing can be done remotely from aircraft/satellites or with a hand-held or vehicle mounted sensor.

FIGURE 2 N-RICH STRIP (110KG N/HA AT SEEDING) VIEWED AT GS31 ON LOW SOIL N RESERVE (25KG N/HA 0–90CM) – LARGE DIFFERENCE IN VISUAL APPEARANCE.
LIVERPOOL PLAINS, NSW 2006 CV VENTURA

443 tillers/m² (N-Rich)

266 tillers/m²

FIGURE 3 TARGET PLANT POPULATIONS FOR WHEAT BY REGION AND SOWING DATE (BASED ON PROJECT TRIALS 2003 — 2006)



N.B. All trials were conducted with complete ryegrass control.
It may be necessary to increase Mallee target populations in the presence of ryegrass.

Seeding rate and date

Achieving the correct plant population is fundamental if sufficient tillers are to be set.

Seeding rates need to be adjusted for seed size and planting date; if this does not occur the first step in controlling the canopy is lost.

How many plants are targeted depends on:

- region – as a general guide drier regions sustain lower plant populations than wetter environments; and
- sowing date – earlier sowings require lower plant populations compared to later sowings, as the tillering window is longer and more tillers are produced per plant.

Overall, earlier planting provides greater opportunities to manipulate the crop canopy during the stem elongation period: the plant's development periods are extended along with the earlier tillering period Figure 3.

In-crop nitrogen

Delaying N inputs from seeding to stem elongation (GS30-31) means they can be better matched to the season. So, in a dry spring no application may be warranted. In spring, with adequate rainfall to justify N application, project trials have shown stem elongation N to give yields equal or better than wheat crops grown with seeding N.

However, applying N in advance of a rain front to ensure good incorporation has been found to be more important than exact growth stage. While GS31 should be the target growth stage for in-crop N application, the window can be expanded from GS25 to 31 in order to take advantage of rainfall. Even applications delayed until flag leaf, can be successful where starting soil nitrogen is not too low (Figure 5).

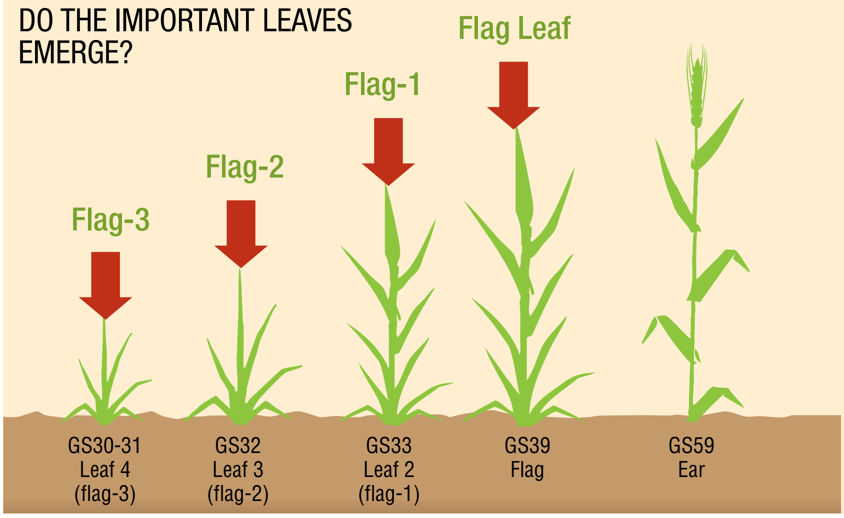
Figure 5 presents the results from winter wheat cropping trials across Australia on the use of in-crop solid nitrogen at stem elongation. This shows that where soil nitrogen reserves are low, N applied at stem elongation is not always the most appropriate strategy if yield is to be optimised.

Stem elongation N applications were found to be less appropriate with shorter season varieties and late sown crops. Drought conditions during the trial period (2006 to 2008) has limited the results produced from trials. These trials assessed stem elongation N use in cereals grown on wider-row spacings 300 to 350mm compared to 175 to 200mm. However, at the same seeding rate, moving to wider rows was found to reduce tillers per unit area and final ear population and yield, the latter by approximately six per cent in the HRZ.

Key growth stages (GS) for input application

After sowing most inputs that manipulate the canopy are applied during stem elongation – pseudo stem erect to flag leaf emergence that is from GS30–GS39. It is important to identify these growth stages correctly.

FIGURE 4: AT WHICH STAGE DO THE IMPORTANT LEAVES EMERGE?



For wheat in the high-rainfall zone (HRZ) the flag leaf and the two leaves below are the most important leaves. They drive the accumulation of carbohydrate in the stem and then post flower in the grain. In drier environments the flag leaf contributes less to the final yield since it does not have the duration post flower that it has in the HRZ. In barley, the flag leaf is generally small and it is the earlier leaves flag-3, 2 and 1, that are important along with the flag leaf sheath and awns. The longer these leaves remain green the greater the yield. Duration of greenness is determined by crop type and variety, availability of water and nutrients, and extremes of temperature.

Detailed descriptions of growth stages and their identification are found in the publications *Cereal Growth Stages – the link to crop management*, and in *Disease Management and Crop Canopies* (see Useful resources).

FIGURE 5 BROAD SCENARIOS BASED ON SOIL NITROGEN LEVEL

1.	2.	3.	4.
If high soil N reserve (over 100kg N/ha 0-60cm)	If moderate soil N reserve (50 -100kg N/ha 0-60cm)	If low soil N reserve (less than 50kg N/ha 0-60cm)	If low soil N reserve (less than 50kg N/ha 0-60cm)
No N constraint on canopy at GS30 - 31	Little constraint on canopy until GS30 - 31	Constrained canopy	Constrained canopy
Advantage of applying tactical nitrogen as early growth driven by soil nitrogen reserves	Early growth driven by soil nitrogen reserves but need for N application during stem elongation unless crop water stressed and outlook dry	Better equipped where dry conditions more prevalent in the spring	Wet spring conditions more probable (or irrigation), inadequate crop canopy to harness the potential of the season even with stem elongation nitrogen or high water holding capacity and no rain fronts for uptake.
Wet spring consider N application from pseudo stem erect up to booting GS30 - 45 dependent on crop status (colour) and rainfronts. For applications of nitrogen over 40-50kg N/ha consider splitting dose with 50-60% dose at GS30 -31 and a second dose at flag leaf dependent on rainfall during stem elongation. TACTICAL N OK.	Use any timing in the window from GS30 - 32 to apply nitrogen based on reliable rainfall events. If no rainfall, consider delaying until flag leaf. if no rain by flag leaf stage, consider whether application is needed. TACTICAL N OK.	Consider small applications of N at seeding 20-40kg N/ha then tactical N at stem elongation. TACTICAL N OK.	Disadvantage in entire N applied as tactical N TACTICAL N NOT OK – CONSIDER UPFRONT N SPLIT with GS30 - 31 Tactical N will be less successful where root disease is present. In these cases it may also not be appropriate.

FUNGICIDES AS CANOPY MANAGEMENT TOOLS

At first there may not appear to be a connection between fungicides and canopy management. The principal yield effect of a fungicide is to maintain the green area of the crop canopy in the presence of disease. The probability of a yield response to a fungicide strongly relates to:

- the level of disease – greater variety resistance less response;
- the earliness of infection – greater response with earlier infection; and
- the differences in green leaf retention due to fungicide application, which are related to the probability of regional rainfall post flowering or available soil moisture.

Soil water availability is a key factor in yield enhancement achieved with fungicide use. Irrespective of the disease control achieved with the fungicide applied at stem elongation the magnitude of yield response will be linked to available soil moisture and therefore crop canopy GAI during flowering and grain fill. For this reason fungicides will only ever be regarded as an insurance input since the difference created in crop canopy duration may or may not occur many days after application.

In areas with historical low yields (less than 2.5 t/ha) grain fill conditions generally do not favour a response to fungicide application. The principal exceptions are where severe disease infects the crop early at stem elongation or where stem rust becomes a threat.

With disease susceptible wheats and barleys grown in long-season, high-rainfall environments the more N applied resulted in more disease and greater need for fungicide protection in order to secure the benefits of higher N applications.

Useful resources:

■ ***Disease Management and Crop Canopies – What are the interactions?***	**Ground Cover Direct, 1800 11 00 44**
■ ***Cereal Growth Stages – the link to crop management***	**www.grdc.com.au**
■ **Yield Prophet®**	**www.yieldprophet.com.au**
■ **Adviser Update proceedings – Southern Region**	**www.grdc.com.au**
■ ***Estimating Plant Available Water Capacity***	**Ground Cover Direct, 1800 11 00 44**
■ **GRDC Water Use Efficiency fact sheet**	**www.grdc.com.au**

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