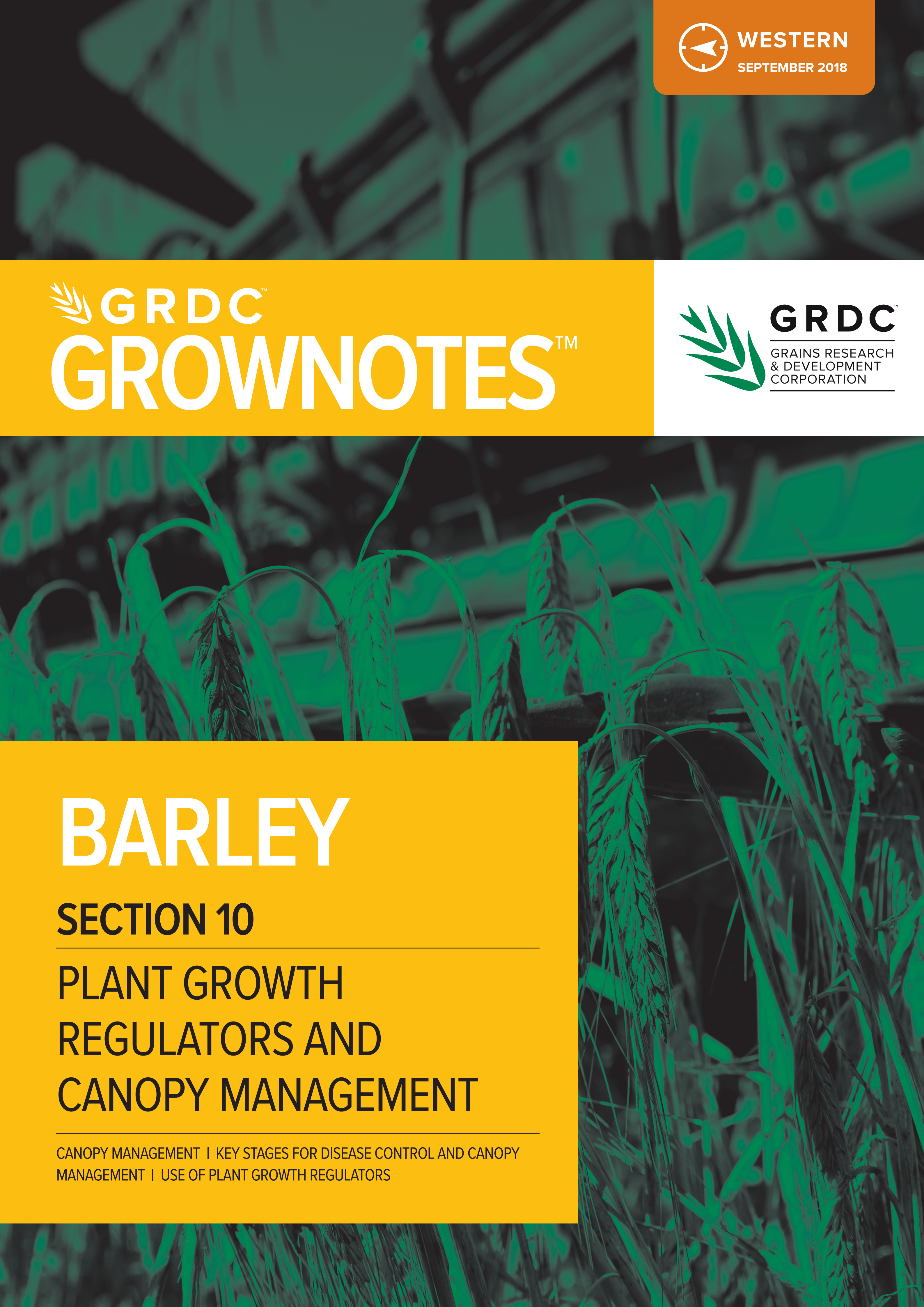

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GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

BARLEY

SECTION 10

PLANT GROWTH REGULATORS AND CANOPY MANAGEMENT

CANOPY MANAGEMENT | KEY STAGES FOR DISEASE CONTROL AND CANOPY MANAGEMENT | USE OF PLANT GROWTH REGULATORS

Plant growth regulators and canopy management

10.1 Canopy management

Canopy management is the manipulation of the green surface area of the crop canopy to optimise crop yield and inputs. It is based on the premise 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]

Canopy management includes a range of crop-management tools for crop growth and development. One of the main tools available to growers is the rate and timing of applied nitrogen (N). [2]

Canopy management in WA

Canopy-management trials in wheat near Wagin, WA, indicate medium plant density (120 plants/m^2) and tactical N applications during the growing season can pay off with higher yields—especially in years with a drier-than-average finish. [3]

Yields can be compromised if plant density is too high (180 plants/m^2) and if too much N is applied at seeding.

Trial sites were set up from 2011 to 2013 at east Wagin, Kulin, Kellerberrin and Kojonup to investigate canopy-management parameters for WA cropping regions. At each site, researchers monitored how wheat canopy density affected grain yield and quality and the level of disease and frost damage. [4]

In the Wagin environment, in a low-to-average-rainfall year, growers can target medium sowing rates and be more flexible in applying N to play the season as it unfolds—without affecting yield.

Restricting canopy growth can conserve soil moisture, reduce disease pressure and allow crops to finish better. Split N application is a good risk-mitigation strategy, especially if the long-term forecast is not promising or if subsoil moisture levels are low.

While this research was conducted on wheat, it clearly shows that there is potential in WA to implement canopy management for barley.

MORE INFORMATION

GRDC (2015) Canopy management in western region.

GRDC (2014) Crop management guide: Advancing the management of crop canopies.

GRDC (2014) Canopy management, Western Update. GRDC Radio

10.1.1 Importance of canopy management

Nitrogen application at stem elongation is associated with higher protein levels. Therefore, growers of malting barley need to be aware that although delayed timing of N can be useful in barley, higher protein content may need to be countered with lower total N doses if a greater proportion of N application is moved from seedbed to stem elongation. [5]

1 N Poole (2005) Cereal growth stages. GRDC, https://www.researchgate.net/file.PostFileLoader.html?id=5780fa6bf7b67e860b4def31&assetKey=AS%3A381929540079624%401468070506798

2 G McMullen (2009) Canopy management in the northern grains region—the research view. Northern Grains Alliance, 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

3 GRDC (2015) Canopy management in western region, GRDC, http://grdc.com.au/Media-Centre/Hot-Topics/Canopy-management-in-western-region

4 GRDC (2015) Canopy management in western region, GRDC, http://grdc.com.au/Media-Centre/Hot-Topics/Canopy-management-in-western-region

5 N Poole (2005) Cereal growth stages. GRDC https://www.researchgate.net/file.PostFileLoader.html?id=5780fa6bf7b67e860b4def31&assetKey=AS%3A381929540079624%401468070506798

If the canopy becomes too big, it competes with the growing heads for resources, especially during the critical 30-day period before flowering. This is when the main yield component (grain number per unit area) is set. Increased competition from the canopy with the head may reduce yield by reducing the number of grains that survive for grainfill.

After flowering, temperature and evaporative demand increase rapidly. If there is not enough soil moisture, the canopy dies faster than the grain develops, leading to the production of small grain.

Excessive N application and high seeding rates are the main causes of excessive vegetative production. Unfortunately, optimum N and seeding rates are season-dependent. Under drought conditions, N application and seeding rates that would be regarded as inadequate under normal conditions may maximise yield, whereas higher input rates may result in progressively lower yields. Alternatively, in years of above-average rainfall, yield may be compromised with normal input rates.

The extreme of this scenario of excessive early growth is haying-off, where a large amount of biomass is produced, using a lot of water and resources. Then, later in the season, there is insufficient moisture to keep the canopy photosynthesising and not enough stored water-soluble carbohydrates to fill the grain. Therefore, grain size and yield decrease.

To attain maximum yield, it is important to achieve a balance between biomass and resources. The main factors that can be managed are:

- plant population
- row spacing
- inputs of N
- sowing date
- weed, pest and disease control.

Of these, the most important to canopy management are N, row spacing and plant population. [6]

10.1.2 Barley trials from the western region

In the high-rainfall zone (HRZ) of WA (Agzones five and six) manipulating the crop canopy in malting barley has had significant effects on grain quality, particularly with the popular cultivar Baudin⁽ᴾ⁾. These quality effects were often at odds with the canopy structure that created the highest yields. The trials on sandy gravel soils after canola with relatively low N reserves (less than 80 kg N/ha) illustrated there was no advantage to delaying N at sowing.

Plant population

Comparing all barley project trials (seven in total), irrespective of location, increasing plant population from approximately 100 plants/m^2 to 150–200 plants/m^2 increased yield. In WA the differences have been small, but statistically significant at one site (Mount Barker).

Baudin⁽ᴾ⁾ with its greater propensity to tiller, has not shown the same yield increases from increasing plant population as were evident with Vlamingh. The response of Baudin⁽ᴾ⁾ to population increases being only 0.05t/ha over the two seasons, compared to 0.13 t/ha with Vlamingh. At the longer season site in southern Victoria the yield increases associated with manipulating plant population were very similar (3–4% – 0.18 t/ ha) but expressed at a higher yield level.

This increase in yield with greater plant population has been associated with consistent positive and negative grain quality effects.

6 N Fettell, P Bowden, T McNee, N Border (2010) Barley growth & development. PROCROP Series. Industry & Investment NSW/ NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/516180/Procrop-barley-growth-and-development.pdf

Positives

- A reduction in grain protein—an increase of approximately 80–100 plants/m^2 over and above a base population of 100 plants/m^2 reduced grain protein by up to 0.3% in WA and Victorian trials

Negatives

- In the same trials increasing plant population resulted in an increase in screenings, the severity of which was linked to the drought in the spring. In the 2009 season the differences were small and not significant, while in 2010 increasing population had significant effects
- In both seasons Baudin$^{\phi}$ screenings were significantly higher than Vlamingh
- The higher plant population was also associated with a small reduction in grain size and test weight

Different soil nitrogen reserves

In the 2009–10 WA trials, soil N reserves were lower than equivalent trials in the east with low to negligible reserves below 30 cm depth. With soil N reserves lower than 80 kg/N/ha after canola and delaying all of the N until early stem elongation (GS30–31) resulted in significant yield losses in both years. Under these circumstances delaying all the N until spring significantly reduced tiller number compared to N applied in the seedbed (IBS—incorporated by sowing). This effect was seen with all of the barley trials and is similar to wheat.

The trial also found it is not possible to apply all N at GS31 and reach the crop's yield potential. In WA trials with malting barley, delaying N until stem elongation led to a lower number of viable heads at harvest and subsequently lower yields.

Correlations

In these WA malting barley trials, it was not only yield that was reduced by delaying N but quality was also impaired. This was not just in the form of higher grain protein but also increased screenings particularly in 2010 when September and October were particularly dry. [7]

10.1.3 Crop row orientation and spacing

Trials in WA have found that sowing barley east–west instead of north–south could halve annual ryegrass seed production.

7 N Poole and J Hunt (2014) Advancing the Management of Crop Canopies. GRDC Publications, https://grdc.com.au/__data/assets/pdf_file/0019/126406/advancing-the-management-of-crop-canopies-pdf.pdf.pdf

Photo 1: *Measuring light availability to the inter-row space in wheat with a Sunfleck Ceptometer*

Source: Glen Riethmuller, DAFWA

Research on several aspects of crop competition between 2010 and 2012 revealed high cereal seeding rates increased crop competition with weeds, reducing ryegrass seed production, and that barley competes more with weeds than wheat. However, the research into crop row orientation was of particular interest as it represents free weed control.

Ryegrass seed production was halved by sowing east-west compared to north-south, according to the field trials conducted at DAFWA Research Stations in Merredin, Wongan Hills and Katanning in 2010 and 2011.

The trials showed an average ryegrass seed production of 2968 seeds/m^2 in east-west crops, compared to 5705 seeds/m^2 in north-south crops. The only exception was Katanning in 2010, where the ryegrass emerged 2 weeks after the crop, ensuring the crop was highly competitive (regardless of crop orientation or seeding rate). [8]

MORE INFORMATION

UWA (2014) Sow west young man.

Table 1: *Ryegrass seed production (seeds/m^2) for east–west versus north–south sown crops from six trials in south-west Western Australia*

Ryegrass seed production: orientation			
Year	**Location**	**East-west**	**North-south**
2010	Merredin	503	911
2010	Wongan Hills	12	159
2010	Katanning	529	465
2011	Merredin	27	125
2011	Wondgan Hills	2,610	6,155
2011	Katanning	14,112	26,272
Average 51% reduction in ryegrass seed set by sowing east-west			

Source: UWA

8 UWA (2014) Sow west young man. University of Western Australia, http://ahri.uwa.edu.au/sow-west-young-man/

10.1.4 Grazing cereal crops as a management tool

Well-managed, dual-purpose cereals provide producers with an opportunity for increased profitability and flexibility in mixed farming systems. They enable increased winter stocking rates and gevnerate income from forage and grain. Typically, these crops are sown earlier, and are longer season varieties that provide greater dry matter production for grazing. Research has shown to avoid grain-yield penalties, stock must be removed from cereals before the end of tillering (GS30). However, the timing and intensity of grazing during the season can incur yield penalties, particularly when grazing pressure is high and late in the grazing period.

Grazing can sometimes be beneficial to grain production by reducing lodging; in seasons with dry springs, grazing can increase grain yields by reducing water use in the vegetative stages, leaving more soil water for grainfill. The challenge for growers is to find the balance of optimising dry matter removal without compromising grain production. [9]

MORE INFORMATION

GRDC (2012) Grazing wheat and barley—impacts on crop management, lodging and grain yield. GRDC Update Paper.

10.2 Key stages for disease control and canopy management

Barley disease requires careful monitoring. Its lower leaves, which emerge earlier than in wheat, are more important to the plant than the lower leaves in wheat. Other points to consider when using fungicide in barley canopy management:

- The flag leaf is relatively small and unimportant in barley compared with wheat, and its appearance is therefore not a convenient midseason focal point for strategies.
- Earlier, more important, leaves that require fungicide application create a later season gap in protection, therefore making two sprays more effective in this crop (Figure 1).
- Barley often suffers from wet-weather diseases early in the season, but then is subject to drier or warmer weather diseases later in the season, again making it more difficult to target a single-spray program under diverse disease pressure

9 GRDC (2102) Grazing wheat and barley—impacts on crop canopy management. GRDC Update Papers, 23 March 2012, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/431273/Grazing-wheat-and-barley.pdf

MORE INFORMATION

[GRDC (2014) Fungicide management and timing keeping crops greener for longer in the high rainfall zone. GRDC Update Paper.]

[GRDC (2014) Advancing the management of crop canopies.]

[GRDC (2013) New tools lift canopy management. Ground Cover Issue 105.]

[GRDC (2009): Disease management and crop canopies. Driving Agronomy Podcast.]

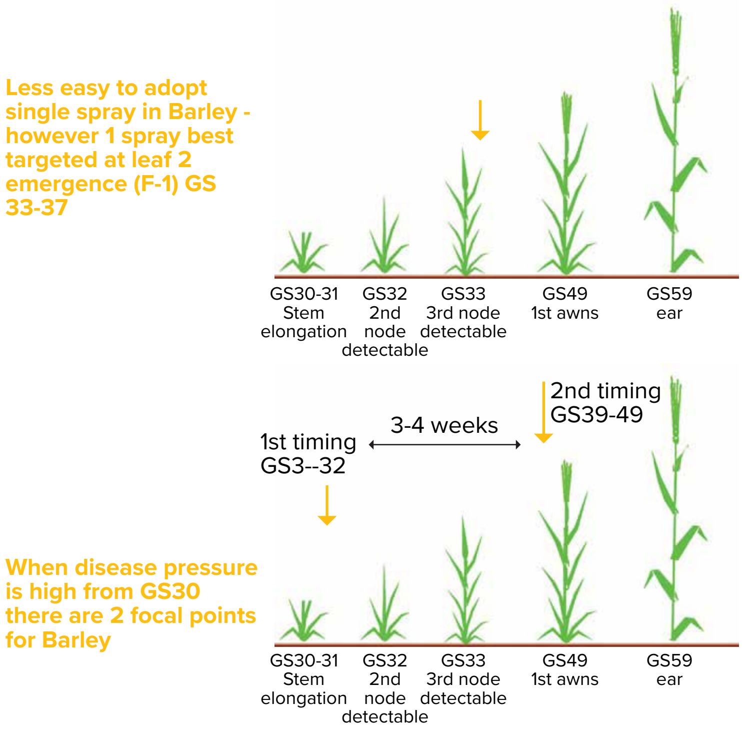

Figure 1: *Key stages for disease control and canopy management.*

Source: FAR

10.3 Use of plant growth regulators

Plant growth regulators (PGRs) may be used to minimise crop lodging and maximise yield, particularly in high-N situations. PGRs have been used routinely in high-input, high-yielding cereal systems in Europe and New Zealand to shorten straw height and reduce the incidence of lodging. Lodging causes significant losses in crop production through reduced movement of water and nutrients and reduced translocation of plant-stored carbohydrates via the stem into the head. Lodging also reduces grain quality and increases harvest losses and the cost of the harvesting process.

Inhibitors of the plant hormone gibberellin and ethylene producers are the two main PGR groups. Research in Australia has focused on gibberellin-inhibitor products, which act by blocking gibberellin biosynthesis to reduce internode length in stems, thereby decreasing plant height. There are several phases in this pathway and different PGRs act at different points. For example, chlormequat (Cycocel®) acts early in the pathway, whereas more recently developed products such as trinexapac-ethyl (Moddus® Evo) act on later stages.

Plant growth regulators are reported to have a yield-enhancement effect by improving the proportion of crop dry matter that is partitioned into grain yield. This effect has been related to a reduction in the plant resources required for stem elongation, with these resources then available for grainfill. Some PGRs have also been associated with increased root growth, resulting in improved water extraction from soil. Yield responses to PGRs are highly variable, with responses ranging from –40% to +2%, depending on product choice, application time, crop or variety and growing-season conditions. [10]

10 M Gardner, R Brill, G McMullen (2013) A snapshot of wheat and barley agronomic trials in the northern grains region of NSW. GRDC Update Papers, 5 March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/A-snapshot-of-wheat-and-barley-agronomic-trials-in-the-northern-grains-region-of-NSW

Use of ethephon has generally been low because responses are viewed as variable, and growers have not regularly seen the benefit of incorporating it into their management programs. There is a lack of understanding of the conditions and situations under which to the use PGRs.

A great deal of resources have been devoted to optimising crop-husbandry strategies to minimise lodging, whereas relatively little has been devoted to identifying the situations in which to use PGRs for optimum results. If the field, variety or growing conditions are not conducive to lodging, the use of a PGR will be of no benefit to the grower; many of the trials undertaken with PGRs have reached conclusions in circumstances where a PGR did not need to be applied in the first place. [11]

Moddus® Evo (trinexapac-ethyl at 250 g/L) is registered for Australian cereal growers to reduce the incidence and severity of lodging and optimise the yield and quality of high yielding wheat, barley and oat crops.

Between 2004 and 2011, field trials with Moddus® Evo were run across Australia by Syngenta, the manufacturer of Moddus® Evo, to investigate the value of applications to Australian cereals in terms of reducing lodging and improving yields. The trials encompassed a range of varieties, climatic conditions and geographical locations, and varied application rates were applied at different growth stages.

Measurements were taken of the effect of Moddus® Evo application on plant growth, stem strength, stem-wall thickness, lodging, lodging score and yield, as well as grain-quality measurements (Figure 2). Several rates of Moddus® Evo were assessed for reduction of lodging and enhancement of yield in barley. Moddus® Evo applied at rates of 300 or 400 mL/ha was consistently found to improve yields and reduce barley lodging (Figure 2a, b). The optimal growth stage for Moddus® Evo application to have the most consistent and greatest impact on yield was GS30–32.

When growth conditions were favourable, a bounce-back effect, where compensation growth occurred, was often observed. To reduce the impact of the bounce-back, a follow-up application of Moddus® Evo was evaluated. With a second application of Moddus® Evo at GS37–39, growth compensation was reduced (Figure 2c). When conditions were favourable for bounce-back, the second application resulted in significant yield improvements. The results in Figure 2d are the average across a number of trials where a second application of Moddus® Evo was applied; not all of the trials favoured bounce-back growth, which has reduced the overall impact. [12]

11 B. Staines, LM Forsyth, K McKee (2013) Moddus Evo: controlling plant growth for reduced lodging and improved cereal yields. GRDC Update Papers, 27 March 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Moddus-Evo-Controlling-plant-growth-for-reduced-lodging-and-improved-yields

12 B. Staines, LM Forsyth, K McKee (2013) Moddus Evo: controlling plant growth for reduced lodging and improved cereal yields. GRDC Update Papers, 27 March 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Moddus-Evo-Controlling-plant-growth-for-reduced-lodging-and-improved-yields

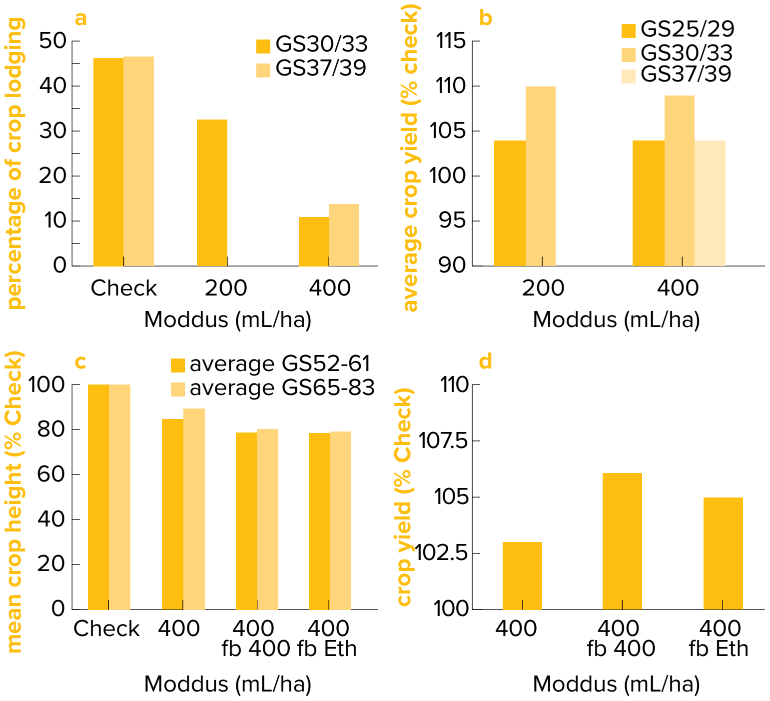

Figure 2: *(a) Effect of Moddus® Evo concentration on lodging when applied at early and late stem elongation in barley crops; data are a summary of multiple trials. (b) Effect of concentration and timing of Moddus® Evo applications on barley yields, data are percentage improvement from untreated. Applications occurred on healthy growing plants, and conditions were not favourable for bounce-back growth. Average data are from five trials run in 2007; 80% of the trials did not have lodging. Effect of second application of Moddus® Evo on (c) barley stem heights and (d) barley yields when conditions favour compensatory growth following initial application.*

Source: GRDC

Overall improvements in yield were often correlated with a reduction in stem height whether or not lodging occurred. Yield improvements through the reduction of lodging are well documented. What is less understood is the impact, often positive, on yields with the use of Moddus® Evo in the absence of lodging.

Conversely, during the evaluation of effects of Moddus® Evo on yield enhancement and reduction in lodging, a few trials had anomalous results, where Moddus® Evo application did not improve yield. Environmental conditions at these trials during the lead-up to Moddus® Evo application were poor, with extensive frosting, drought, poor subsoil moisture profile or nutrient deficiencies within the crop. Therefore it is recommended Moddus® Evo be applied only to healthy growing crops with optimum yield potential.

Syngenta concluded from its trials that Moddus® Evo offers growers in environments conducive to lodging an in-season option to reduce the impact of lodging while allowing them to manage crops for maximal yields. The timing and concentration of Moddus® Evo applications is critical to optimal yield improvements and it should only be applied to healthy growing crops. [13]

MORE INFORMATION

GRDC (2014) Plant growth regulators. GRDC Update Paper.

13 B. Staines, LM Forsyth, K McKee (2013) Moddus Evo: controlling plant growth for reduced lodging and improved cereal yields. GRDC Update Papers, 27 March 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Moddus-Evo-Controlling-plant-growth-for-reduced-lodging-and-improved-yields