Lodging management for Commander Barley

Matthew Gardner and Guy McMullen

NSW Department of Primary Industries, Tamworth Agricultural Institute, 4 Marsden Park Rd, Tamworth, NSW 2340, matthew.gardner@dpi.nsw.gov.au

Abstract
Commander is a malting barley variety that is gaining popularity with growers throughout the northern grains region. However, one of the major limitations to the further adoption of Commander is its susceptibility to lodging. Lodged crops can limit grain yield by up to 40% and reduce grain quality, not to mention the difficulties associated with harvest. Trials investigating lodging management options including, plant population, defoliation, potassium application and Plant Growth Regulators (PGRs) were conducted over 4 years between 2008 and 2011 across multiple sites throughout the northern grains region. The defoliation of crops just prior to stem elongation has been shown to reduce the severity (8 – 35 %) and area affected by lodging (15 – 45 %). However, defoliation must occur prior to stem elongation to avoid yield penalties. Manipulating plant populations is an effective and easy means to reduce lodging severity. Reducing plant populations from 120 to 80 plants/m^2 reduced lodging severity by up to 32% in some trials, however further reducing populations can also significantly reduce yield potential. In general, the application of PGRs has resulted in reductions of lodging severity, which has been associated with reductions in plant height of between 5 and 12 cm. In some cases unexpected yield benefits have been observed with 0.4 to 0.9 t/ha yield increases observed where PGRs have been applied compared to no PGRs in the absence of lodging. Due to the strong susceptibility of Commander to lodge, the combination of appropriate plant populations, defoliation and PGR have been shown to give the greatest reductions in lodging severity.

Key Words
Grain protein concentration, Commander, Gairdner, retention, test weight

Introduction
Reductions in profit due to lodging in cereals are often underestimated by the grains industry (Berry *et al.* 2004). Lodging generally occurs in paddocks with high yield potential, when the top of the plant is so heavy and/or buffeted by wind, that the plant buckles (stem lodging), or levers the root system out of wet soil (root lodging) (Berry *et al.* 2004). It generally reduces yield the most when it occurs during flowering or early grain fill, as lodged crops don't intercept sunlight efficiently (Peake *et al.* 2012). Lodging at the beginning of the grain filling period has been shown to reduce grain yield by 15 - 50% but can be as high as 80% (Berry *et al.* 2004). The lower yields can result from the crop by setting less grain and producing smaller grains (Berry *et al.* 2004; Peake *et al.* 2012). Severe lodging can also reduce yield or increase harvest costs through shattering, slower harvesting, and increased risk of sprouting (Peake *et al.* 2012). Besides decreasing yield, lodging has decreased grain test weight, kernel weight, percent plump kernels, kernel numbers and increased percent of thin kernels (Jedel and Helm 1991). Therefore the grain yield losses associated with lodging are amplified as lodging also reduces grain quality which also reduces the potential to meet malt specifications and hence a reduced financial return for grain.
There are a range of lodging management options available to growers including variety selection, planting date, plant population, defoliation, nutrition and plant growth regulators (PGRs). Early planting and high plant populations have been shown to exacerbate lodging issues while variety selection can be used as a very effective management tool to negate lodging risk. Defoliation during tillering (GS25) and up to stem elongation (GS31) can be an effective means for reducing the canopy biomass and shading which consequently reduces the incidence and severity of lodging. High rates of N generally increase the severity of lodging as it drives a greater shoot:root ratio which is conducive for lodging (Rajkumara 2008). Plant Growth Regulators are a widely used management tool for preventing lodging of cereal crops in Europe and New Zealand (Berry *et al.* 2004; Moes and Stobbe 1991).
Commander is a malting barley variety that is gaining popularity with growers throughout the northern grains region and with industry for its high yields and malting quality. However, one of the major agronomic limitations to the further adoption of Commander is its susceptibility to lodging.

Proceedings of the 16th ASA Conference, 14-18 October 2012, Armidale, Australia. Web site www.agronomy.org.au

Methods

Trials investigating lodging management options including, plant population, defoliation, N nutrition and PGRs were conducted over 2 years between 2010 and 2011 across multiple sites throughout the northern grains region. In 2010 two barley varieties (Commander and VB0611 – an experimental line) and one wheat; EGA Gregory; were defoliated either early (at GS25), late (at GS30) or both early and late. Commander, lodging susceptible, and Oxford good straw strength, were grown in 2011 at Tamworth and Spring Ridge. The two varieties were grown at plant populations of 80 or 120 plants/m^2 across which four PGR treatments nil, Cycocel® (0.2 L/ha), Synexp (Syngenta Experimental PGR) (1.0 L/ha) and a combination of Cycocel® and Synexp. The application of PGRs was at stem GS31 and was applied with a boom at 100 L/ha water rate. The affect of N management on lodging was investigated at Breeza for Commander and Gairdner, which were grown at plant populations of 60 and 120 plants/m^2 in 2011. In the trial 4 rates of N were applied at sowing including 0, 20, 40 and 80 kg N/ha as granular urea (46 % N). Two additional N treatments were implemented, 40 kg N/ha applied at growth stage 31 (GS31 - stem elongation) and a split application treatment where 20 kg N/ha was applied at sowing with a further 20 kg N/ha applied at GS31. Lodging severity scores were taken during early grain fill on the 1st November and are presented in Table 2. The aim of this paper is to compile the results from these trials and give some best bet lodging management options specific to Commander barley.

Results

Defoliation

Late defoliation reduced lodging severity by up to 45 %, whereas an early defoliation reduced lodging severity by only 10 % compared to the undefoliated treatment. The 2010 trial highlights 2 key points a) the susceptibility of Commander to lodging under high yield conditions and b) the influence of variety selection on lodging with the experimental barley line exhibiting approximately half the lodging severity under the same growing conditions. Grain yield for the late and early + late defoliation treatments was similar regardless of variety but had approximate reductions of 0.6, 1.0 and 0.4 t/ha of grain for Commander, VB0611 and EGA Gregory, respectively. The early defoliation had no significant effect on grain yield compared to the control.

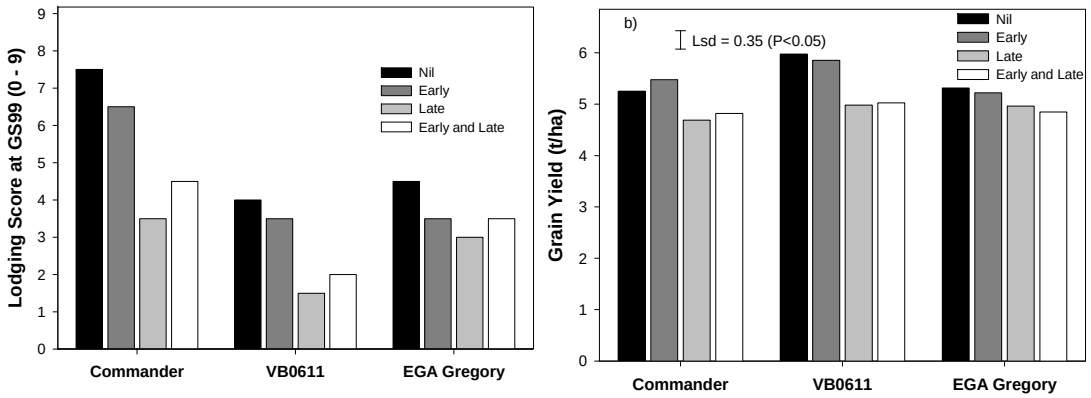

Figure 3: a) Influence of ungrazed, early, late and early + late defoliation systems on lodging severity scores (0 = standing, 9 = flat) and **b)** grain yield for Commander, VB0611 and EGA Gregory under either ungrazed, early, late or a combination of early and late grazing systems

PGRs

Although the Tamworth site had lower lodging compared to Spring Ridge the trends were similar (Table 1). At both the Tamworth and Spring Ridge sites lodging severity for Commander were approximately 3 times what was observed for Oxford, again highlighting the importance of variety selection (Table 1). Reducing plant population from 120 to 80 plants/m^2 reduced lodging severity regardless of variety or PGR treatment by approximately 10 – 55% (Table 2). The combination of Cycocel® and Synexp was the most effective PGR treatment to reduce lodging severity compared to the control treatment (Nil PGR and – defoliation) (Table 1).

The ability of PGRs to reduce the severity of lodging appears to be related to the capacity to restrict plant height (Figure 1). The nil PGR treatments had the greatest plant heights while Cycocel® + Synexp was the most effective treatment at reducing plant height (approximately 4-5 cm) (Figure 1). Synexp restricted plant height to a greater extent than Cycocel® (Figure 1). Again similar trends were observed at Tamworth, where Cycocel® + Synexp significantly restricted plant height by 3 – 4 cm compared to the control treatment.

Table 1: Lodging scores (Scale 0-9, where 0 is standing and 9 is flat on the ground) at harvest for the Spring Ridge and Tamworth sites.

PGR Treatment	Spring Ridge				Tamworth			
	Commander		Oxford		Commander		Oxford	
	120 plants/m^2	80 plants/m^2	120 plants/m^2	80 plants/m^2	120 plants/m^2	80 plants/m^2	120 plants/m^2	80 plants/m^2
Nil (Control)	7.2	5.2	3.0	1.9	3.0	2.3	1.0	1.0
Cycocel®	6.2	5.3	1.8	1.6	2.0	1.7	0.2	0.7
SynExp	5.3	4.9	1.8	1.6	2.0	1.3	0.0	0.0
Cycocel® + SynExp	4.6	4.3	1.9	0.9	1.8	1.4	0.0	0.0

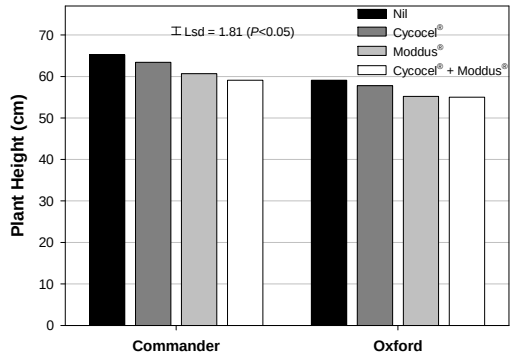

Figure 1: The effect of 4 PGR treatments on plant height of Commander and Oxford at Spring Ridge 2011.

During the early grain fill period minimal lodging was observed in the Gairdner plots at either population or any N rate. For Commander on the other hand there was evidence of lodging observed in all plots. The most severe lodging was recorded at the 120 plants/m^2 population and at the higher N rates. Using a 60 plants/m^2 population reduced lodging severity by approximately 34 % compared to the 120 plants/m^2 population. Increasing N rate generally increased the risk of lodging, however, delaying all N application until GS31 minimised lodging severity to similar levels as the 0 N treatments for both plant populations.

Table 2. Effect of N rate, either applied at sowing (SB) or growth stage 31 (GS31), on lodging severity score (Scale 0-9, where 0 is standing and 9 is flat on the ground) during early grain fill at Breeza.

N Treatment	Commander		Gairdner	
	60 plants/m^2	120 plants/m^2	60 plants/m^2	120 plants/m^2
0 (Control)	1.9	4.1	0.0	0.0
20	2.3	4.3	0.0	0.0
40	3.5	4.8	0.0	0.1
80	4.0	5.4	0.0	0.5
20 SB:20 GS31	1.9	4.6	0.0	0.1
0 SB:40 GS31	2.4	4.0	0.0	0.0

Discussion

Defoliation of Commander was shown to be an effective means of reducing lodging severity, particularly when defoliation was later near stem elongation. Later defoliation has the greater potential to remove crop biomass and to keep the final biomass levels lower. The greater biomass removal reduces shading within the canopy, potentially reducing plant height and can help avoid excessive biomass during stem elongation (Rajkumara 2008). However, care must be taken as defoliation just prior to stem elongation increases the risk

of grain yield penalties, which was observed in our studies. High plant populations increase the risk of lodging. At higher plant populations plants tend to grow taller with smaller diameter stems and there is greater potential for shading within the canopy (Berry *et al.* 2004). Plant populations of 120 plants/m^2 resulted in high levels of lodging severity in Commander compared to the 60 and 80 plants/m^2, however it should be noted that reducing the plant population below 80 plants/m^2 may also result in significant reductions in grain yield. Lodging at high plant populations can be further exacerbated by high N nutrition. High levels of N have been reported to increase lodging due to increased canopy height, increased length of lower internodes, reduce development of secondary roots (anchorage) and increases in the shoot:root ratio (Berry *et al.* 2004; Peake *et al.* 2012; Rajkumara 2008). Delaying N application until stem elongation can be an effective means of minimising the negative impacts of N on lodging. There have been some cases where N application is delayed until ear emergence, however, the later N is applied the greater the risk of driving high grain protein concentration. Of the PGR treatments used in these trials the combination of Cycocel® and Synexp reduced the severity of lodging to the greatest degree. Applying both Cycocel® and Synexp blocks the synthesis of Giberellin (growth hormone) in 2 places as opposed to when a single product is applied, this may explain why this treatment was most effective at reducing crop height (Moes and Stobbe 1991). Responses to the application of PGR products have been highly variable between trial sites and between seasons. The mechanism that influences the efficacy of PGR products is not well understood under dryland conditions in Australia and requires further investigation.

Conclusion

Overall, trials have shown that there are some effective management options available to growers to minimise lodging in Commander. The best bet lodging management practices are:

- Establish plant populations of approximately 80 – 100 plants/m^2, higher plant population may be targeted in high yielding situations but other lodging management practices will also need to be implemented
- Defoliation through grazing can be used to minimise lodging. The closer to stem elongation that defoliation occurs the more effective lodging risk is reduced.
- Avoid paddocks with excessively high soil N at sowing and if possible delay the application of N until stem elongation, where yield can be still increased without driving excessive grain protein concentration.
- PGRs do have the potential to reduce lodging through reduced plant height. A combination of PGR products offers the greatest reduction in lodging severity.
- In high lodging risk situations a combination of management practices may be required.

Acknowledgements
This project is funded by NSW DPI and GRDC under the Northern Barley Agronomy Project (DAN00131). Trial sites provided by Angus Murchison and technical support provided by Stephen Morphett, Alan Bowring, Jim Perfrement, Patrick Mortell, Jan Hoskings and Rod Bambach are gratefully acknowledged.

References

Berry PM, Sterling M, Spink JH, Baker CJ, Sylvester-Bradley R, Mooney SJ, Tams AR, Ennos AR (2004) Understanding and reducing lodging in cereals. In 'Advances in agronomy' pp. 217-271. (Academic Press.

Jedel PE, Helm JH (1991) Lodging effects on a semidwarf and two standard barley cultivars. *Agronomy Journal* **83**, 158-161.

Moes J, Stobbe EH (1991) Barley treated with ethephon: I. Yield components and net grain yield. *Agronomy Journal* **83**, 86-90.

Peake A, Rebetzke G, Chapman S, Dreccer F, McIntrye L, Hundt A (2012) Agronomy for high yielding cereal environments: Varieties, agronomic strategies and case studies. In 'GRDC Goondiwindi Advisor Update'Goondiwindi).

Rajkumara S (2008) Lodging in cereals - a review. *Agricultural Reviews* **29**, 54-61.