Regrowth and grain recovery of spring wheats following early defoliation

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Abstract
The suitability of spring cereals for dual grazing and grain uses is limited by their short vegetative stage compared with winter cereals. However, in some regions only spring wheats are suitable. This experiment examined the effect of timing of defoliation (GS25, GS28 and GS31) on regrowth and grain yield of two spring wheat varieties (short-season *cv*. Longreach Crusader and mid-season *cv*. EGA Gregory). At GS 28, Crusader had produced just 0.8 t/ha biomass, while Gregory had produced 1.7 t/ha. Grain yield and total biomass of both cultivars decreased due to defoliation even prior to GS 30. Grain reduction in Crusader was 6%, 18% and 43%, while it was 11%, 10% and 38% in Gregory corresponding to defoliation at GS25, 28 and 31, respectively. Yield reduction in Crusader was caused by reduced grain number per spike, while in Gregory kernel weight was reduced more. This study shows significant reductions in grain yield due to defoliation prior to GS30 in spring wheat, though it appears there may be variation in ability of spring wheat cultivars to recover after defoliation.

Key Words
Dual-purpose, yield, leaf area, grazing,

Introduction

Dual purpose use of cereal crops is widely practiced all over the world, and the safe grazing window (before GS 30) is essential for ensuring grain yield recovery is maximized (Harrison *et al*. 2011). In most cases winter genotypes are used which require a vernalization before reproductive development begins, but in some regions these long-season varieties are not suitable. For example, in Australia's northern cropping regions crops may not receive the vernalization required, and in strongly Mediterranean climates, early sowing opportunities are rare. Opportunities for grazing spring genotypes and how these crops should be managed to maximize regrowth and grain recovery has received little investigation. In general, spring genotypes are considered less suitable for dual-purpose use than winter genotypes, because the period between when minimum biomass for grazing is attained and the end of the safe grazing window is short and thus the allowable grazing period is brief (Moore 2009). Some studies have shown short-season cultivars to be equally capable of recovering grain yield after cutting to long-season genotypes (Royo and Ramagosa 1996). Exploring the effects of defoliation on spring wheat cultivars and their capacity to recover its growth and grain yield is required to better understand their potential for dual-purpose use in farming systems.

Our hypothesis is the final grain yield will be correlated to the recovery capability of early regrowth immediately after the defoliation. In this experiment different timings of defoliation were imposed on two common spring wheat varieties used in Australia's northern grains region to examine the relationship between crop regrowth and grain yield recovery under conditions where adequate nutrients and water were supplied to ensure these factors did not limit the recovery from defoliation.

Material and Methods

This field experiment was conducted at Gatton Research Station, Queensland (27°54'S, 152°34'E; Elev. 84 m) with adequate irrigation and nutrients (250 kg N/ha) supplied to ensure crop growth was not limited by moisture or nutrient stress. Two spring wheat (*Triticum aestivum*) cultivars, Gregory (mid-season) and Crusader (short-season) were planted on 16 May and 3 June 2011, respectively. The objective of different sowing times was for both varieties to reach anthesis at the same time. Both varieties were sown at a seed rate of 80 kg/ha with a row spacing of 25 cm. Four replicates (2 × 10 m) of four defoliation treatments, cut at GS25, GS28 and GS31 and an uncut control were arranged in a randomized split plot design, with variety as the main plot. The plots were defoliated using a self propelled mower to a height of ~3cm.

Crop biomass, tiller number and leaf number on the main stem were recorded on the day of cutting. Biomass (2 rows x 1m) and leaf area (measured with a Decagon's AccuPAR model LP-80 PAR/LAI Ceptometer) of

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regrowth was measured every 6-8 days after defoliation and compared to the uncut crop. At crop maturity 3 x 1 m rows were sampled, and maturity biomass, number of heads, 100 grain weight and total grain yield were measured.

Results

Forage available and regrowth after defoliation

Forage available for grazing during tillering (GS 25-28) ranged from 0.5~0.8 t DM/ha and 1.2~1.7 t DM /ha for Crusader and Gregory, respectively. The total biomass of each cultivar increased to 2.0 t DM /ha for Crusader and 2.3 t DM /ha for Gregory when harvested after floral initiation (GS 31).

Crop growth rates in the first week after cutting were greatly reduced compared to the uncut controls in the same period (Fig. 1); with the exception of Gregory cut at GS28. For example, the first weeks growth of both cultivars cut at GS25 was significantly reduced by 40-50% compared with the uncut crops over the same period (P<0.05) (i.e. 11 vs 23 kg DM/ha/d in Crusader and 51 vs 81 kg DM/ha/d in Gregory). In general, the rate of regrowth in Gregory was significantly higher than Crusader in the first week after defoliation (P<0.05) but in subsequent weeks its growth rates were much lower. Meanwhile in Crusader, regrowth rates increased as time progressed after cutting. This suggests that Gregory mobilized stored carbohydrates to stimulate early regrowth, but once this was depleted its growth rate was much lower than Crusader. This is seen in the Leaf Area Index (LAI) of the crop after defoliation (Fig 1), with Crusader obtaining much more leaf area than Gregory, especially 4 weeks after defoliation (P<0.05).

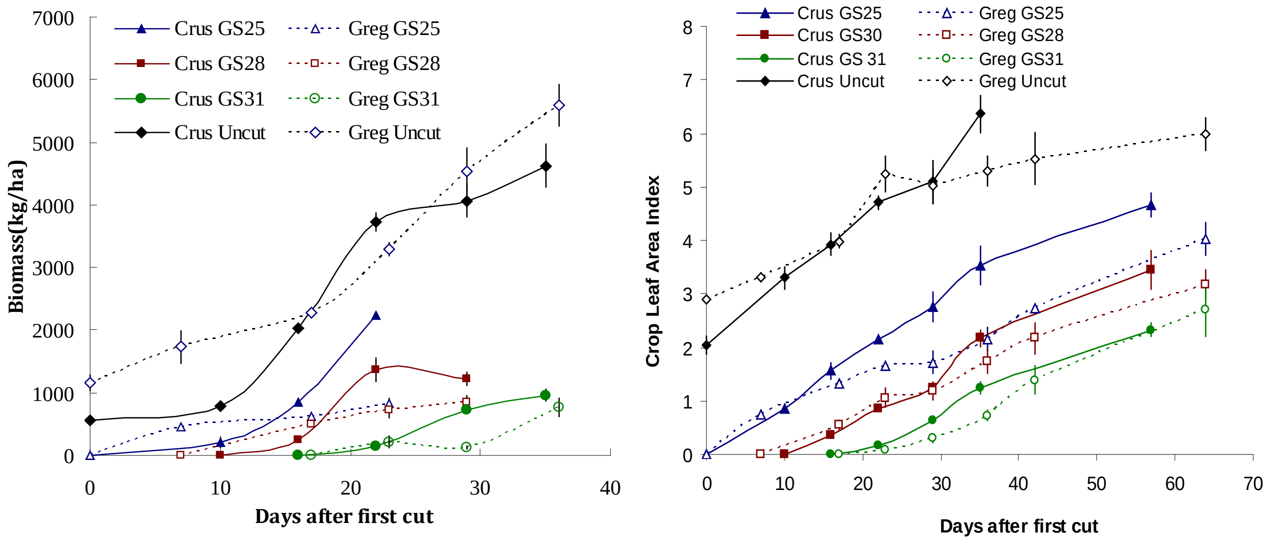

Figure 1. Comparison of biomass (left) and leaf area (right) recovery of two spring wheat cultivars (Crusader and Gregory) after cutting at different growth stages.

Grain yield recovery

In both cultivars, grain yield reduction that occurred after defoliation at GS 25 was not statistically significant compared with the uncut control; grain yield reduction in Crusader was just 6% and 11% in Gregory (Table 1). Defoliation at GS 28 caused a larger decrease in Crusader grain yield (18%) than Gregory (11%) but was not significantly different from the uncut crop (P>0.05). Grain yield was significantly reduced after defoliation at GS 31; 43% reduction in Crusader and 38% in Gregory (P<0.05). The reduced crop biomass at grain maturity was much more than the biomass removed by cutting, indicating that the crop was unable to completely compensate its growth after cutting. Maturity biomass was reduced by 7%, 22% (P<0.05) and 44% (P<0.05) for Crusader and 20%, 21% (P<0.05) and 41% (P<0.05) for Gregory following the defoliation at GS 25, 28 and 31, respectively. The harvest index of Crusader was slightly higher in defoliated treatments, but there was no significant difference between defoliated and uncut crops. However, in Gregory, the harvest index of defoliated crops at GS 25 and GS 28 was significantly increased, but no significant difference was found between defoliation at GS 31 and the uncut crops (P<0.05).
In crops defoliated at GS 25 and GS 28, the main yield reduction occurred due to a reduced number of grains/m^2, kernel size was not significantly different from the uncut crops (Table 2). The yield components that were affected varied between cultivars and defoliation treatments. Defoliation at GS 25 did not affect

spikes/m^2 in Crusader but a significant decrease of 24% was measured in Gregory, though this reduction was compensated by a higher number of kernels/spike. Spike/m^2 was reduced by 12% and 5% when Crusader and Gregory were defoliated at GS 28, though kernels/spike was not significantly reduced. Cutting at GS 31 reduced kernel mass and kernels/spike in both cultivars, though Gregory produced as many spikes as the uncut control. Spike number was reduced by 39% in Crusader.

Table 1. Grain yield and dry biomass at harvest (t/ha) of two spring wheat varieties after mowing at different growth stages compared to an uncut control.

	Grain yield (t/ha)		Total biomass (t/ha)		Harvest index	
Cutting treatment	Crusader	Gregory	Crusader	Gregory	Crusader	Gregory
Uncut	6.24	6.00	14.5	15.1	0.43	0.40
GS 25	5.88	5.35	13.5	12.1	0.44	0.44
GS 28	5.13	5.40	11.3	12.0	0.45	0.45
GS 31	3.53	3.71	8.0	8.9	0.44	0.42
$LSD_{0.05}$	*0.95*	*1.11*	*2.0*	*2.3*	*0.03*	*0.03*

Table 2. Components of yield of two spring wheat cultivars after mowing at different growth stages compared to uncut control.

Cutting treatment	Spikes/m^2		Grain no ('000)/m^2		Kernel mass (mg)		Kernels/spike	
	Crusader	Gregory	Crusader	Gregory	Crusader	Gregory	Crusader	Gregory
Uncut	490	444	77.5	59.6	32	40	40	34
GS 25	492	339	71.6	54.9	33	39	37	41
GS 28	431	424	62.9	57.2	33	38	37	34
GS 31	395	449	47.6	42.7	30	35	30	24
$LSD_{0.05}$	*121*	*104*	*2.9*	*3.4*	*1.2*	*2.6*	*6.2*	*6.3*

Conclusions

The longer-season spring variety Gregory produced more forage than the shorter-season Crusader at the same growth stage, confirming that more grazing might be obtained from longer-season spring genotypes (Moore 2009). This study showed that both spring cultivars suffered a large yield penalty due to cutting prior to GS 30 despite adequate water and nutrition supplies. This may be because the time between defoliation and physiological maturity in short-season cultivars is much less and plants don't get enough time to recover before grain filling begins (Royo 1997). Consequently, to avoid the large grain yield penalties grazing may need to finish earlier in spring varieties than recommended in winter types, though this will further reduce the grazing window available for short-season cultivars. Grain yield reduction after early defoliation was much less in the shorter-season Crusader and the reduction was almost determined by its greater regrowth rate and LAI, which may be due to faster or greater carbohydrate translocation (Fig 1). This response suggests differences between spring varieties in their capacity to recover after grazing.

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