

Wheat morphological defoliation regimes and regrowth potential

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Abstract

Dual-purpose wheat forage yield potential is linked with plant stature and growth habit. An experiment was established at Launceston, Tasmania, to study the relationship between plant structure, forage yield and crop recovery. Four wheat varieties (Tennant, Revenue, Chara and Bolac) were planted in a greenhouse. Five cutting treatments were applied at Zadoks Growth Stage (GS25) or the five-tiller stage to estimate forage yield. These included 'Clipping' at 50% and 75% of leaf length (LL50% and LL75%), and 'Crash' treatments, which were cut at the end or half way along the leaf sheath (LL100% and LS50%), and were compared to an uncut control (C0). Total dry matter was estimated by cutting all treatments to ground level at terminal spikelet (GS31). Plant height was monitored at GS25, fortnightly after GS25 and at GS31. Clipping treatments had positive effects on the plant height and biomass. Compared to the Crash and control treatments, Clipping treatments increased the height of Tennant (25% at LL50% and 17% at LL75%) and Revenue (1.8% at LL50%, 4.4% at LL75%) at GS31. Moreover, Clipping had positive effects on regrowth and increased crop height by 15% when compared to Control treatments. Forage production at GS25 and total biomass yield at GS31 were not significantly influenced by cutting treatment or variety. This study has shown that Crash treatments produced greater forage yield than Clipping, but the former generally reduces final recovery and biomass. We found that irrespective of growth habit, wheat plants defoliated at mid tillering can potentially produce more forage than unclipped plants followed by a rapid increase in plant height, provided plants are clipped above the leaf sheath.

Keywords

Clipping, Defoliation, Forage dry matter, Regrowth.

Introduction

In dual purpose crop management systems, crops have a longer vegetative phase compared with grain only systems, which maximises plant biomass available for grazing or cutting as forage (Redmon et al. 1996). Crash defoliation has more potential for forage yield but higher risk of less regrowth compared with light grazing, which produces lower forage utilisation but better regrowth potential (Seymour et al. 2015). Besides defoliation intensity, crop growth stage is equally important for crop final yield, since defoliation after terminal spikelet (GS31) increases the chances of crop meristematic apex removal and thus loss of viable grain tillers (Harrison et al. 2011). Moreover, it is believed that crop regrowth and grain yield of defoliated crops are dependent on post-defoliation leaf area development (Winter and Thompson 1987). Past studies have mostly focused defoliating dual purpose crops based on height from the ground. Therefore in this experiment the response of plant height, forage and total biomass accumulation were investigated based on morphology, by defoliating plants by cutting at consistent proportions along the leaf and sheath lengths. Such research will enable a better understanding of the threshold point of defoliation from the tip of the plant to the ground level by identifying the safe zone for defoliation at mid tillering stage.

Methods

Experiments were conducted at the Mt Pleasant laboratories (Lat 41.46°S, Lon 147.14°E), Launceston, Australia. To ensure cutting treatments were replicable, hand defoliation was conducted instead of animal defoliation. This study investigated the relationship between defoliation heights and dry matter (DM) production. Zadoks Growth Stage (GS) (Zadoks et al. 1974) was used as a standard for applying treatments and data recording. Treatments are shown in Table 1. These include "Clipping" (a proxy for lighter defoliation by only removing leaf segments with respect to GS) and "Crash defoliation" (a proxy for heavy defoliation from ground level to the middle or end of the leaf sheath). Four wheat cultivars (Bolac, Revenue, Chara and Tennant) were grown from sowing to stem elongation (8 weeks) in a glasshouse experiment planted on 21st July 2015. Twelve seeds of each variety were sown in pot (pot size: 12 cm diameter) filled

with pine bark quartz sand potting mixture. These were reduced to 10 plants per pot before any treatments were applied. Plant height was recorded on three occasions before biomass was cut; first at GS25, second 14 days after application of treatments at GS25, and last at GS31, when taking the final biomass cut. Forage dry matter and total biomass were determined by drying samples overnight at 56°C.

Table 1. Details of the treatment applied according to morphological position.

Treatment	Description	Defoliation category
C0	Control	Uncut
LL50%	Cut 50% of leaf length	Clipping
LL75%	Cut 75% of leaf length	Clipping
LL100%	Cut at point where leaf sheath ends	Crash
LS50%	Cut at 50% of leaf sheath length	Crash

Results

No significant differences were observed in plant height at GS25 among varieties and treatments. However, significant differences were found among genotypes and cutting treatments for plant height at GS31 (Figure 1). At GS31, mean heights of LL50% (50.7 cm), LL75% (50.3 cm) and the uncut treatment (49.4 cm) were not significantly different, whereas LS50% was reduced (39.3 cm). At GS31, the height of Tennant under the LL50% and LL75% treatments (50.1 cm, 47 cm) and Revenue (43.8 cm and 44.9 cm) were greater than uncut controls, whilst a decline in the height of other cultivars was recorded for the LS treatments. Changes in plant height from GS25 to GS31 were significantly different across treatments and varieties. Clip treatments (LL50% and LL75%) grew 15% more in height compared to the control, whereas the Crash treatment of LS50% reduced the plant height by 36%. Bolac and Chara showed significantly higher regrowth potential with respect to plant height compared with Revenue and Tennant.

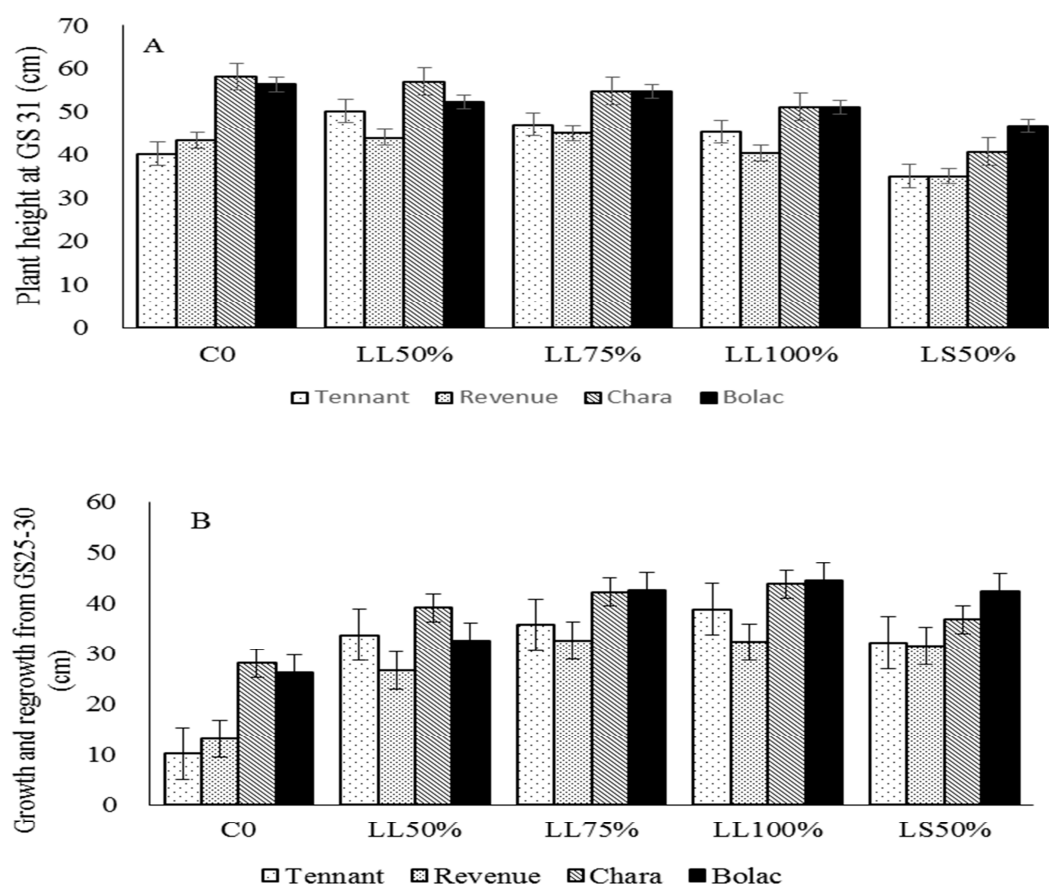


Figure 1. Plant height (cm) of wheat at GS31 (A) and growth (control) or regrowth from GS25 to GS30 (B) subjected to four cut and one control treatment during the growing season from 21st July 2015 to 19th September 2015 at Launceston, Australia.

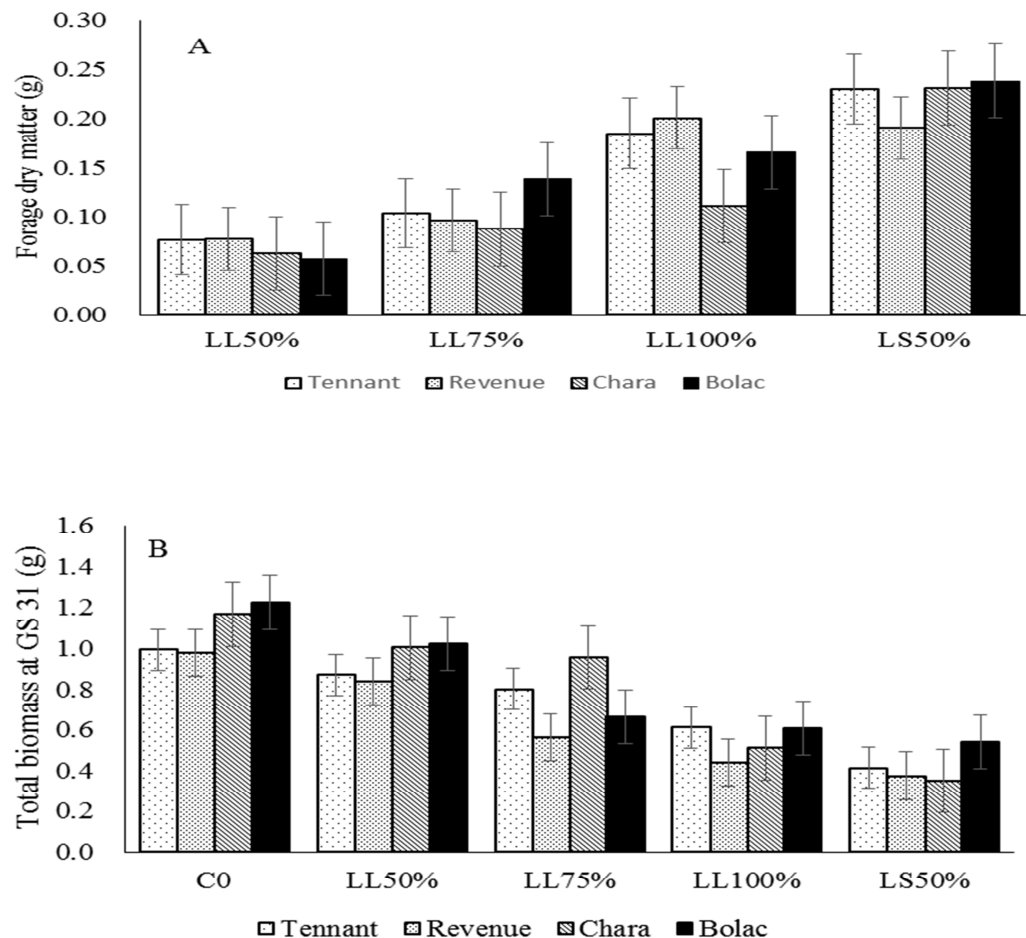


Figure 2. Forage dry matter at GS25 (A) and total biomass at GS31 (B) subjected to four cut and one control treatment during the growing season from 21st July 2015 to 19th September 2015 at Launceston, Australia.

Forage dry matter cut at GS25 was significantly affected by the main effects of cutting treatment and cultivar (Figure 2), whereas there was no significant interaction between cutting treatment and cultivar. However, there were differences in the amount of forage removed within cultivars across cutting treatments, as well as across cultivars but within individual cutting treatments. LL50% and LL75% (0.07 and $0.11 \text{ g plant}^{-1}$) removed less forage dry matter per plant compared with LL100% and LS50% (0.17 and $0.22 \text{ g plant}^{-1}$). At GS31, the control treatments had accumulated the highest total biomass plant^{-1} , among which Bolac ($1.23 \text{ g plant}^{-1}$) and Chara ($1.27 \text{ g plant}^{-1}$) had accumulated the most. Similarly, Bolac and Chara were not significantly affected by Clipping at LL50% compared to the Control treatment. Moreover, defoliating 50% and 75% of leaf length reduced the total biomass from 18 to 20%, whereas cutting below the ligule (LS50%) reduced the total biomass yield more than 100% compared to control. The interaction between treatments and cultivars were found non significant.

Discussion and Conclusions

The plant height at GS25 for all the varieties was found to be non significant, with all varieties responding similarly to environmental conditions (Johnson 1953). Moreover, lighter defoliation treatments (Clipping) had higher plant height than uncut at GS31 cf. Crash treatments. This may due to the reason that apical meristems were not removed in clipping (Virgona et al. 2006). Similarly, clipping at LL50% and LL75% had positive effects on regrowth as the plants of the clipped treatments were taller than heights of control plants, indicating compensatory growth, though this was not reflected in amount of biomass regrown at GS 31. Cutting plants below the leaf sheath affected the regrowth and the total plant biomass at GS31 when comparing Clipped and Crash treatments. This is likely because the amount of photosynthetic tissues removed with Clipping was less than that removed for the Crash treatment, and so the recovery of plants

with leaves removed as opposed to leaf sheaths significantly influenced regrowth capacity (Seymour et al., 2015).

At GS 25 the varieties clipped at LL50% and LL75% resulted in a relatively less forage yield than Crash treatments (LL100%, LS50%). This is because of the difference in cutting height due to the arrangement of cut positions as only expanded leaves were cut (photosynthetic material removed, explained above) in the Clipped treatment, whereas in the Crash treatments, unemerged leaves were also cut. It is possible that assimilate and carbohydrate stored in the stem as well as greater photosynthetic area of Clipped plants allowed greater regrowth compared to Crash treatments (Ehdaie et al. 2006; Richards 2000). Immediate recovery post Clipping would be by greater expansion of any growing leaves rather than faster rate of new leaf development, hence regrowth ends up taller but with similar total leaf area. However, Crash plants do not have sufficient resources to completely recover.

All treatments except LS50% did not affect total biomass significantly. The same amount of dry matter for all cutting treatments at GS31 might be due to greater growth at an early crop stage (Tian et al. 2012). The decision of stock removal from a crop depends on factors like growth stage, stocking rate, climatic conditions and crop management. For optimal crop development after defoliation, low and light stocking rate are recommended (Harrison et al. 2012). Grazing longer increases the risk of poor crop recovery. We found that at the plant-level, although significant differences in height may exist due to defoliation, differences due to cutting according to plant position were small. This indicates that for growth stages prior to GS31, using plant height as a proxy for biomass in monitoring grazing of field crops may be a reliable method subject to complete knowledge of plant growth habit and reproductive stage for termination of defoliation.

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