Spring regrowth of lucerne is affected by the level of winter perennial reserves.

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Abstract

To understand the effect of lucerne perennial biomass (crown and taproots) on yield during the first spring regrowth, a two year old 'Kaituna' lucerne crop was grazed at 28 or 42–day intervals during the 2002–2003 growing season. By the end of autumn (02 June 2003) when shoot growth was negligible, perennial biomass was 3.2 and 5.2 t DM ha^{-1} in the 28 (low reserve; LR) and 42–day (high reserve; HR) crops respectively. Spring dry matter yield from LR was about half that of HR throughout the first regrowth period with 3000 kg ha^{-1} in HR by 30 September 2003. At this time green area index (GAI) was 3.5 for HR and 1.6 for LR crop. This difference was due to a 40% reduction in the size of primary leaves and a 70% decrease in axillary leaf area for LR. Stem population and leaf appearance rate were unaffected during the first spring regrowth cycle. These results indicate that winter perennial reserves must be considered when predicting spring DM production with crop simulation models.

Media summary

Optimum spring lucerne yield depends on maximizing crown and root reserves of the crop during autumn-winter period.

Key Words

leaf area index, *Medicago sativa*, root reserves.

Introduction

Lucerne (*Medicago sativa* L.) biomass production is closely related to the amount of radiation that the crop intercepts (Gosse et al., 1984). This interception is driven mainly by canopy expansion, quantified as green area index (GAI), during a growth period. These relations are integrated in agricultural crop models, like APSIM-lucerne, to simulate seasonal shoot yield (Moot et al., 2001; Robertson et al., 2002). However, GAI expansion depends on C and N reserves stored in lucerne perennial organs (Avice et al., 1997) which are not considered in APSIM–lucerne (Zahid et al., 2003). Furthermore, GAI is the product of morphological (stem population and leaf size) and developmental (leaf appearance rate and branching) components and the influence of perennial biomass on each of these components deserves further investigation (Brown, 2004). The objective of this research was to quantify the influence of two contrasting levels of perennial biomass on spring DM production and its components during the first spring regrowth cycle of a lucerne crop.

Methods

To create two contrasting levels of perennial biomass (crown and taproots) a two year old irrigated 'Kaituna' lucerne crop was grazed at 28 or 42–day intervals from 15 September 2002 to 12 June 2003. The experiment was conducted at Lincoln University, Canterbury, New Zealand (43°38'S, 172°28'E, 11 m a.s.l), in a randomised complete block design with 4 replicates giving 16 plots of 315 m^2. On 12 June 2002 both crops were grazed and trimmed to 50 mm above ground when shoot growth had ceased. Perennial biomass (crowns and taproots) was sampled from a 0.2 m^2 area to 0.3 m depth on 02 June 2003. The 42–day crop had 5.2 t DM ha^{-1} of perennial biomass compared with 3.2 t DM ha^{-1} in the 28–day crop. Therefore, these treatments were defined as high (HR) and low (LR) perennial reserves, respectively. Shoot yield was measured from 0.2 m^2 quadrats harvested at crown level fortnightly from 1 July to 28 August 2003 and weekly after that. The LR crop was harvested on 14 September. A 1 m^2

exclosure area was maintained for phenological measurements. Therefore, the last shoot data point for the LR crop (30 September 2003) was estimated from linear regression (R^2=0.84) of DM against stem height from this area. From August 2003, GAI was measured weekly using a LAI-2000 canopy analyser (LI-COR Inc., Lincoln, USA). Main stem nodes and stem height were measured on five marked stems in each plot. On the final harvest (1 October 2003), five stems per replicate were sampled and the area of primary and axillary leaves were measured at each individual node position by digitally photographing detached leaves and analysing images with the software 'QUANT' (Vale et al., 2003). The height of each individual main stem node from the stem base was also measured to describe stem extension per node.

Results

The final DM from the HR crop was ~3000 kg ha^{-1} by the 30 September 2003 compared with an estimated value of 1500 kg ha^{-1} for LR. Both treatments showed an exponential increase in DM from the beginning of August but the HR crops always yielded about twice as much as LR (Figure 1a). A similar pattern was apparent in GAI, which was 3.5 in HR and 1.6 in LR by the end of the rotation (Figure 1b). The lower GAI was caused by smaller primary leaves above node 5 and a reduced contribution from axillary leaf area (Figure 2). Leaf area was 4600 and 2700 mm^2 stem^{-1} for HR and LR respectively. Furthermore, the node height from LR crops was about half of HR crops in the end of the rotation (Figure 3). In contrast, the stem population (~550 m^{-2}) and leaf appearance rate (~9 leaves stem^{-1}) were similar between treatments.
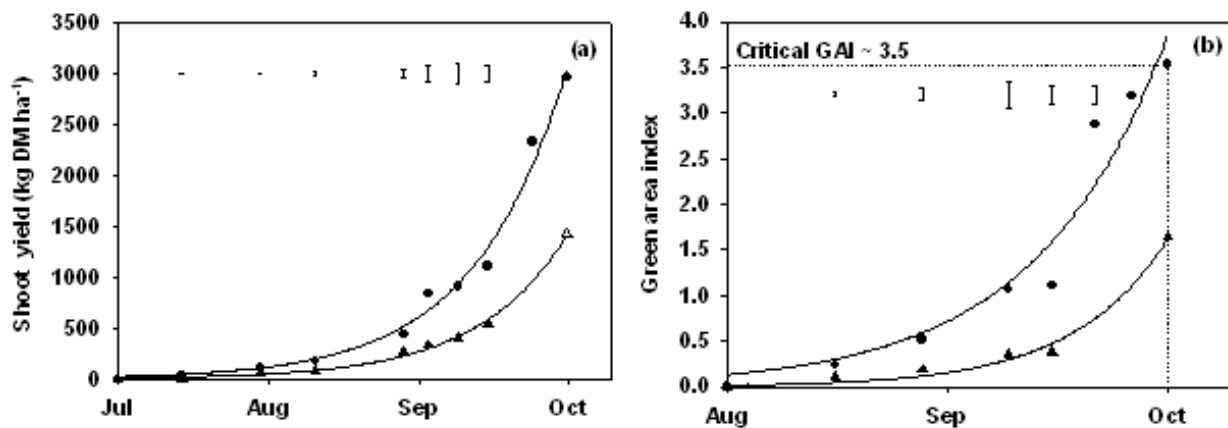

Figure 1. Shoot yield (a) and green area index (b) of lucerne crops with high (●) or low (▲) crown and taproot biomass, grown at Lincoln University, Canterbury, New Zealand. Open triangle (△) is estimated from regression of biomass against stem height in LR treatment (R^2=0.84). Bars are pooled SEM. Exponential regressions are y=23*exp(0.05*x), R^2=0.98 (a, HR); y=9.5*exp(0.06*x), R^2=0.99 (a, LR); y=0.13*exp(0.07*x), R^2=0.94 (b, HR); and y=0.015*exp(0.08*x), R^2=0.99 (b, LR).

Discussion

The consequences of low winter perennial reserves were reflected in the initial spring regrowth of lucerne crops. Crops with higher reserves produced more shoot DM during spring as a consequence of greater radiation interception, specifically due to increased leaf area from primary and axillary leaves. It seems likely that during this early spring period the HR crops remobilised a greater amount of stored C and N to enable rapid canopy expansion. This would allow greater light interception for the HR crops throughout the rotation. This is particularly important in early spring when GAI is below critical (Figure 1b) and temperatures are cool and therefore node appearance is slow due to a slower thermal-time accumulation. The conservative results for leaf appearance and stem population indicate that differences were mainly attributed to the growth components of canopy expansion. The implication is that successful crop simulation of lucerne needs to consider levels of winter perennial reserves and the impact on potential

spring DM production. Additionally, studies comparing lucerne varieties with contrasting levels of winter-activity and grazing tolerance would allow the quantification of intra specific variation in the responses to different levels of perennial reserves.
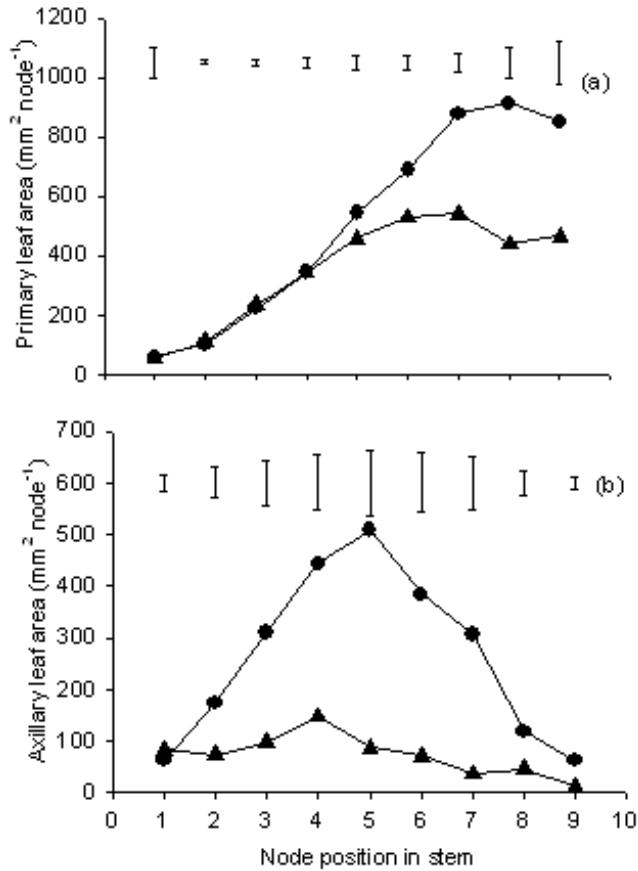

Figure 2. Leaf area per node position of (a) primary, and (b) axillary leaves of lucerne crops with high (●) or low (▲) crown and taproot biomass, grown at Lincoln University, Canterbury, New Zealand. Bars are pooled SEM.
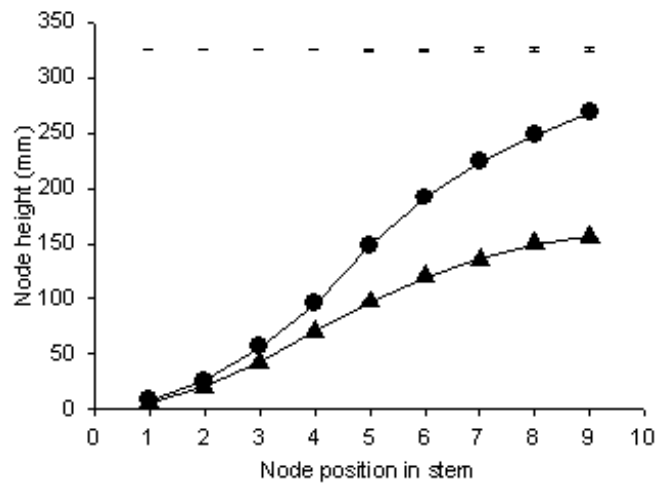
Figure 3. Node height of stems of lucerne crops with high (●) or low (▲) crown and taproot biomass, grown at Lincoln University, Canterbury, New Zealand. Bars are pooled SEM.

Conclusions

Lucerne canopy expansion during the first spring regrowth was reduced in crops with a limited amount of crown and taproot biomass. Reduced GAI was a consequence of reduced leaf expansion in primary and axillary leaves. Leaf appearance rate and stem population were not affected by perennial biomass. These results indicate that the growth components of the crop (leaf area expansion and stem elongation) were most affected by perennial reserves during spring regrowth cycle. As a consequence there is a need to integrate the role of perennial reserves in lucerne simulation crop models.

Acknowledgements

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