Lucerne canopy expansion in spring was affected by the level of winter root reserves.

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Abstract

The effect of different winter levels of lucerne root biomass on the following spring regrowth was studied in a 'Kaituna' lucerne crop grown in Canterbury, New Zealand. To induce the different levels of root biomass, crops were subjected to a consistent 28 or 42-day regrowth interval in 2002/03. Annual shoot dry matter yield was 23 t/ha in the 42-day crop but only 14 t/ha in the 28-day crop. Root biomass in the 28-day crop was also reduced by ~33% compared with the 42-day crop, which had 5.0 t/ha of root dry matter in June 2003. In the subsequent spring regrowth shoot yield in the 28-day crop was half that of the 42-day crop. This was caused by low rates of leaf expansion in the 28-day crop, which reduced radiation interception. Treatments caused no significant effects on shoot population or branching and both crops had a similar high radiation use efficiency of 1.64 g DM/MJ PAR.

Key words

alfalfa, *Medicago sativa*, modelling, morphology, root reserves.

Introduction

Shoot yield of lucerne (*Medicago sativa* L.) can be analysed as the product of the accumulated intercepted photosynthetic active radiation ($\sum PAR_i$, MJ/m^2) and the radiation use efficiency (RUE, g DM/MJ PAR_i) for aerial biomass. This framework is often used as the basis of computer simulation models, including lucerne in APSIM-Lucerne (Robertson *et al.*, 2002). The $\sum PAR_i$ is a function of canopy development, quantified as the leaf area index (LAI). LAI expansion is dependent on node development (i.e. leaf appearance rates and branching) and individual leaf expansion (Brown *et al.*, 2005). In lucerne, the level of carbon and nitrogen reserves in roots also modulates shoot growth rates, especially during early-spring regrowth. However, it is not clear wether limited levels of root reserves affect shoot yield by changing: (i) LAI development and/or (ii) RUE. This information is essential to improve the accuracy of model predictions. The aim was to determine if LAI expansion or RUE in early-spring were affected by root biomass in winter.

Materials and methods

To induce different levels of root biomass, a two year old fully irrigated 'Kaituna' lucerne crop was subjected to 10 grazing cycles of 28 days (28-day crop) or 7 grazing cycles of 42 days (42-day crop) from 12 June 02 to 10 June 03. Treatments were arranged in a randomized complete block design with four replicates (315 m^2) at Lincoln University, New Zealand (43?38'S and 172?28'E). Annual shoot dry matter yield in the 2002/03 growth season was 23 t/ha in the 42-day crop but only 14 t/ha in the 28-day crop with shoot population at a similar ~780 shoots/m^2 in both crops (Teixeira, 2006). In the following winter (02 June 03), root biomass (300 mm depth) was 5.0 t/ha in the 42-day crop but ~30% lower for the 28-day crop (Teixeira *et al.*, 2006). Shoot yield, radiation interception and the main LAI components (shoot population, leaves per shoot and individual leaf area) were measured during the following winter/spring regrowth (11 June 03 to 15 September 03). Bell-shaped functions were used to describe differences in individual leaf area with node position.

Results and discussion

Accumulated early-spring shoot yield in the 42-day crop was twice ($P<0.05$) that of the 28-day crop by 14 September 03 (Figure 1). Nevertheless, in both crops shoot dry matter (DM) was produced at a similar

RUE of 1.64 g/MJ PAR_i. This implies that neither net carbon assimilation nor DM partitioning were affected by the limited levels of root biomass of the 28-day crop. The differences in shoot yield between crops were mostly (R^2=0.96) explained by the amount of intercepted PAR (Figure 1). The low $\sum PAR_i$ in 28-day crops was explained by the slower LAI development caused by limited levels of root biomass in these crops. The slower LAI development in the 28-day crop was caused by smaller individual primary and axillary leaves after the 4-5th node position (Figure 2 a). This was expressed as a reduction in the parameter Y_0, which represents the largest leaf area per main-stem node position. The position of the largest leaf (X_0) was similar ($P<0.16$) in both treatments, being nodes 7-8 or 4-5 for primary and axillary leaves, respectively. The shoot population was 540 shoots/m^2 on 14 September 03 for both treatments ($P<0.30$). At this time, there were 10 expanded primary leaves in the 42-day crop, one more ($P<0.05$) than in the 28-day crop. Branching pattern was unaffected ($P<0.60$) by the level of root biomass with crops exhibiting a similar exponential increase (R^2=0.98) in the total number of leaves (Figure 2 b).

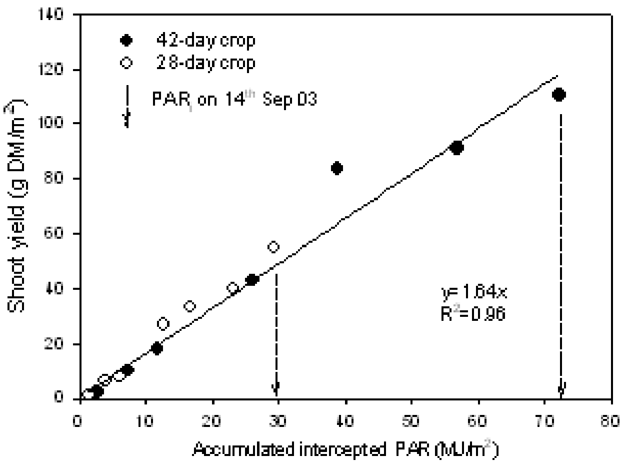

Figure 1. Shoot dry matter yield and the amount of intercepted photosynthetic active radiation (PAR) during the early-spring growth of lucerne crops grazed previously with 28 or 42-day regrowth interval.

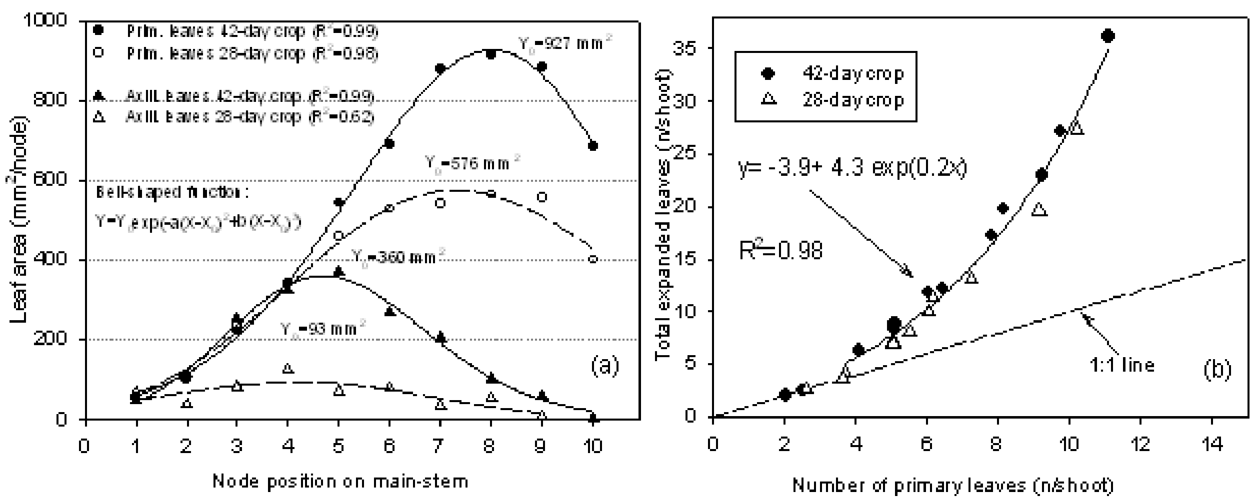

Figure 2. The (a) area of individual primary and axillary leaves at each main-stem node position on early-spring and; (b) total number of expanded leaves (primary and axillary) in relation to main-stem leaves (primary) of lucerne crops subjected to 28 or 42-day regrowth cycles.

Conclusions

Early-spring shoot yield of lucerne crops were reduced by low levels of winter root biomass. Reduced levels of root biomass limited the expansion of individual leaves on primary and axillary nodes. This then limited LAI development and reduced PAR interception. Other LAI components had a minor influence on yield differences and RUE was similar in both crops. These results indicate that lucerne models should allow for the effect of root reserves on leaf expansion.

References

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