Seasonal changes in root dry matter and N content of lucerne crops under contrasting defoliation regimes

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Abstract

Lucerne shoot growth is reliant on the mobilization of N from root reserves. The level of total root N (TN, kg/ha) in a crop is the product of root dry matter (DM_{root}, kg/ha) and their N concentration (N%). The seasonal responses of DM_{root} and N% to either a long (42-day) or short (28-day) defoliation cycle were investigated throughout two years in a 'Kaituna' lucerne crop in Canterbury, New Zealand. The DM_{root} differed seasonally with the highest levels of >5.0 t/ha observed in autumn for the 42-day crop compared with 3.5 t/ha in the 28-day crop. The N% showed a similar seasonal pattern decreasing from 1.8% in winter to a summer value of 1.4% in the 42-day crop and 1.0% in the 28-day crop. In both crops, N% increased during autumn but was 20% lower in the 28-day crop. In the 42-day crop, the combined seasonal effect of N% and DM_{root} gave an increase in TN from ~40 kg/ha in summer to >80 kg/ha in autumn. In contrast, TN did not recover above 40 kg/ha in the 28-day crop.

Key words

alfalfa, *Medicago sativa*, grazing, below-ground reserves.

Introduction

In lucerne crops (*Medicago sativa* L.), the level of total root nitrogen reserves (TN, kg N/ha) is a major determinant of shoot regrowth rates after defoliation and early-spring growth in temperate climates (Avice *et al.* 1997b). After defoliation, N reserves are mobilized from roots to meet the demand imposed by regrowing shoots. TN is the product of the N concentration of roots (N%) and root biomass (DM_{root}). At non-limiting availability of N (i.e. N_2 fixation or soil mineral levels), root N% is influenced by defoliation frequency (Avice *et al.* 1997a) and season of the year (Cunningham and Volenec, 1998). Overall, N% drops in response to frequent defoliations and during early-spring when N uptake and fixation are limited by low temperatures and endogenous N is mobilized from roots to shoots. However, the seasonal pattern of accumulation and depletion of DM_{root} requires further investigation in response to defoliation frequency. Thus, the objective of this research was to assess the seasonal variation in TN through the measurement of both DM_{root} and N%.

Methods

The experiment was conducted at Lincoln University, Canterbury, New Zealand (43?38'S, 172?28'E) in a ?Wakanui? deep silt loam soil where a two year old fully irrigated 'Kaituna' lucerne crop was established. Soil moisture deficit was maintained <150 mm to a depth of 2.3 m. Defoliation treatments were imposed as a short (28-day: 3 days grazing + 25 days regrowth) and a long (42-day: 4 days grazing + 38 days regrowth) regrowth cycle for two growth seasons (2002/03 and 2003/04). This gave 7 harvests/year for the 42-day crop and 10 harvests/year for the 28-day crop. Crops were grazed by sheep of mixed ages at variable stocking rates to maximize the removal of shoot DM. The residual of grazing was mowed to ~50 mm above ground. Treatments were set out in a randomized complete block design (4 replicates) with 315 m^2 plots. Root dry matter (DM_{root}) was determined from one 0.2 m^2 quadrat sample per plot where crowns and taproots were excavated to a depth of 0.3 m. Kjeldahl N% was analysed in taproots to calculate TN.

Results and discussion

The annual shoot DM yield was on average 23 t/ha for the 42-day crop and 12 t/ha for the 28-day crop. Taproot dry matter (DM_{root}) was depleted during winter/spring and accumulated throughout mid-summer/autumn in both treatments (Figure 1a). In September 2002, before treatments were applied, the DM_{root} was ~3.0 t/ha in both crops. For the 42-day crop, the DM_{root} then increased to 5.0 t/ha in May 2003 before declining to ~4.0 t/ha in Nov 2003. This loss of DM_{root} during winter/early-spring could be attributed to (i) the low levels of DM partitioning to roots at this period, (ii) the high mobilization of root reserves in spring and (iii) the rate of root maintenance respiration (Teixeira, 2006). The DM_{root} of the 42-day crop then increased to >5.0 t/ha in summer/autumn before a further winter decline. The same pattern was observed in the 28-day crop but DM_{root} ranged from 2.5 to 3.5 t/ha. The significant decrease in the levels of DM_{root} of 28-day crops could be explained mostly by a reduction in the amount of intercepted solar radiation caused by incomplete canopy cover in frequently defoliated crops (Teixeira, 2006).

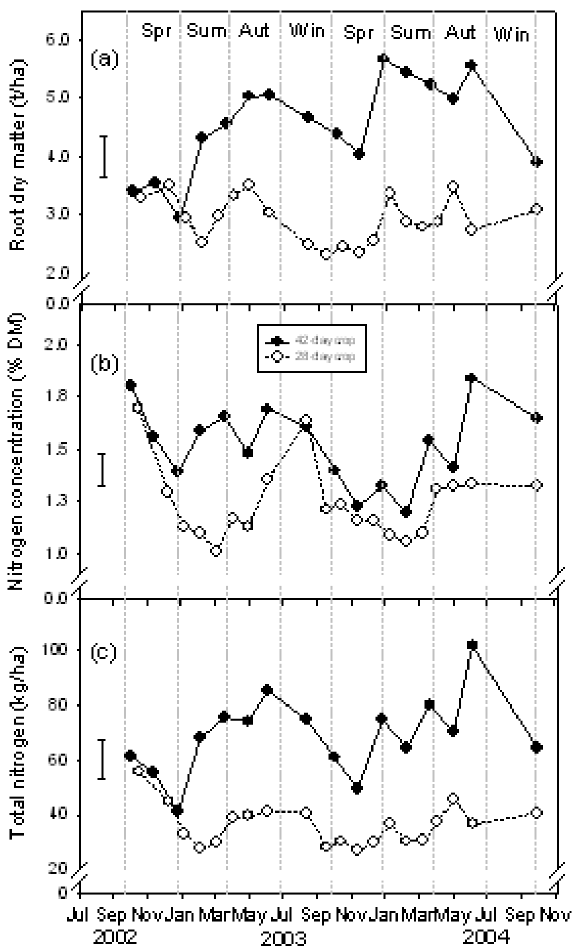

Figure 1. Seasonal variation of a) taproot dry matter (DM_{root}), b) nitrogen concentration (N%) and c) total root nitrogen (TN) in lucerne crops subjected to 28-day (○) and 42-day (●) grazing rotation. Bars indicate one SEM.

The highest concentration of nitrogen in taproots (N%) was ~1.8% in autumn/winter but decreased through spring in both crops. The N% in the 42-day crop decreased to a minimum of 1.3% in summer before increasing again to 1.8% in autumn. In contrast, the decline in N% in the 28-day crop progressed until a minimum of ~1.0% was achieved in March and only recovered to 1.3% by May (Figure 1b). As a consequence of the combined changes in DM_{root} and N%, the TN increased ($P<0.05$) from ~40 kg/ha in summer to >80 kg/ha in autumn in the 42-day treatment but was always less than 40 kg/ha in the 28-day treatment. The decline in N% and TN in the 28-day treatment indicates that these crops were not able to replenish root reserves through mineral uptake or N_2 fixation.

Conclusions

Taproot nitrogen reserves (TN) differed seasonally and increased two fold from summer to autumn in 42-day crops. This was caused by an increase in both the N concentration in taproots (N%) and the mass of the taproots (DM_{root}). The similarity in the direction of response of DM_{root} and N% to environmental signals and defoliation managements suggests the inclusion of both variables is required to accurately assess shoot growth rates. In temperate climates, frequent defoliations should be avoided during mid-summer/autumn to increase TN reserves and maximize the following early-spring regrowth.

References

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