The effect of defoliation severity during late autumn on herbage production, regrowth and nitrogen uptake of diverse pastures in Canterbury, New Zealand

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Abstract

Pasture management strategies are sought to reduce nitrate leaching by enhancing nitrogen (N) uptake over the winter period. The objective of this study was to determine the effect of five post grazing heights on herbage production, and N uptake of a diverse pasture mixture containing perennial ryegrass, white clover, chicory, plantain, and lucerne during the late autumn/winter season. In late autumn, pastures were defoliated to five residual heights (20, 30, 40, 50, 60 mm), and herbage dry matter (DM) and N accumulated over a 112 d regrowth period was measured. Swards defoliated to 20, 30 and 40 mm accumulated more herbage above ground level (1884, 1508, 1322 kg DM/ha, respectively) than those defoliated to 60 mm (1289 kg DM/ha) over 112 days. Repeated measures analysis on herbage N concentration showed a significant interaction (P=0.012) of defoliation treatment with time. For the 20 mm defoliation, N concentration increased over time from 18.8 to 29.7 g N/kg while for the 60 mm defoliation, decreased from 26.1 to 24.9 g N/kg during the regrowth period. During this 112 d regrowth period, pastures defoliated to 20 mm accumulated more DM and more N than plots defoliated to 60 mm (56 vs. 32 kg N/ha, respectively). The results indicate grazing severely to post grazing heights <40 mm may improve growth and N uptake in the late autumn/winter.

Keywords: grazing, winter, nitrate leaching

Introduction

In southern parts of New Zealand, animal demand is at its highest relative to new pasture growth in early spring and winter pasture management has a significant impact on the early spring feed supply and pasture growth. While increased summer growth has been demonstrated with diverse pastures containing chicory and plantain (Nobilly et al., 2013), the effects of increased DM production is more valuable in late autumn or winter as less feed is available, and strategies are needed to increase herbage DM production in these time periods.

Nitrate leaching is an important environmental factor in livestock production in temperate pastures with leaching losses often high in the autumn/winter. Urinary N concentration and total urine excretion are key drivers leading to high N loading in a urine patch and consequently nitrate (NO_3^-) leaching (Moir et al., 2013). Herbs such as chicory and plantain, when included in a diverse pasture mix, have been suggested as a tool to reduce nitrate leaching losses in grazed pasture systems (Sanderson et al., 2004). Reduced N leaching from diverse pastures is achieved either by capturing N in soil (Malcolm et al., 2014) or reducing urinary N excretion in cows (Totty et al., 2013). Pastures which grow rapidly after defoliation may have greater potential to increase N uptake during the late autumn period, thereby reducing the risk of nitrate leaching. One of the important factors affecting regrowth after defoliation is post grazing height (Brougham, 1970). The objective of this experiment was to determine the effect of five post grazing heights on herbage production, regrowth and N uptake of a diverse pasture mixture during the late autumn and winter season.

Materials and Methods

The experiment was conducted between May and September 2015 (late autumn-end of winter) at the Lincoln University Research Dairy Farm (LURDF) in Canterbury, New Zealand (43°38S', 172°27E'). The experimental site was established on 17 October 2013, when it was drilled with diverse pasture species (*i.e.,* perennial ryegrass, white clover, lucerne, chicory, plantain; Table 1) following cultivation. In April 2015, a month prior to the experiment, the plots were grazed by cows to a compressed height of 35 mm and N was applied at a rate of 25 kg N/ha as urea. Four blocks of five plots (20 plots in total; 2x4 m each) were defoliated by a rotary mower in May to five defoliation heights (20, 30, 40, 50, 60 mm) in a randomised block design.

Table 1. Plant species, cultivar and sowing rate of diverse pasture mixtures for the defoliation severity trial during the autumn-winter season

Species	Common name	Cultivar	Sowing Rate (kg/ha)
Lolium perenne	Perennial ryegrass	Arrow AR1	12.0
Trifolium repens	White clover	Weka	3.0
Medicago sativa	Lucerne	Torlesse	8.0
Cichorium intybus	Chicory	Choice	1.5
Plantago lanceolata	Plantain	Tonic	1.5

Herbage sampling and measurements

Regrowth

Regrowth for all treatments was measured at 0, 22, 41, 64, 90 and 112 days after defoliation treatments in May, by cutting all herbage to ground level in three quadrats (0.2 m^2) per plot using electric hand shears. Herbage samples were dried at 60°C for 48h and weighed. Samples were passed through a 1mm sieve using a ZM200 rotor mill (Retsch Inc., Pennsylvania, USA) and analysed for N% using near-infrared spectroscopy (NIRS).

Final herbage yield

On day 112 a strip (0.45 m x 3 m) within each sub-plot was harvested to a consistent height of 35 mm using a push mower and the fresh weight from each catcher was recorded. . A subsample (approximately 200g fresh weight) was taken and dried at 60°C for 48h for determination of DM content and N% by NIRS. Herbage yield (kg DM/ha) was calculated as fresh weight x DM% x area. Herbage yield was multiplied by N% of herbage to calculate N uptake in each plot. These data were used to estimate the amount of herbage that would be harvested by dairy cows when pastures are grazed to a constant height in spring.

Statistics

The effects of defoliation severity on DM production, botanical composition and nutritive value were analysed by a repeated measures ANOVA with 5 treatments (20, 30, 40, 50, 60 mm), day as a repeated-measure and 4 replicates for regrowth interval. Polynomial contrasts were embedded in the ANOVA treatment structure to test for linear trends with defoliation heights and the final regrowth period. All statistical analyses were performed using GENSTAT 16 (VSN International).

Results

Mean weather data, including 24 h max and min temperatures (°C), radiation (MJ/m^2), soil temperatures (°C) and total regrowth interval rainfall (mm) were recorded over the trial period at a weather station less than 1 km from the trial site and presented in Table 2.

Table 2. Mean regrowth weather data for the experimental period

	Regrowth period				
	Days 0-22[a]	Days 22-41	Days 41-64	Days 64-90	Days 90-112
Maximum air temperature (°C)	14.1	12.3	11.7	12.6	11.8
Minimum air temperature (°C)	2.6	1.6	1.1	1.7	3.1
Radiation (MJ/m^2)	5.6	4.9	5.2	7	7.6
Soil temperature at 100 mm (°C)	5.9	4.3	3.3	4.2	5.8
Total rainfall (mm)	17.6	55.2	25.6	36.2	15.2

[a]Regrowth beginning May 14, 2015

Accumulation of herbage DM, from the five mowing heights, is shown in Figure 1. Post grazing residuals at time of mowing (day 0) ranged from 400 kg DM/ha for the 20 mm residual to 900 kg DM for the 50 and 60 mm residual. At the end of the regrowth period, the herbage accumulated (final yield - initial yield) for defoliation treatments: 20, 30, 40, 50 and 60 mm were 1884, 1508, 1322, 1124, 1289 kg DM/ha, respectively (P=0.16). The contrast showed evidence of a linear trend (P=0.03) in defoliation treatments over the final regrowth period.

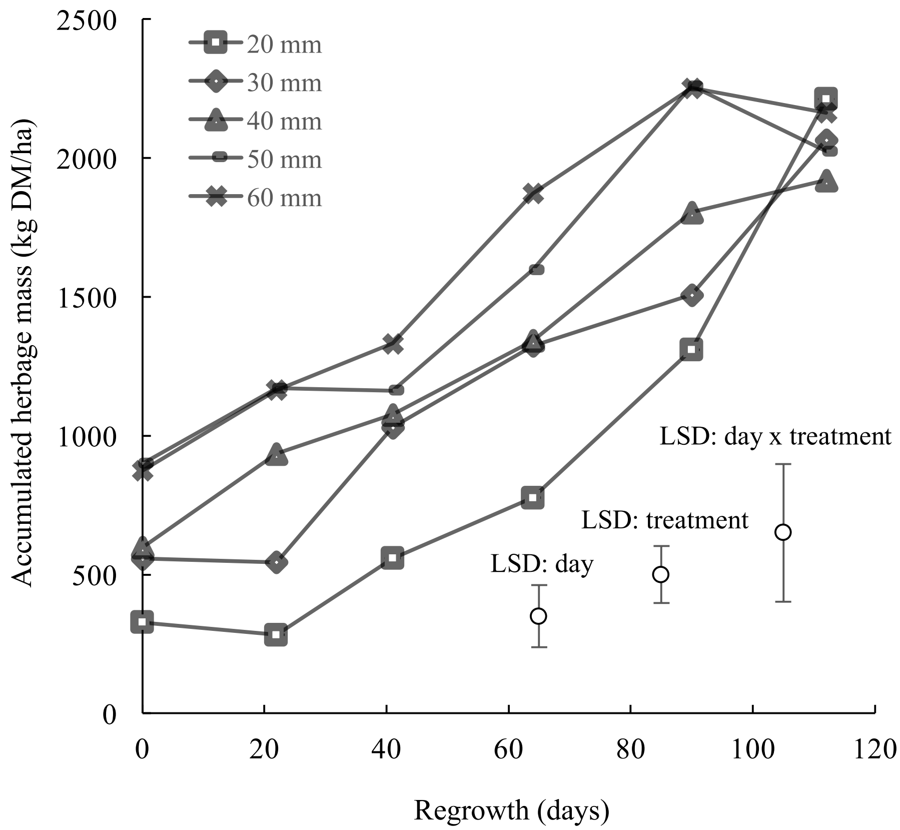

Figure 1. Herbage mass above ground level during regrowth of diverse pastures initially defoliated to treatment heights. LSD from ANOVA on days, defoliation treatment and interaction are shown as error bars. LSD=least significant difference (α=0.05).

Repeated measures analysis on N concentration of herbage showed a significant interaction (P=0.012) of defoliation treatment with time. For the 20 mm defoliation, N concentration increased from 18.8 to 29.7 g N/kg while the 60 mm defoliation decreased from 26.1 to 24.9 g N/kg during the regrowth period (P<0.001) when pastures were cut to ground level. Nitrogen uptake over the total 112 day period was significantly greater (P=0.01) in pastures defoliated to 20 mm (56 kg N/ha) than to taller heights (26-39 kg N/ha) (Table 3).

Table 3. Nitrogen uptake (kg N/ha) above ground level at final regrowth (day 112) of diverse pastures defoliated to various heights

Defoliation height treatment	N% (Day 0)	N% (Day 112)	Nitrogen uptake (kg N/ha)
20 mm	1.88	2.97	56
30 mm	1.86	2.57	39
40 mm	2.21	2.47	33
50 mm	2.27	2.35	26
60 mm	2.61	2.49	32
P-value	0.012	0.012	0.01
LSD	0.47	0.47	15

Final herbage yield and N uptake above mowing height for day 112 is presented in Table 4. The N% above 35 mm was higher in the severely defoliated pastures (20 mm) compared to higher residuals (P=0.04). The difference in DM yield above 35 mm at final regrowth (day 112) was not significantly different between treatments. There was no effect of treatment on N uptake in herbage harvested above 35 mm.

Table 4: Dry matter yield (kg DM/ha) and nitrogen uptake (kg N/ha) of pastures cut to 35 mm at final regrowth (day 112) of diverse pastures defoliated to various heights

Defoliation height treatment	N% above 35 mm	DM yield above 35 mm	Nitrogen uptake above 35 mm
20 mm	2.91	1574	46
30 mm	2.66	1565	42
40 mm	2.54	1767	45
50 mm	2.53	1914	49
60 mm	2.54	2218	56
P-value	0.04	0.17	0.48
LSD	0.26	600	17

Discussion

There was a tendency for more rapid herbage regrowth above defoliation height at low simulated grazing residuals. In spite of a two-fold difference in herbage yield at the time of cutting, the estimated final DM yield/ha was not significant between pastures defoliated to 20 mm and to 60 mm (2212 vs. 2163 kg DM/ha, respectively) when measured to ground level or 35 mm. The greater dry matter herbage accumulation in our pasture mixtures when grazing residuals were lower is consistent with previous results (Reid, 1959; Binnie and Harrington, 1972; Fulkerson and Slack, 2003). Residual leaves remaining after defoliation are generally older and less photosynthetically active than younger leaves (Gay and Thomas, 1995) and therefore the older leaves contribute little to subsequent regrowth despite greater leaf area remaining.

It is noteworthy that growth was greater initially (days 0-64) with higher residuals probably reflecting greater initial leaf area and then slowed down due to senescence. However through time, the severely defoliated pastures accumulated less herbage initially, but reached a similar DM yield to the laxly grazed pastures after the end of the regrowth period. Though not presented here, the majority of the pasture mix in this study consisted of ryegrass as other species were less active in the cool winter conditions, so variation in yield reflected the growth response of the ryegrass species. Fulkerson and Slack (2003) noted that in winter, severely defoliated perennial ryegrass prioritised water soluble carbohydrates (WSC) away from roots to leaf and above ground growth. In their study this accounted for higher DM accumulation in spring following severe defoliation in winter but the trade-off was reduced plant survival after summer compared with lenient defoliation. However, in a mixed sward containing legumes and herbs, reductions in perennial ryegrass tiller numbers in spring may be compensated for by growth of alternative species. For these reasons, a more intensive grazing may be beneficial to growth over the winter as it has been shown in this experiment and others (Brougham, 1957; 1959; 1970).

When determined above ground level, severe defoliated pastures (20-30 mm) accumulated more N over winter, than lax defoliated pastures, (50-60 mm) due to more rapid herbage growth and higher N%. A higher N uptake is important during the winter season as nitrate leaching losses are more prone to occur due to low temperatures, higher rainfall and slow plant uptake.

Conclusion

The results suggest grazing severely to post grazing heights <40 mm may improve growth and N uptake in the late autumn/winter period in diverse pastures and consequently minimize nitrate leaching losses with no apparent detrimental effects on herbage DM yield/ha in spring.

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