Herbage production in grazed grass-white clover plots: effect of N fertilizer application

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Abstract

The objective of the experiment was to evaluate herbage removed (HR) and sward clover content in grass-only (GO) and grass-white clover (GW) swards under frequent tight grazing conditions. A series of grazing plots (8×8 m) were established as a 2-sward (GO and GW) × 5-fertilizer N rate (0, 60, 120, 196, 240 kg N ha^{-1}) experiment. Measurements were taken from 2010 to 2013. Dairy cows grazed swards 8-10 times yr^{-1} to a target post-grazing sward height of 4 cm. GW swards had 14-46% greater (P<0.05) HR than GO swards receiving the same N rate (0GO: 9.1; 60GO: 9.2; 120GO: 11.0; 196GO: 11.3; 240GO: 12.6; 0GW: 13.3; 60GW: 13.1; 120GW: 13.1; 196GW: 13.8 and 240GW: 14.4; standard error of the mean (SEM): 0.55 Mg dry matter (DM) ha^{-1}). Clover content was reduced (P<0.01) as N rate increased (0GW: 33.3; 60GW: 30.6; 120GW: 27.0; 196GW: 21.7 and 240GW: 19.6; SEM: 2.31 DM%). Regardless of N rate, the GW swards were able to, at least, match the HR of 240GO swards. Every percentage point increase in clover content corresponded with an increase of 0.2 Mg DM ha^{-1}. It is concluded that under frequent tight grazing conditions clover inclusion can increase overall HR regardless of N rate applied.

Keywords: *Trifolium repens*, mixed sward, yield, herbage, fertilizer, nitrogen

Introduction

There is interest in the inclusion of white clover (*Trifolium repens* L.; clover) in grazed grass swards due to the potential of grass-clover (GW) swards to improve the sustainability of grazing systems as it can increase nitrogen (N) availability for herbage production. However, the amount of N fixed is influenced by a range of factors, including N fertilizer application (Andrews *et al.*, 2007). Nitrogen fertilizer application can reduce sward clover content (Ledgard *et al.*, 1995) as the clover can be out-competed in terms of growth rate and nutrient uptake by the grass, and shading reduces the persistency of the clover. The objective of this experiment was to identify an appropriate N-fertilizer application rate to maximize annual herbage removed (HR) in grass-only (GO) and GW swards on a free draining soil subjected to frequent and tight grazing without compromising sward clover content.

Materials and methods

A series of grazing plots (8×8 m) were established as a 2-sward (GO and GW) × 5-fertilizer N rates (0, 60, 120, 196, 240 kg N ha^{-1}) factorial arrangement with 3 replicates according to a split plot design. Both swards were sown with a perennial ryegrass (*Lolium perenne* L.) mixture (50% Dunluce and 50% Tyrella cultivars; 37 kg ha^{-1}) and the GW swards had an even mixture of Chieftan and Crusader clover cultivars (5 kg ha^{-1}). Measurements were taken from 2010 to 2013. Dairy cows grazed swards 8-10 times yr^{-1} during the grazing season (from February until October) to a target post-grazing sward height of 4 cm. The dry matter (DM) harvested herbage (HR) was estimated by cutting a strip with an Etesia lawn mower (Etesia UK Ltd., Warwick, UK). Sward clover content was estimated by removing a herbage sample (approx. 70 g) and separating into grass and clover components. Annual values were calculated from the values taken before each grazing. Data were analysed using the Mixed procedure in SAS (SAS,

2005) including sward type, N rate, year and the interactions in the model as fixed effects; the sward type × block interaction as a random factor and the year was used as a repeated measure.

Results and discussion

There was an effect of sward type, N rate and their interaction on HR (P<0.01 for all), but the three-way interaction was not significant. The HR increased from 2010 until 2012 but was lower in 2013 due to a severe summer drought. However, despite the year-to-year variation, the GW swards had 14 to 37% greater HR than the GO swards across years (Table 1; P<0.05). There was no significant year×N rate interaction for clover content, but while clover content was high in the first two years of the experiment, the mild and wet grazing season of 2012 and the drought in late summer and autumn of 2013 favoured clover growth at the expenses of grass growth across all treatments (Table 1). Increasing the N rate increased HR on GO swards, but had little effect on HR from GW swards (Table 2). The GW swards had between 14 to 46% greater HR than GO swards receiving the same N rate (Table 2). However, the annual clover content was reduced from 8 to 41% (P<0.01) as N rate increased from 60 to 240 kg N ha^{-1} (Table 2) and the strongest effect was observed during the warmest months (Figure 1), which is in agreement with previous findings (Harris *et al.*, 1998; Ledgard *et al.*, 1995). As the N rate increased the clover-content plateau observed during the July to September period was smaller, but less so up to 120 kg N ha^{-1}. Frame and Boyd (1987) reported a 48 and 81% reduction in clover content when 120 and 240 kg N ha^{-1}, respectively, were applied to GW swards. Thus, it seems that the frequent and tight grazing management used in this experiment alleviated the suppression effect of N fertilizer on clover, most markedly up to 120 kg N. Regardless of N rate, the GW swards were able to, at least, match the HR of GO swards receiving 240 kg N ha^{-1}. Every percentage point increase in clover content corresponded with an increase of 0.2 Mg DM ha^{-1}. Although the clover contribution to HR should not be dismissed, and the overyielding of GW compared to GO swards receiving up to 450 kg N ha^{-1} has previously been

Table 1. Effect of sward type (sward) and year of the experiment on annual herbage removed (Mg dry matter (DM) ha^{-1}) and white clover content (DM %).

	Year				SEM	*P*-value		
	2010	2011	2012	2013		Sward	Year	Sward × Year
Herbage removed yield								
Grass only	8.6^{a}	11.5^{bc}	13.9^{d}	8.5^{a}	4.9	<0.01	<0.01	<0.01
Grass white clover	11.8^{c}	15.6^{e}	15.9^{e}	11.0^{b}				
White clover content	30.7^{c}	32.1^{c}	19.2^{a}	23.8^{b}	1.5	-	<0.01	-

[1] Values with different superscript letters are significantly different (P<0.05). SEM = standard error of the mean.

Table 2. Effect of sward type (sward) and nitrogen (N) application rate on annual herbage removed (Mg dry matter (DM) ha^{-1}) and white clover content (DM %) across the four experimental years.

	N application rate (kg N ha^{-1}yr^{-1})					SEM	*P*-value		
	0	60	120	196	240		Sward	N	Sward × N
Herbage removed yield									
Grass only	9.1^{a}	9.2^{a}	11.0^{b}	11.3^{b}	12.6^{c}	5.5	<0.01	<0.01	<0.01
Grass white clover	13.3^{cd}	13^{c}	13.1^{c}	14.0^{cd}	14.4^{d}				
White clover content	33.3^{c}	30.6^{c}	27.0^{bc}	21.7^{b}	19.6^{a}	2.31	-	<0.01	-

[1] Values with different superscript letters are significantly different (P<0.05). SEM = standard error of the mean.

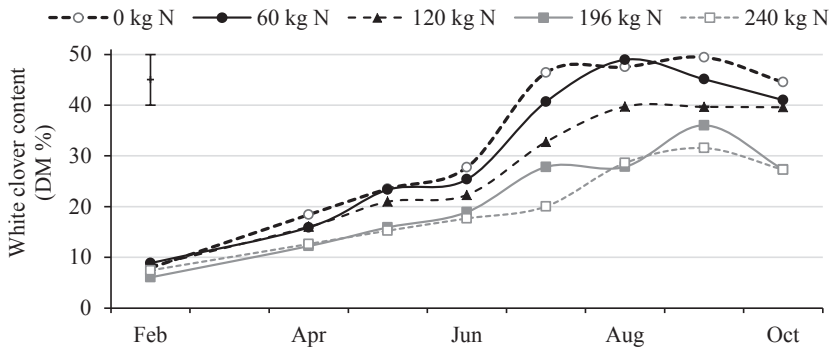

Figure 1. Effect of nitrogen (N) application rate (kg N ha^{-1}) on sward white clover content (% dry matter (DM)) of the grazing seasons across the four experimental years.

reported (Nyfeler *et al.*, 2009), it is possible that the outstanding GW sward performance could be related to the poor response of the GO swards to N application (average 18.5 kg DM ha^{-1} per kg N applied).

Conclusions

Under frequent and tight grazing management white clover inclusion increased overall herbage removed regardless of the N rate applied. The management strategy applied in this experiment may be capable of alleviating the detrimental N fertilizer effect on clover to a point between 60 and 120 kg N ha^{-1}.

Acknowledgements

This experiment was funded through the Irish Farmers Dairy Levy Trust and the Teagasc Walsh Fellowship Scheme.

References

Andrews M., Scholefield D., Abberton M.T., McKenzie B.A., Hodge S. and Raven J.A. (2007) Use of white clover as an alternative to nitrogen fertiliser for dairy pastures in nitrate vulnerable zones in the UK: productivity, environmental impact and economic considerations. *Annals of Applied Biology* 151, 11-23.

Frame J. and Boyd A.G. (1987) The effect of fertilizer nitrogen rate, white clover variety and closeness of cutting on herbage productivity from perennial ryegrass/white clover swards. *Grass and Forage Science* 42, 85-96.

Harris S.L., Auldist M.J., Clark D.A. and Jansen E.B.L. (1998) Effects of white clover content in the diet on herbage intake, milk production and milk composition of New Zealand dairy cows housed indoors. *Journal of Dairy Research* 65, 389-400.

Ledgard S.F., Sprosen M.S., Steele K.W. and West C.P. (1995) Productivity of white clover cultivars under intensive grazing, as affected by high nitrogen fertiliser application. *New Zealand Journal of Agricultural Research* 38, 473-482.

Nyfeler D., Huguenin-Elie O., Suter M, Frossard E., Connolly J. and Lüscher A. (2009) Strong mixture effects among four species in fertilized agricultural grassland led to persistent and consistent transgressive overyielding. *Journal of Applied Ecology* 46, 683-691.

SAS (2005) *SAS User's Guide Statistics*. SAS Inst. Inc., Cary, NC, USA.