Long-term effects of nitrogen fertiliser on nitrogen fixation in grazed perennial ryegrass / white clover dairy pastures in south west Victoria

Frank McKenzie **and Joe Jacobs**

Department of Natural Resources and Environment, 78 Henna Street, Warrnambool, VIC 3280
frank.mckenzie@nre.vic.gov.au

Abstract

Effects of nitrogen (N) (0, 75, 150, 225 kg N/ha/annum) as three equal applications from mid autumn to late winter onto grazed perennial ryegrass white clover dairy pastures, were examined from 1997 to 1999, inclusive. Percentage N derived from the atmosphere (% Ndfa) through white clover N fixation was decreased as the rate of N fertiliser application increased during 1997, but was unaffected during 1998 and 1999. The amount of N fixed by white clover was decreased from 43 kg N/ha/annum (at 0 kg N/ha fertiliser) to 23 kg N/ha/annum (at 150 kg N/ha fertiliser) during 1997. The amount of N fixed by white clover during 1998 and 1999, however, was unaffected by increasing rates of N fertiliser application and averaged 17 and 12 kg N/ha/annum in 1998 and 1999 respectively. White clover sward composition, as the proportion of total sward dry matter produced, was unaffected by the rate of N fertiliser application. The average white clover composition across treatments declined from 23 %DM in 1997 to 12 %DM in 1999.

Key Words

Trifolium repens, urea, clover content, climate, dry matter, *Lolium perenne*

Introduction

Traditionally, dairy farmers in temperate Australia have relied on white clover nitrogen (N) fixation to meet pasture N nutritional requirements. However, N fixation rarely supplies sufficient N to achieve more than 70 % of potential pasture production (1). While white clover has the potential to contribute up to 500 kg N/ha/annum to a perennial ryegrass / white clover pasture in certain temperate climates (UK and New Zealand), indications are that these levels are not achieved on dryland dairy pastures in south west Victoria (2). Consideration is now given to the possibility of both N fertiliser and N fixation contributing to the N nutrition of the pasture, but at different times of the year. Total estimated amounts of N fixed by clover at various levels of N fertiliser input were examined in this study and are discussed in the context of white clover content within the pasture, climate and additional pasture dry matter (DM) produced by N fertiliser.

Methods

A grazing experiment near Terang (142?55'E, 38?14'S) in south west Victoria from 1997 to 1999, inclusive, examined effects of multiple applications of different rates of N fertiliser over autumn and winter on clover N fixation. Four treatments, replicated 3 times in a randomised block included: zero N (N0), 3 applications of each of 25 (N1), 50 (N2) and 75 kg N/ha (N3). Urea (46 %N) was the N source and grazed plots measured 30m x 30m. Plots were grazed at a pre-grazing mass of 2200 to 2600 down to a residual of 1100 to 1500 kg DM/ha. DM yield was calculated from pre and post grazing estimates based on a calibrated rising plate meter (3). Prior to grazings, 15 random pasture samples (15cm x 15 cm) cut to ground level were collected from each plot, hand sorted into white clover and grass and oven dried. Dried clover and grass were ground to 1.0 mm and separately analysed for protein content using NIR Spectroscopy (4). The percentage N derived from the atmosphere (% Ndfa) was also determined from clover and grass samples using ^{15}N natural abundance ($\delta^{15}N$) methods (5). Total N fixed was calculated using DM estimates, composition (%DM), % Ndfa and plant N. All % Ndfa data were angular transformed while N fixed data for 1998 / 1998 were log transformed. Data were analysed by subjection to a linear mixed model and a cubic spline of time was fitted using ASREML (6) to test for the effects of N fertiliser,

and allowing for random plot effects. Total annual white clover DM yield responses to N and total N fixed were analysed by ANOVA (8).

Results

The % Ndfa through white clover N fixation was decreased ($P<0.05$) as the rate of N fertiliser application increased during 1997, but was unaffected ($P>0.05$) during 1998 and 1999 (data not presented). Correspondingly, the amount of N fixed by white clover was decreased ($P<0.05$) from 43 kg N/ha/annum (N0) to 23 kg N/ha/annum (N2) during 1997 (Table 1). The amount of N fixed by white clover during 1998 and 1999, however, was unaffected ($P>0.05$) by increasing rates of N fertiliser application and averaged 17 and 12 kg N/ha/annum in 1998 and 1999 respectively. White clover sward composition, estimated as the proportion of total DM produced, was unaffected ($P>0.05$) by the rate of N fertiliser application. The average white clover composition across treatments declined from 23 (1997) to 12 %DM (1999).

Table 1: Annual white clover DM yields (also as a percentage of the total pasture DM yield in brackets) and annual amounts of N fixed by clover in response to increasing levels of N fertiliser

	0 kg N/ha	75 kg N/ha	150 kg N/ha	225 kg N/ha	l.s.d. (P=0.05)
			Total clover DM yield (kg DM/ha/annum)		
1997	1942 (27)	1812 (23)	1558 (19)	2150 (24)	535
1998	930 (17)	1088 (17)	1126 (16)	1410 (16)	524
1999	682 (12)	634 (10)	849 (12)	1055 (14)	315
			Total N fixed (kg N/ha/annum)		
1997	43	35	23	30	11.4
1998	17	17	14	19	11.8
1999	15	7	12	11	8.8

Discussion and conclusion

Total N fixed by white clover was low, averaging 33 kg N/ha/annum in 1997 and decreasing to an average of 12 kg N/ha/annum in 1999. This paralleled the decline in white clover content over time. Such levels of N fixation would not sustain high levels of pasture production (2), reinforcing the consideration to use both white clover and applications of N fertiliser to meet pasture N requirements for growth. This was highlighted by the fact that total pasture DM yield responses to N fertiliser were high - N applications consistently increased annual pasture DM yields by 900 to 3300 kg DM/ha for total applications of 75 to 225 kg N/ha/annum (8). There are two major considerations for low levels of N fixation by white clover in south west Victoria (2). These are the typically low proportions of white clover for dryland dairy pastures in south west Victoria (2), a consequence of environmental effects (8), and the relatively dry summers. White clover has good potential to fix N during the warm summer months, however, its growth is retarded by a lack of soil moisture. Whilst it is acknowledged that N fertiliser can reduce N fixation by white clover,

as evidenced in the first year of the current study, the results highlight the importance of good grazing management of N fertilized pastures. Under the grazing practice adopted in this trial, white clover composition was unaffected by N fertiliser.

References

(1) Ball, P.R. and Field, T.R.O. (1982) Nitrogen fertilisers in New Zealand agriculture. Ray Richard, Auckland.

(2) McKenzie, F.R., Jacobs, J.L., Riffkin, P., and Kearney, G. (1999) Afr, J. Range For. Sci., 15:1-6.

(3) Earle, D.F., McGowan, A.A. (1979) Aust. J. Exp. Agric. 19: 337-343.

(4) Smith, K.F., and Flinn, P.C. (1991) Agric. Res.31: 205-210.

(5) Shearer, G. and Kohl, D.H. 1986. Aust. J. Plant Phys.13: 699-756.

(6) Gilmour, A.R., Thompson, R., Cullis, B.R., Welham, S.J. (1998) *Biometrics Bulletin, NSW Agriculture*.

(7) Genstat 5 Committee (1997) Clarendon Press: Oxford.

(8) McKenzie, F.R., Jacobs, J.L. and Kearney, G. (2002) Aust. J. Agri. Res. 53: (in press).