

# NITROGEN FERTILISER ON GRAZED HILL PASTURES

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## *Abstract*

The effect of N fertiliser on pasture yields and species composition, and spring stock carrying capacity was measured undergrazing at Ballantrae, the Grasslands Division hill country area. N fertiliser was applied as urea in early spring at rates up to 100 kg N/ha. Paddocks were set stocked with sheep with additional sheep being added to N fertilised paddocks to maintain similar herbage availabilities. N fertiliser increased pasture growth by an average of 7 kg DM/kg N applied. Stock carrying capacities over spring ranged from 18 sheep/ha without N, to 26 sheep/ha with 100 kg N/ha. The major species composition effects of N was a reduction in clover yields and clover nitrogen fixation rates, in the spring, summer and autumn after the spring application. Clover growth and N fixation decreased most over summer when clover yields and nitrogen fixation were 41% and 52% lower respectively on hill slopes, at the highest rate of N fertiliser. Pasture yields were lower in autumn on pastures previously N fertilised.

## INTRODUCTION

Pasture growth responses to nitrogen (N) fertiliser applied over late winter/early spring have been large in North Island hill pastures (Sherlock and O'Connor 1973; Ball et al. 1976; Luscombe 1980a; 1980b; 1981). N has been advocated for use in cattle wintering (Nielson 1973), and as a possible means of intensifying sheep farming (Luscombe 1980a).

Most N fertiliser trials have investigated short term effects on pasture yields of mown pasture. In severely N deficient hill pastures, N fertiliser is likely to have long term effects through animal cycling of nitrogen (Luscombe 1980a). Changes from browntop (*Agrostis tenuis* Sibth.) to ryegrass (*Lolium perenne* L.) (Luscombe et al. 1981a), and reduced clover growth and N fixation because of increased grass competition (Luscombe et al. 1981b) have been observed in cutting trials, where N fertiliser was applied to hill pastures.

In this study N fertiliser was applied to sheep grazed paddocks on a hill slope to determine the effects of N fertiliser on pasture productivity, species composition and clover nitrogen fixation, and to determine the sheep carrying capacity attainable with N fertiliser over late winter/spring.

## METHODS

The study was conducted at Ballantrae, the hill country research area of Grasslands Division, DSIR, in the southern Ruahine Range near Woodville.

The trial was on an easterly sloping area on Kumeroa hill soil formed from sandstone under a rainfall of approximately 1100mm. The site had received little fertiliser and soil phosphorus was low (Olsen P of 6). The soil pH was 5.1. Eight paddocks each of 0.07 ha were fenced so that each paddock contained a slope area (slope about 20°) at the base of the hill area (base), a steep tracked hill face (slope about 31°) (steep), and a near flat camp site at the top of the slope (camp). Base, steep and camp areas represented 44%, 40% and 16% respectively of total paddock area. Three sites were selected on each slope class for pasture measurements.

Lime (500 kg/ ha), superphosphate (750 kg/ ha), muriate of potash (100 kg/ ha) and molybdenum (150 g/ha) were applied to all plots in the autumn before the trial. Nitrogen fertiliser treatments were: 0, 25, 50, and 100 kg/ ha of N, with two replicates of each treatment. N fertiliser was applied, as urea, in early spring (8 August, 1980).

Paddocks were set stocked with two tooth wethers of 15 sheep/ ha through the autumn before fertiliser application. As pasture N responses became apparent, stocking rates were adjusted weekly on fertilised paddocks, after visual assessment of herbage availability. This was done to maintain the same pastures availability on all paddocks. By mid-November N responses were no longer evident and stocking rates were similar on N fertilised paddocks. At this stage gates were opened and sheep allowed to graze over all plots, so that paddocks received the same grazing pressure. Stocking rate was 15/ ha from November until the following winter.

Pasture yields and species composition were measured under 0.5m<sup>2</sup> cage enclosures that were relocated after pasture cutting onto previously grazed pasture. Herbage under cage enclosures was cut to 10-20mm height, using electric shears, at 3 to 6 weekly intervals depending on pasture growth rate.

Herbage mass and species composition of grazed pastures was determined by cutting stripes of pasture (2.0m x .08m) to ground level near each pasture measure site. When herbage mass on the set stocked pastures was too low to trim and collect effectively in the field, herbage was hand trimmed from tiller plugs (42 per paddock). These measurements were repeated at monthly intervals throughout the trials.

Clover nitrogen fixation in the set stocked pastures was determined at approximately 3 weekly intervals using the acetylene reduction assay (Crush and Tough 1981).

## RESULTS

Pasture production and species composition data were analysed by regression analyses, using a general-linear-model program, to allow for different N response characteristics on the three slope types within each paddock.

### PASTURE NITROGEN RESPONSE FROM CUT PLOTS **SPRING**

Total pasture yields increased significantly ( $P < 0.01$ ) with N from August to the end of October. Herbage yields differed significantly ( $P < 0.001$ )

between slope classes but N response efficiencies (kg DM/ kg N applied) did not (Fig. 1).

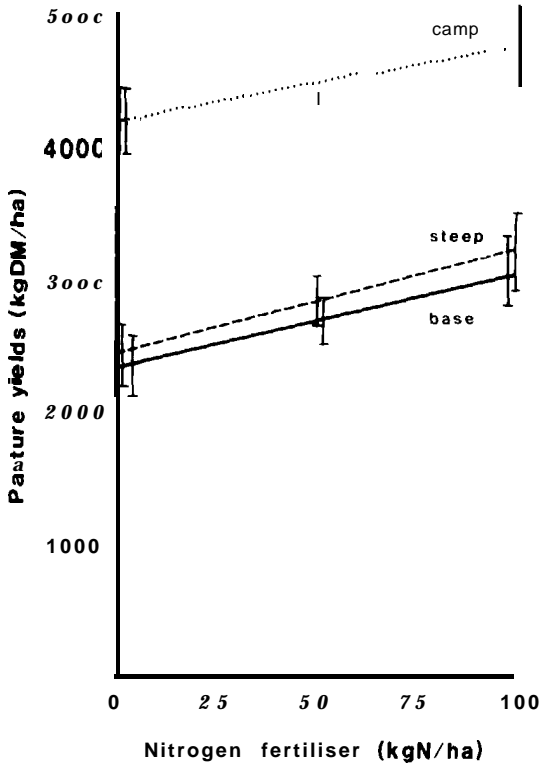


FIG. 1. Nitrogen fertiliser responses, measured on each of the three slope classes in the hi// paddocks, over spring. (Standard Errors (S. E.) are indicated).

Species composition and N responses of species varied with slope class. Stock camp areas were ryegrass dominant (52% ryegrass, measured in October 1980); and contained Poa (*Poa* spp), browntop and Yorkshire fog (*Holcus lanatus* L.). Ryegrass yield was significantly ( $P < 0.05$ ) increased with N with a response efficiency of 10 kg DM/kg N applied. Yields of other grasses were reduced with N. Swards contained little clover with or without N.

There was much more browntop on steep and base slope areas (25% and 22% respectively). These pastures also contained a lot of sweet vernal (*Anthoxanthum odoratum* L.) (20% and 24%) and some crested dogstail (*Cynosurus cristatus* L.), Yorkshire fog, and Poa, but substantially less ryegrass (38% and 20%) than camp areas. On these areas N significantly

( $P < 0.05$ ) increased yields of non ryegrass grasses, these species having an average response of 9 kg DM/ kg N applied. Ryegrass yields were reduced with N while clover yields, predominantly white clover (*Trifolium repens* L.) which comprised less than 6% of the dry matter, were not significantly affected by N.

#### LATE SPRING/SUMMER

Nitrogen fertiliser did not significantly increase total pasture, or grass yields after the initial 12 week response period. However clover yields were significantly ( $P < 0.01$ ) reduced from November to February on both steep and base slopes where N had been applied (Fig. 2). Clover yields on these pastures differed significantly ( $P < 0.05$ ) (Fig. 2) but N effects on clovers were similar.

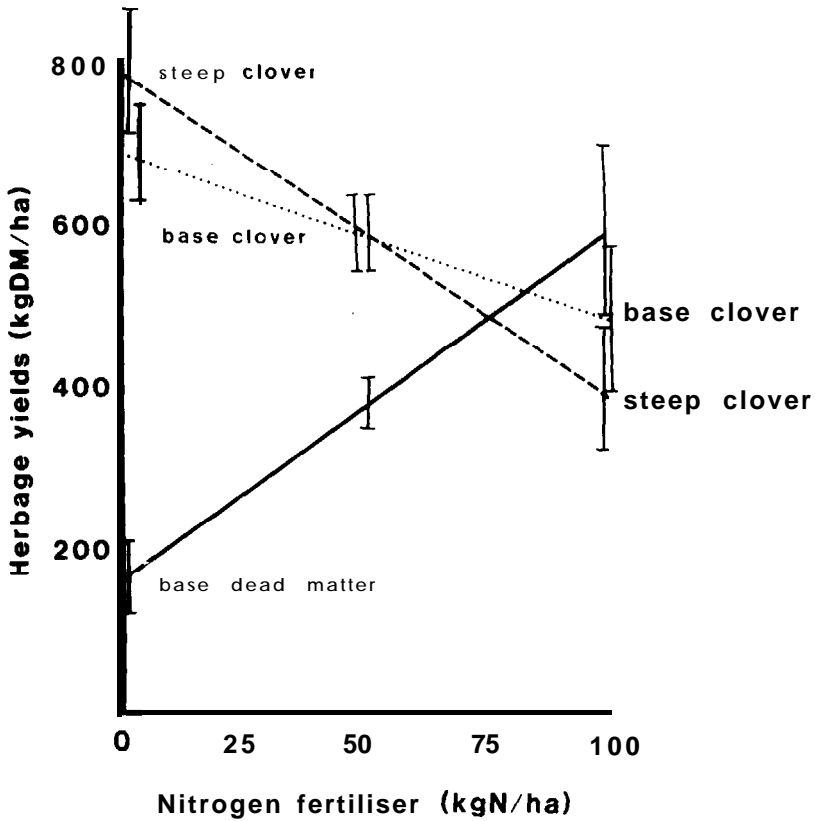


FIG. 2: Clover and dead material yields from harvested plots over the late spring/summer post N response period. (S. E. are indicated).

Clover yields on camp areas were significantly ( $P < 0.001$ ) lower than on steep and base slopes (144 cf 783 and 688 kg DM/ ha respectively). On these sites clover yields represented less than 2% of pasture yields and were not measurably affected by N.

Dead material in harvested herbage, predominantly grass, increased significantly with N ( $P < 0.01$ ) on base slopes and was also greater on steep sites.

### AUTUMN

In this period herbage yields were lower ( $P < 0.1$ ) with N on base and steep slopes (Fig. 3) because of a reduction ( $P < 0.05$ ) in total grass yields (Fig. 3). Clover yields were not significantly affected by N. Total pasture and grass yields differed significantly between base and steep slopes but N effects were similar. Camp sites were not affected by N.

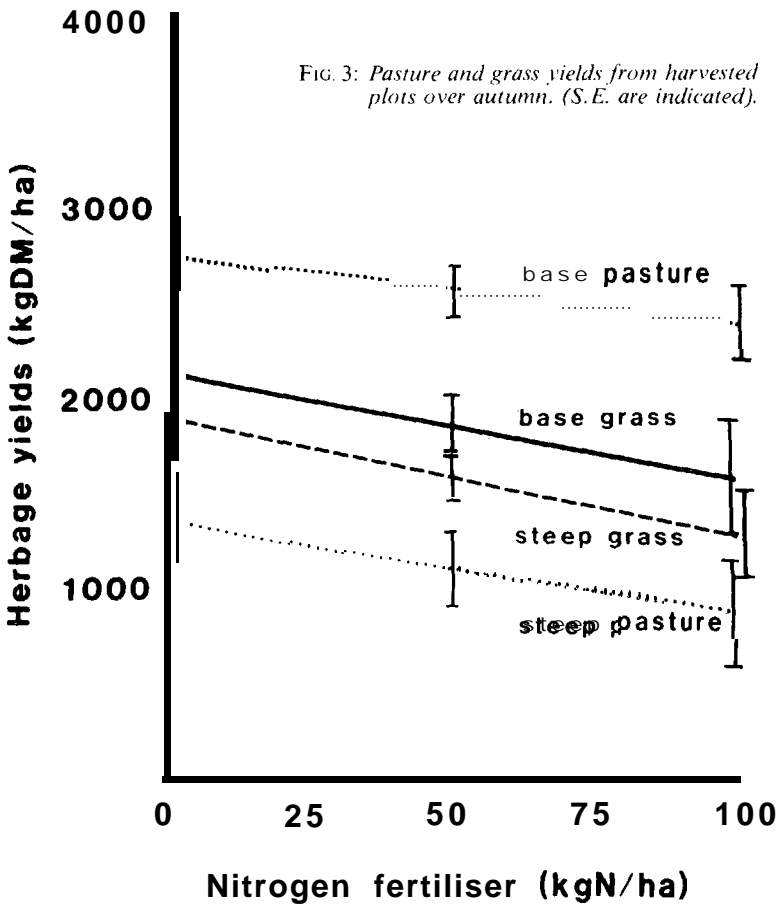


FIG. 3: Pasture and grass yields from harvested plots over autumn. (S.E. are indicated).

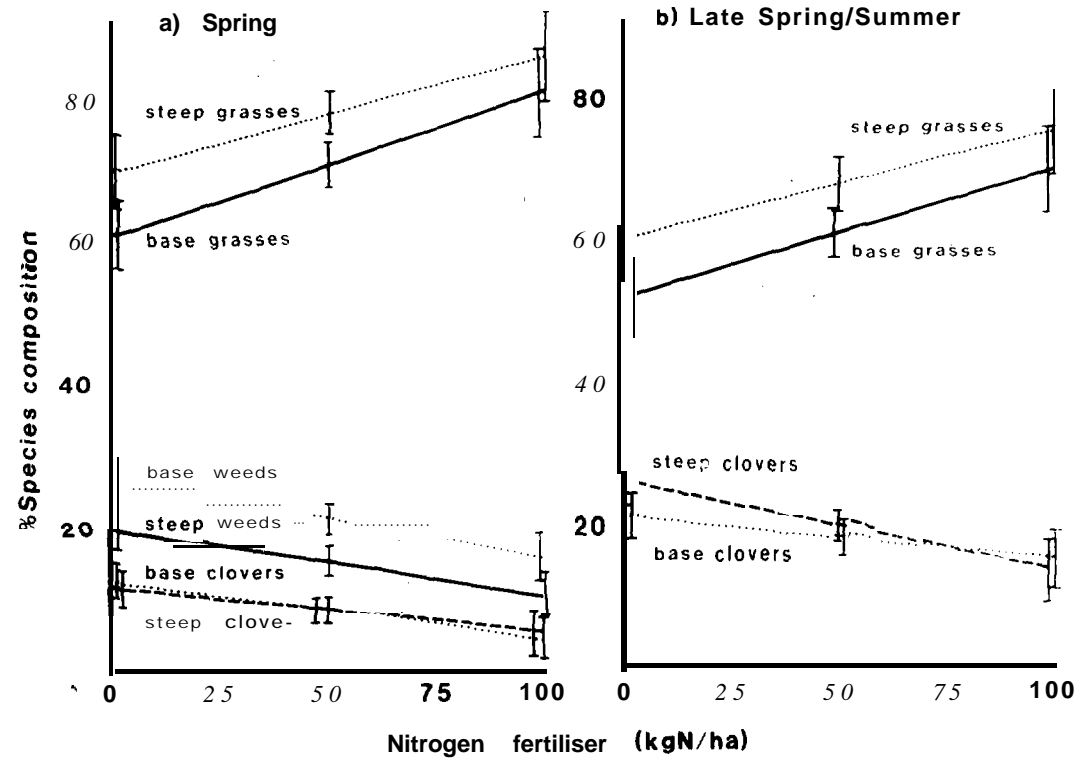


FIG. 4: Species composition of set stocked pastures over the (a) spring, and (b) late spring/summer period. (S. E. are indicated).

## NITROGEN EFFECTS ON SET STOCKED PASTURES

### SPRING

Average herbage mass on set stocked pastures was 770 kg DM/ ha and did not vary significantly between slope classes or with N fertiliser. This suggests that the stocking rate changes had effectively maintained the same pasture availabilities.

With N fertiliser there were species effects that were not evident in caged plots. Weed, (predominantly moss (*Musci* spp.), hawbit (*Leontodon taraxacoides* (Vill.) Merat.) and catsear (*Hypochaeris radicata* L.)) and clover compositions were significantly ( $P < 0.05$ ) reduced on steep and base slopes (Fig. 4a). Grass compositions were significantly ( $P < 0.01$ ) increased on these areas (Fig. 4a). Although differences between weed, clover and grass contents of base and steep slopes were significant, they were similarly affected by N. Species composition of camp areas was not affected with N fertiliser.

### LATE SPRING/SUMMER

Mean herbage mass increased to 1330 kg DM/ ha and was unaffected by N treatment. Species composition effects were still evident (Fig. 4b). The increased grass content and reduced clover contents were significant at  $P < 0.05$  level.

### AUTUMN

Clover contents of all pastures declined and grass content increased. Clover content was still significantly lower, however, in N fertilised pastures ( $P < 0.05$ ), on base slopes but not on other sites. Differences in grass, other species and dead matter contents were no longer evident.

### CLOVER NITROGEN FIXATION

Clover nitrogen fixation on base and steep slopes was significantly reduced with N in spring, summer and autumn ( $P < 0.001$ ,  $P < 0.001$  and  $P < 0.05$  respectively (Fig. 5)). N fixation on camp sites was much lower in all seasons and was not affected by N. The effect of N fertiliser on N fixation was similar on base and steep slopes.

Annual N fixation inputs (June 1980-June 1981) on plots without N were 64, 63 and 23 kg N/ha on base, steep, and camp slopes respectively. The reduction in annual N fixation with N fertiliser was 0.25 and 0.31 kg N fixed/ kg N fertiliser applied on base and steep slopes.

### SHEEP STOCKING RATES AND PASTURE YIELDS

The relationship between N fertiliser and mean stocking rate over the major N response period from 8 August to 10 November was given by:  $SR = 17.57^{***}$

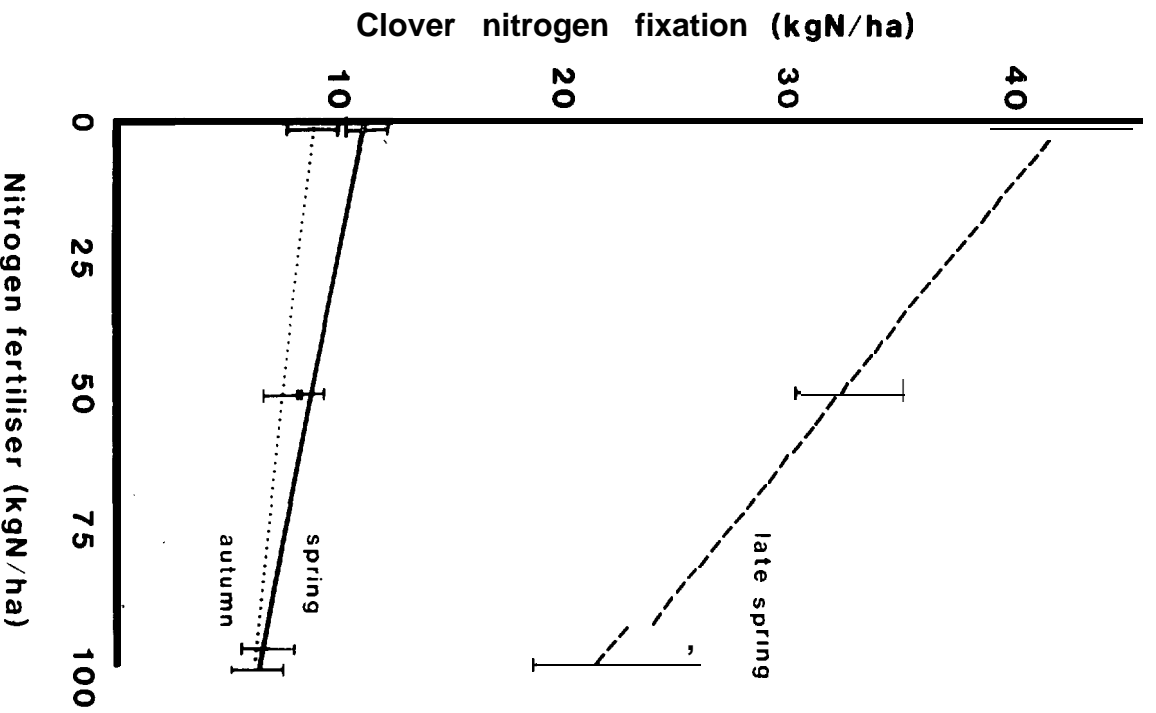


FIG. 5. Mean clover nitrogen fixation over spring, late spring/summer, and autumn on sheep and base slopes (S.E. are indicated).

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+ 0.0833N\*. This relationship indicates that approximately 12 kg N/ha was required to carry an additional sheep over this period.

#### DISCUSSION

The mean paddock pasture N response efficiency, calculated from the response on each slope class and the proportion of this slope class in each paddock, was 7.2 kg DM/ kg N fertiliser. The similar response on the various hill slope classes confirms results of other cutting trials that early spring N deficiency is likely to be essentially independent of site productivity (Luscombe 1981). The response efficiency is lower than observed over early spring in other trials on North Island hill country pastures (Sherlock and O'Connor 1973; Ball et al. 1976; Luscombe 1980a, 1981). The wet but mild weather over the spring may have contributed to the reduced pasture N response.

From the pasture N response efficiency data and the relationship between N input and stocking rate it can be calculated that each additional wether required approximately 1.0 kg DM/day over the trial spring period. From feeding trial work (Rattray 1978) this appears to be a realistic pasture requirement for these heavily stocked wethers. This suggests that on intensively utilised pastures of high feed quality, additional spring animal carrying capacity with N fertiliser, is likely to be closely related to pasture response measured in cut plots.

Reduced clover yields on N fertilised pastures have been observed in other studies in which N has been applied heavily or repeatedly (e.g. Ball 1979; Hay 1980; Luscombe *et al.* 1981a). The results from this study suggest that a single spring application of N can markedly affect clover growth and nitrogen fixation. Although previous studies with single spring N dressings have generally not shown significant clover effects, this probably reflects the experimental methods used. Cutting studies (e.g. Luscombe 1980a; 1981) with a 3 to 4 week spell after N application often have low clover yields over spring, making effective statistical analysis difficult. The N-clover effects were not clearly evident in our plots, nor statistically significant, until clover growth had increased in summer. In the study of Ball et al. (1976) where an August N application (58 kg/ ha) was applied on sheep grazed hill pastures, clover effects were not statistically significant but clover yields were 20% lower over the spring response period. Reduced clover yields were still evident in the final cut reported (from mid October to mid November) and at this stage they were 36% lower on the N fertilised pastures.

Grass competition can severely reduce clover yields (Harris and Thomas 1973), and probably was intensified with N, and led to the lower pasture clover content (Luscombe et al. 1981a). Clovers appear to have large growth potential in spring and summer, but intense grass growth over the spring period can markedly reduce spring clover growth (Luscombe et al. 1981b). Although grass growth in set stocked pastures would shade clovers to a lesser extent than in spelled pasture plots, competition for light probably occurred in the base of these swards (Jackman and Mouat 1972). Clover growth is likely

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to be further reduced with a laxer grazing management.

Reduced feed material from clovers is probably of little agronomic importance over spring, as clover contribution to pasture yields is small compared with grass growth with N. Over summer, the effect is likely to be more important as clovers not only have the potential for much greater growth, but also have a higher feeding value than grasses (Ulyatt *et al.* 1977).

The difference between the feeding value of previously N fertilised pastures and unfertilised pastures would probably be accentuated when pasture utilisation is low. Where standing grass accumulates and reduces clover yields by shading, it is likely that with the onset of dry, summer conditions a pasture composed mainly of dead matter, of very low digestibility (Rattray 1978) will result.

The reduction in clover nitrogen fixation was large and occurred mostly in summer. The reduced grass yields in autumn suggest that the reduced clover growth in spring and summer can lower soil N availability. Clover N from summer, probably contributes substantially to grass N nutrition over the following autumn. Application of N in autumn rather than spring may reduce the depression in clover growth and therefore be more complementary to clover-based pastures.

Nitrogen fertiliser has not increased long term productivity of these pastures. Animal cycling of N fertiliser was probably ineffective, as much of the N is likely to have been aggregated onto stock camp areas. Residual pasture response from animal cycling of N may be more important on uniformly sloping paddocks, but even here, our results suggest that reduced clover yields and symbiotic N fixation are likely to largely negate any long term benefits of N fertiliser on pasture productivity.

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