NITROGEN FERTILIZER RESPONSES ON GISBORNE-EAST COAST PASTURES

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ABSTRACT

Eight mowing experiments were conducted over a three year period in the Gisborne-East Coast Region to measure pasture responses to nitrogen (N) fertilizer. Each experiment had a range of fertilizer rates (up to 200 kg N/ha) and application dates (March to September). Experimental sites had a wide range of soil fertility, as indicated by pasture species composition and soil chemical tests. Efficiency of response (kg pasture DM/kg applied N) decreased with increased N application rate, and varied with month of N application. Mean efficiency of response for different rates were: 25 kg N/ha 10.0, 50 kg N/ha 9.0, 100 kg N/ha 8.1 kg DM/kg N. Mean efficiency of response for different months of N application were: March 6.7, April 8.6, May 3.8, June 12.0, July 12.3, August 11.6 and September 8.5 kg DM/kg N. Experimental sites with a low soil N had larger autumn responses than sites with higher soil N levels ($r^2 = 0.712$).

INTRODUCTION

The response of pastures in New Zealand to nitrogen (N) fertilizer has been widely investigated (Ball and Field, 1982; O'Connor, 1982; Ball *et al.*, 1982) but there are no published experimental results for the Gisborne-East Coast region. The present investigation was undertaken to measure the response of Gisborne-East Coast hill country pastures to N fertilizer applied in different months. It was anticipated that N fertilizer use recommendations to East Coast farmers could be more clearly defined as a result of the research. This report gives a summary of results.

EXPERIMENTAL

Treatments

Eight experiments were carried out on farmers properties at Whangara (near Gisborne), Nuhaka (near Wairoa) and Matawai (higher altitude), during 1984-86 (Table 1). At 3 sites, experiments were repeated on separate but adjacent areas of pasture in the same paddock for a second year (6 experiments). Each experimental area was fenced in autumn to exclude grazing animals, mown, and either 72 (1984) or 140 (1985-86) plots, each 1.5 m by 4.0 m, marked out for the treatments. A blocked split-plot experimental design was used with 3 (1984) or 4 (1985-86) block replicates. Main plots (7) in each replicate were month of N application (usually March-September), and sub-plots were rates of N application (0, 25, 50, 100 kg N/ha in 1984 or 0, 25, 50, 100, 200 kg N/ha in 1985-86). Nitrogen was applied in the form of urea (1984) or calcium ammonium nitrate (1985-86). The change to a less concentrated N fertilizer in 1985-86 was to avoid possible herbage desiccation at the 200 kg N/ha rate. No such damage was noticed. In 1984 no basal fertilizers were applied, but in 1985-86 all plots received basal dressings equivalent to 500 kg/ha potassic superphosphate (10% P, 15% K) at the start of the experiment in March and again in August.

Experimental sites

All the experiments reported in this paper were conducted on hill country sheep/beef farms, but were restricted to rolling or flat sites since it was considered that farmers would be most likely to apply N fertilizer to rolling or flat parts of their property, rather than steep areas. As such, results were presumably little affected by topographic effects (aspect, slope etc.).

Except for one site (Farm 2), all experimental sites had old established pasture. At Farm 2 the pasture was 2 years old, having been sown with ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.). Herbage samples were taken from all sites during the winter of 1987 and species composition measured (Table 1).

Prior to the experiments being conducted, all sites (except Farm 5) had received regular annual fertilizer applications (255 kg/ha superphosphate). The experimental site on Farm 5 had not been fertilized for at least 4 years before the experiment. Soil samples (0-75 mm) were taken at the start of experiments to measure organic C (Allison, 1960), total N (Bremner, 1960), MAF quick test pH, Ca, Mg, K, and Olsen P (Mountier *et al.*, 1966). Results are given in Table 1. Except for Farm 5, nutrient levels were sufficiently high to encourage vigorous pasture growth (O'Connor & Gray, 1984).

Yield measurement

Pasture was harvested with a reel mower that had steel studs on the roller, allowing slopes up to 25° to be mown. Pasture was mown when herbage was 7-10 cm in length, although in spring more herbage sometimes accumulated. Clippings from 2 strips (36 cm wide) in each plot were weighed, subsampled (200 g) for dry matter (DM) determination, then discarded. After measurements were completed remaining herbage was mown and discarded. Usually 2-3 cuts were taken following the final N application.

Analysis

Cumulative yields were calculated and responses taken as the difference between the control (0 kg N/ha) and other N rates. Residual maximum likelihood (REML) was used to calculate standard errors for individual trials.

TABLE 1: Details of experimental sites.

District	Whangara	Whangara	Nuhaka	Matawai	Matawai
Farm	1	2	3	4	5
Trials	1984, 1985	1986	1985, 1986	1984, 1985	1986
Location					
Map[1]	N98	N98	N116	N88	N88
Reference[1]	539466	565488	092926	908715	887706
Altitude (m)	50	20	30	600	580
Slope (°)	0-8	20-25	15-20	5-8	0-5
Aspect	Flat	South	East	West	Flat
Soil series	Pakarae	Pouawa	Pahiatua	Mamaku	Mamaku
Soil tests[2]					
Olsen P	13	17	25	16	8
K	10	8	10	6	3
pH	5.6	5.7	5.3	5.2	5.9
P retention	30	30	26	45	37
C (%)	12.3	6.0	6.6	13.2	11.2
N (%)	0.9	0.4	0.5	0.8	0.6
C:N	14	14	13	16	19
Pasture (% DM)					
Ryegrass[3]	63	89	47	19	2
Poa	—	—	12	12	—
Yorkshire Fog	13	—	—	41	16
Sweet Vernal	13	1	1	Tr	19
Browntop	7	—	—	23	59
Ratstail	—	—	23	—	—
Other grasses	—	—	10	—	4
White clover	3	4	Tr	3	2
Sub clover	1	—	4	—	—
Weeds	Tr	6	3	2	2

[1] Map references from Department of Land and Survey NZMS1 Topographic series.
[2] 0-75 mm soil depth.
[3] Grasses arranged in descending order of soil fertility requirement (Levy, 1970). Measured in winter 1987 at all sites.

RESULTS

Responses were seldom fully expressed at the first cut after N application, but reached a peak 1-3 cuts later, then declined slightly. As a result, different conclusions could be reached from comparisons made at different times during the trial. In this paper, comparisons were made by accumulating responses for the first and second cut after nitrogen application. This ensured that most of the response had been expressed, but that as few results as possible were excluded (due to insufficient cuts after N application).

Responses to 50 kg N/ha in individual experiments are shown in Table 2. Missing responses were caused by cattle grazing the trial (Farm 1, May 1985), or by N not being applied in the nominated month. Responses were highly variable, both between years on the same farm, and between farms in the same district. As no obvious reasons could be found to explain the variation in magnitude of responses, responses were averaged across experiments. The mean efficiency of response to N was higher for late winter/early spring applications (June, July and August) than for autumn applications (March, April and May), but there was considerable variation between sites for individual months.

Usually there was a statistically significant ($P<0.05$) response to increasing rate of N. Efficiency of response to N fertilizer decreased with increased rate of application, with mean efficiencies (all months) for 25, 50 and 100 kg N/ha respectively being 10.0, 9.0 and 8.1 kg DM/kg N applied. Where 200 kg N/ha was applied, efficiency of response was lower than for 100 kg N/ha.

For autumn applied N (March, April, May) efficiency of response was associated with soil N status ($r^2=0.712^{**}$). Mean efficiency declined as soil N increased (Fig. 1). A similar association was not obvious for late winter (June, July, August) N applications ($r^2=0.055$).

TABLE 2: (a) Pasture responses to 50 kg N/ha applied in different months in individual experiments and (b) average efficiency of response.

Month N applied		Mar	Apr	May	Jun	Jul	Aug	Sep
(a) Responses (kg DM/ha)[1]								
Farm 1	1984	—	−33	46	207	512	211	—
	1985	—	—	−8	529	975	—	—
Farm 2	1986	658	524	600	1029	−58	654	358
Farm 3	1985	526	—	38	852	571	1380	570
	1986	460	446	198	951	416	599	235
Farm 4	1984	—	186	16	386	449	736	—
	1985	221	316	178	—	683	402	408
Farm 5	1986	393	505	912	763	608	508	—
SE[2]		156	157	175	214	223	240	251
(b) Efficiency[3] (kg DM/kg N)								
Mean		6.7	8.6	3.8	12.0	12.3	11.6	8.5

[1] Response measured as difference between 50 kg N/ha and 0 kg N/ha treatments, with cumulative yields at the second cut after N application being given.
[2] Average standard error for individual farms.
[3] Efficiency = Response[1]/N applied. Values adjusted for unequal and unbalanced number of months N applied, and averaged for 25, 50, 100 kg N/ha.

DISCUSSION

Responses to N fertilizer measured in this series of experiments were in general similar to those recorded in other regions. For example O'Connor (1982) found that N application in July-September gave large and relatively reliable responses throughout most of New Zealand, while applications in February-May were less reliable and smaller. Applications of N fertilizer in June, for which relatively little data is available in other publications, gave similar responses to July or August applications in this series of experiments.

It was expected that the higher altitude sites (Farms 4 & 5), because of colder winters than at the coastal sites, would have poorer responses to June and July applications of N fertilizer (Ball and Field, 1982). However, this did not appear to be true, although responses to June applications took longer to appear than at coastal sites. Pasture growth was slower in winter at higher altitude sites than at coastal sites, delaying the expression of responses (and dates of herbage cut).

Ball and Field (1982) found under Manawatu conditions, that as N rate increased the marginal efficiency of DM production per kg N declined at a relatively uniform rate. For individual months and farms the changes in efficiency with N rate were relatively variable, but when averaged across all months of application, a similar pattern to that reported by Ball and Field (1982) was evident. Because they found no clearly defined point where marginal deficiency markedly declined, Ball and Field (1982) were unwilling to define an optimum rate of N application. However, as N fertilizer reduced the already low clover content of pasture (results not presented here), it is suggested that high N rates should be avoided. The low clover content of swards is mainly due to climatic factors (unpublished data).

The amount of soil nitrogen available for plant uptake reflects the balance between N supply (from mineralisation of organic matter, urine and fertilizer N) and N losses through leaching and denitrification (Field and Ball, 1982). Autumn N responses were presumably correlated with soil N (Fig. 1) because mineralisation increased with soil N level. The importance of soil N status in affecting pasture responses has been recognised in hill swards with high C:N ratios (Ball *et al.* 1982). However, it has not always been possible to demonstrate such relationships because of other confounding factors (Ledgard *et al.* 1983) or possibly because experiments covered only a small range of soil N status. Morrison (1987) considered that although soil N status should be considered when applying N fertilizer, standard measurement techniques are currently inadequate for grassland. Total soil N is unlikely to be universally suitable for identifying pastures "responsive" to N fertilizer; incubation techniques are generally regarded as being most accurate (Quin *et al.*, 1982).

Knowledge of nitrogen relationships with pasture composition could assist in identifying "responsive" pastures. Sites on Farms 2 and 5 were selected on the basis that they were likely to be "responsive" and proved to be so. Farm 2 had new pasture and it was thought that previous cultivation and brassica forage crops may have reduced soil N availability (Steele, 1982). Farm 5 had received no phosphorus fertilizer, and it was expected that reduced clover growth and N fixation would result in reduced soil N availability. Both Farms 3 and 5 had old pastures with more low fertility (N) grasses than the comparable farm in the same climatic zone (compare summer dry Farms 1 and 3, and summer wet Farms 4 and 5 in Table 1). It is suggested that to obtain maximum benefit from autumn applied N fertilizer, farmers could attempt to identify "responsive" paddocks, perhaps based on pasture species composition.

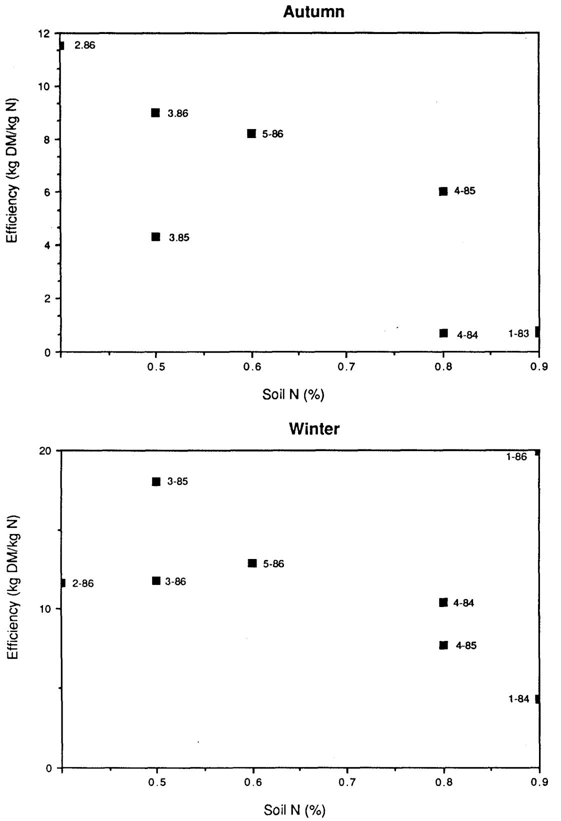

Figure 1: Average efficiency (kg N/kg DM) for autumn (March, April, May) and late winter (June, July, August) N applications at different soil N levels. Farm (1-5) and year (84-86) are indicated beside plotted values. Efficiency is mean of 25, 50, 100 kg N/ha treatments.

CONCLUSIONS

N fertilizer applications in June-September will usually result in reliable responses on Gisborne-Wairoa sheep/beef farms. Applications in March-May may not give responses, and responses will be smaller than if application is delayed until June-September. Because responses can differ under mowing and grazing, the magnitude of responses may be different than indicated in Table 3 (O'Connor, 1982; Morrison, 1987).

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