NITROGEN FERTILIZER TRIALS ON PASTURES

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Summary

On twenty-four sites throughout the country the effect of time and rate of applied nitrogen on "out-of-season" pasture production was studied over two seasons (1969-70 and 1970-71). Responses to spring-applied nitrogen were more reliable than to autumn-applied. Spring responses varied from slight (2-7 kg DM/kg N) in the Waikato, Bay of Plenty and parts of Canterbury to very good (10-20 kg DM/kg N) in Taranaki, Dannevirke, southern Wairarapa, northern South Island, Westland and parts of Southland. When yield responses are considered as a substitute for hay, or other supplementary feedstuffs, payable results occur above about 7 kg DM/kg N. Factors such as time of application, soil type, pasture composition and amount of nitrogen in the soil affected the response to applied nitrogen.

INTRODUCTION

THE SUPPLY of nitrogen is of paramount importance for the productivity of grassland. A ryegrass/white clover pasture producing 10,000 kg/ha of dry matter with a mean content of 3.5 to 4.0% N, has an annual requirement for 350 to 400 kg/ha of nitrogen. There is strong evidence in the work of Sears and his co-workers (Sears, 1953; Sears *et al.*, 1965) to support the value of white clover as a source of nitrogen in our farming system and measurements of the amount fixed have reached 670 kg/ha/annum under the climatic conditions prevailing at Palmerston North. However, seasonal shortages of nitrogen are likely to occur in pastures when conditions are unsuitable for clover growth and for the mineralization of appreciable amounts of soil nitrogen. This may result from low temperature (in winter-early spring) or moisture deficiency (in later summer-early autumn). Shortage of available soil nitrogen may then limit pasture production once conditions become favourable for plant growth.

The numerous experiments conducted throughout New Zealand have been reviewed by Lynch (1953, 1967), During (1967) and During and Weeda (1968). In the majority of cases, promising results from late winter-early spring applications of nitrogenous fertilizer were obtained. During (1967) calculated that extra pasture dry matter production amounting to 450 to 550 kg/ha could be obtained in the northern half of New Zealand, and 224 to 336 kg/ha in the cooler regions, from the application of 25 kg N/ha (1 cwt nitrolime/acre) . Further yield increases, expressed in terms of the efficiency of nitrogen usage by the pasture (kg DM/kg N) were given by During and Weeda (1968) as 20 to 25 for the northern North Island, 10 to 20 for southern North Island and 8 to 15 for the South Island.

The trend in recent years for world production of nitrogenous fertilizer to outpace consumption has led to a general fall in price. Current New Zealand prices approximate 17.6 c/kg N (8 c/lb) and can be down to below 15.4 c/kg (7 c/lb) inclusive of subsidy. It was with such factors in mind that the Field Research Section of the Research Division of the Department of Agriculture considered a reappraisal of the place of fertilizer nitrogen in pasture production was warranted.

This paper will review the part of this programme concerned with short-term trials aimed specifically at the production of "out-of-season" (spring and autumn) pasture production. Consideration will be given to that period just prior to the onset of spring growth when stresses on the animal are high owing to calving or lambing and when supplementary feed in the form of either hay or meal may be required. Alternatively, in the autumn period, additional feed may be required for the flushing of ewes or for the late lactation period in dairy cows. No attempt wil! be made to consider applications of nitrogen at other periods of the year or methods of utilizing extra pasture production from the use of applied nitrogen. An attempt will be made, however, to highlight some of the factors involved in obtaining pasture responses to nitrogen.

TRIAL DESIGN AND LOCATION

Short-term trials, placed adjacent to one another on the sites selected, were conducted over three consecutive months in the spring and autumn of 1969-70 and 1970-7 1. Trials were conducted on the same properties in both years. The trials consisted of four rates of nitrolime (equivalent to 0, 25, 50 and 100 kg/ha of nitrogen) and were replicated six times. Pastures chosen

consisted of high producing perennial ryegrass/white clover swards. Trial areas were fenced and trimmed with the mower approximately two weeks prior to the application of fertilizer. Adequate basal dressings of other nutrients were applied. Plots were harvested when growth reached 15 cm or after 6 weeks. Fences were then removed and the areas returned to grazing.

Trials were located on twenty-four sites extending from North Auckland to Southland. Soils selected were representative of major soil types in the different areas.

RESULTS AND DISCUSSION

The spring' and autumn responses obtained to nitrogen fertilizer are shown in Tables 1 and 2.

TABLE 1: SPRING RESPONSE TO NITROGEN (1969, 1970)
(25 kg/ha applied N)

Location	No. of Trials	Yield Increase (kg DM/ha)	Efficiency (kg DM/kg N)	Cost of Additional Dry Matter (cents/kg DM)*
North Auckland	5	200-300	8-12	1.3-2.0
South Auckland+	3	200-300	8-12	1.3-2.0
Waikato:				
Morrinsville†	2	50	2	7.9
Tokoroa†	3	130-200	5-8	2.0-3.2
Bay of Plenty:				
Tauranga†	3	100-200	4-8	2.0-4.0
Whakatane†	5	100-300	4-12	1.3-4.0
Taranaki†	4	350-450	14-18	0.9-1.1
Dannevirke†	6	400-700	16-28	0.6-1.0
Wairarapa	6	400-600	16-24	0.7-1.0
Golden Bay	6	400-500	16-20	0.8-1.0
Murchison	6	120-450	5-18	0.9-3.2
Westland†	3	200-400	8-16	1.0-2.0
Canterbury:				
Lincoln†	3	0-50	o-2	> 7.9
Northern Southland	6	120-350	5-14	0.9-3.2
Southern Southland	3	140-300	6-12	1.3-2.6

*Based on 15.8 c/kg N applied (7.2 c/lb N) .
†1970 only.

If a payable response is considered to be one producing dry matter at 2.2 c/kg (1.0 c/lb), which approximates the cost of hay, then Table 1 shows **that** payable responses to early spring applications were possible in our trials in most districts except perhaps' parts of the Waikato, Bay of Plenty and Canterbury. Payable responses to autumn applications did exist (Table 2) but were more variable.

TABLE 2: AUTUMN RESPONSE TO NITROGEN (1970, 1971)
(25 kg/ha applied N)

Location	*No. of Trials*	*Yield Increase (kg DM/ha)*	*Efficiency (kg DM/ kg N)*	*Cost of Additional Dry Matter (cents/kg DM)* *
Waikato:				
Morrinsville†	2	0-90	0-4	> 4.0
Tokoroa†	2	240	10	1.6
Bay oi Plenty:				
Tauranga†	9	0-200	0-8	> 2.0
Whakatane‡	2	0-140	0-6	> 2 . 6
Southern Hawke's Bay-)	3	50-120	2-5	3.2-7.9
Dannevirke‡	2	200-400	8-16	1 .0-2.0
Wairarapa	6	100-330	4-13	1.2-4.0
Golden Bay†	3	200-350	8-14	1.1-2.0
Murchison†	3	150-200	6-8	2.0-2.6
Westland‡	2	280	11	1.4
Canterbury:				
Lincoln	5	30-140	1-6	2.6-16.0
Northern Southland	5	90-500	4-20	0.8-4.0
Southern Southland	6	100-500	4 - 2 0	0.X-4.0

*Based on 15.8 c/kg N applied (7.2 c/lb N).
†1970 only.
‡1971 only.

The magnitude of the response to nitrogen, in terms of extra dry matter production, was similar to that shown by During (1967) . The present trials, however, have failed to show any superiority of warm zones over cool zones as noted by During (1967) and During and Weeda (1968).

In the discussion to follow, an attempt will be made to highlight **some** of the factors involved in obtaining responses to nitrogen with particular reference to the trial series conducted. The main emphasis will be placed on spring applications.

TIME OF APPLICATION

Applications of nitrogen were made in July, August and September or in August, September and October depending on the situation. Best responses were obtained to July applications in South Auckland, Waikato and Bay of Plenty; August applications in North Auckland, Taranaki, Wairarapa, Golden Bay and Murchison; September applications in Tokoroa and Dannevirke; and September-October in Westland and Southland. Periods of best response must, however, be considered in relation to the rate of pasture production at the time. There is little value in applying nitrogen to pastures already at their peak of spring growth under normal systems of farm management. Figure 1 shows the response to time of application in three districts, South Auckland, Wairarapa and northern Southland, for spring 1970.

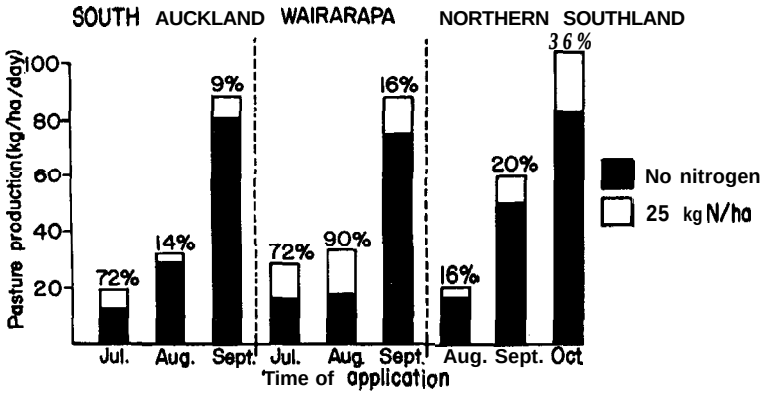

FIG. 1: *Time of application and response to nitrogen (spring 1970) (% increase in daily pasture production over no nitrogen.)*

Responses to nitrogen application decline from July to September in South Auckland and the Wairarapa as the daily pasture production on non-nitrogen plots increases. In northern Southland, however, responses increase to October, presumably because nitrogen from the mineralization of soil organic matter is still insufficient to provide for full pasture growth potential.

CLIMATE AND SOIL

Climatic conditions, in particular soil moisture and soil temperature, can markedly affect plant growth and response to nitro-

gen. Blackman (1936) has shown that grass growth stops when the soil temperature at 4 in. reaches 5.6" C (42" F) . Soil type can also have a marked influence. For example, in these trials a Waikare clay in North Auckland and an alluvial soil, Karamea silt loam, in Golden Bay responded best to nitrogen in August. Although mean air temperatures for August probably varied by 4 or 5" C between the two areas, soil temperature as modified by soil type was possibly very similar.

PASTURE COMPOSITION

Greatest respoases to nitrogen are obtained from grass-dominant swards. In grass/clover swards, responses are reduced as the proportion of white clover increases. Two trials in the Bay of Plenty in the spring of 1970 had swards containing 60% white clover and gave negligible responses to nitrogen. In the present trials the average pasture composition was 48% perennial ryegrass, 22% white clover and 30% other species (mainly grasses).

The application of fertilizer nitrogen to a grass/clover sward tends to reduce the proportion of white clover present (Whitehead, 1970). However, at the rates of nitrogen used in the present trials, up to 100 kg/ha (4 cwt nitrolime/acre) , no decrease in clover content occurred and in one or two instances increases were noted. Under irrigation at Rukuhia, Weeda (1970) maintained a reasonably high clover content (15%) in spite of applications of nitrogen of approximately 900 kg/ha/annum.

There is evidence to suggest that a depression in growth can occur after the effect of a nitrogen application has disappeared (During and Weeda, 1968). In the present trial series, areas were returned to grazing immediately after harvest and no depressions in growth were visually apparent. Again rates of application were probably too low to cause concern.

RATE OF APPLICATION

Yield increases to up to 100 kg N/ha were obtained in some instances in the present trials although the optimum rate overall was 50 kg N/ha (or 2 cwt nitrolime/acre). In terms of the efficiency of nitrogen usage, a fall-off was noted above the lowest rate, 25 kg/ha in most instances.

TIME INTERVAL BETWEEN APPLICATION AND HARVEST

Uptake of applied nitrogen in grasses tends to be rapid but dry matter production proceeds more slowly and at least 8 weeks are required for maximum response (Whitehead, 1970).

In the spring-applied trials, the cutting interval averaged 30 days, in the autumn trials 40 days. Some curtailment of maximum growth response probably occurred as a consequence of this.

THE AMOUNT OF NITROGEN AVAILABLE IN THE SOIL.

In the present trials percentage total nitrogen values in the soil varied from 0.30 to 1.14, rather high by overseas standards The mineralization and release of soil nitrogen from the organic matter is obviously an important source of mineral nitrogen. Drs W. M. H. Saunders and J. N. Parle (pers. comm.) are currently measuring the activity of nitrifying bacteria in the soil, and relating this to responses in field trials. Hopefully, such a laboratory technique could provide a useful soil test to measure the contribution of nitrogen available from the soil and hence to predict the likely response to applied nitrogen.

SOURCES OF LOSS OF APPLIED NITROGEN

Loss by Leaching

Loss of applied nitrogen from grass/clover swards is considered to be small owing to the ability of grasses to absorb 95% of the available nitrogen (Walker et al., 1956). On sandy soils in the Netherlands, heavy rain immediately after the application of nitrogen can cause leaching of nitrate (Harmsen and Kolenbrander, 1965). In the Whakatane area in the spring of 1970, an August application of 25 kg N/ha (as nitrolime) gave a reduced response over a July application (4.0 kg DM/kg N compared with 6.4 kg DM/kg N) . When daily rainfall figures at a nearby site were investigated (S. R. Hewitt, pers. comm.) it was seen that 91.4 mm (3.6 in.) was recorded two days after laying down in August followed by falls of 28.4 mm (1.12 in.), nil, 2.5 mm (0.11 in.) and 11.4 mm (0.44 in.) in consecutive days. This caused widespread flooding in the district. The soil type, a Tarawera gravel, is a free-draining pumiceous gravel and leaching of nitrate beyond the root zone is considered a district possibility.

Gaseous Loss

Gaseous loss of nitrogen from soils is difficult to measure. Attempts have been made to conduct balance experiments (Allison, 1955) but with little success. This autumn two balance experiments were conducted on a fertile Wakanui silt loam at Lincoln College. With a March application of nitrolime, only 40 to 50% of the applied nitrogen was recovered in the herbage and soil. This suggests that losses by volatilization as ammonia and denitrification processes could have been high in the hof dry conditions prevailing, particularly at rates above 50 kg N/ha. An April application, on the other hand, gave an 85 to 90% recovery of applied nitrogen. Climatic conditions in April were cooler and slightly wetter than in March.

CONCLUSIONS

(1) Early spring applications of nitrogen gave payable responses in most districts except for parts of the Waikato, Bay of Ylenty and Canterbury.

(2) July and August applications were best for most districts; September for the Tokoroa, Dannevirke, Westland and Southland areas.

(3) Responses to autumn applications were variable,

(4) Marked yield increases to fertilizer nitrogen were nut confined to the warm zone areas of New Zealand and occurred throughout the country.

(5) A number of factors affected the responses to applied nitrogen. Further work will be necessary to define clearly how these modify nitrogen responses.

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DISCUSSION

Mitchell (Palmerston North) asked for comment on the reasons for the apparently poor responses to nitrogen in Bay of Plenty and Waikato areas and also on the implementation of the results in practice. O'Connor considered that in those particular areas growth tended to continue throughout winter and that under conditions suitable for mineralization there was a build-up of soil N. At this stage he felt that the best use of N would be in implementing out-of-season growth. Brougham (Palmerston North) suggested that no account had been taken of the cost of application of N or of the efficiency of utilization of the extra feed provided and that farmers should be cautioned on these factors. O'Connor replied that he had taken into account the cost of spreading the fertilizer by the farmer himself. To a question by Edmond (Palmerston North) as to whether phosphate or potassium was limiting, O'Connor stated that at least 4 cwt/acre of potassic superphosphate had been applied as a basic dressing. Asked by Cullen (Invermay) what form of N had been used, O'Connor said that nitrolime was used. Various forms had been compared, in a separate series of trials, namely, urea, sulphate of ammonia and nitrolime, and responses to all had been similar. Organic forms of N had all given much slower responses. Elliott (Ruakura) commented that the low responses in Waikato might be due to high stocking rates and consequent rapid turnover of N in urine. O'Connor said that they had purposely avoided this aspect in these trials as they wished to try to cost out the use of nitrogen, and so had not considered methods of pasture utilization. All the trials had been carried out on old swards. He felt that they should be carried on for at least three years to allow for the differences in conditions which could occur.