YIELD OF PARA GRASS *(BRACHIARIA MUTICA)* AS INFLUENCED BY SOURCE, RATE AND FREQUENCY OF APPLICATION OF FERTILIZER NITROGEN

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ABSTRACT

Ammonium sulphate, ammonium nitrate and urea at rates of 100 and 200 kg per ha per year were applied to a Para grass pasture in the wet tropics over three periods of about a year each. In the first period, a single initial application was compared with three splits at about 15 week intervals. In the second and third periods, comparison was between 4 splits at 12 week intervals and 8 splits at 6 week intervals.

Drymatter yeilds averaged 36 kg per kg N applied for ammonium nitrate, 29 kg for ammonium sulphate and 25 kg for urea. Response to frequency of application was small. There was little residual effect beyond six weeks after application. Response appeared almost linear to increasing rates up to 50 and perhaps even 200 kg per ha per application.

Nitrogen content of herbage cut at 6 to 8 week intervals averaged about 1%, with very little effect of treatments. Recovery of applied nitrogen averaged 42, 28 and 27 per cent in the three successive periods.

INTRODUCTION

Para grass (*Brachiaria mutica*) is an important pasture species in high rainfall areas of the Markham Valley and in other well-watered locations in Papua New Guinea, both lowlands and highlands. Most of these Para grass pastures are pure grass swards as it has been difficult to find legumes which will persist in combination with this highly competitive species. No nitrogen fertilization has been practised commercially, although there is evidence from overseas that Para grass responds well to nitrogen. This paper presents results of an experiment running over three years studying the response of Para grass to different types, rates and frequencies of application of nitrogen fertilizers.

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PROCEDURE

The experiment began in August 1971, on a three year old Para grass pasture and covered three periods of about one year each, concluding in February, 1975. The site was Narakapor, 15 km from Lae in the lower Markham Valley (latitude 6 deg. 40 min. S, altitude about 50 m, mean temperature about 26°C, annual rainfall about 2,000 mm). The site had previously been planted with coconuts but these had been cut down to promote pasture growth. Soil was an alluvial clay loam of pH 7.5 to 7.7. Soil samples were taken at the end of the first and third years and were analysed by the Agricultural Chemistry Section of the Department of Agriculture, Stock and Fisheries. Results are shown in *Tables 1* and *2*.

The trial compared three fertilizers; ammonium sulphate, ammonium nitrate and urea. All were applied at rates of 100 and 200 kg N per ha per year.

Table 1

Soil Analysis Data from Nil Nitrogen Plots, Sampled in 1972 and 1975

	1972	1975
pH	7.6	8.1
Specific Conductivity (Mhos x 10^3)	0.018	0.130
Total Soluble Salts	0.006	0.039
Olsen P (p.p.m.)	32.3	12.3
Exchangeable Cations (m.e.%)		
Ca	63.0	67.5
Mg	9.6	8.7
K	1.54	1.75
Na	2.57	2.46
Cation exchange capacity (m.e.%)	54.0	67.8
Base saturation %	100	100
Carbon (W and B)%	1.7	1.9
Nitrogen %	0.17	0.23
C/N Ratio	10.5	8.2

Fertilizer was hand broadcast onto the grass after slashing it to a height of about 15 cm. Two application frequencies were compared in each period. In the first period, the comparison was between a single initial application and three equal splits applied after every second grass harvest. Because the fertilizer response was found to be very short-lived, frequencies were changed and the comparison in the second and third periods was between application at every harvest and at alternate harvests. Details are shown in *Table 3.* Design was randomized blocks with four replications, each block including two nil-nitrogen plots in addition to the twelve factorail combinations.

At the start of the first and second but not the third period, potassium sulphate was applied to all plots not receiving ammonium sulphate, so as to equalize sulphate levels. Basal dressings of phosphorus, potash and trace element mixture, each at 50 kg per ha, were applied at the start of the first period only.

To estimate drymatter yield, six harvests were taken in the first year, at about seven-week intervals, and eight harvests each in the second and third periods, at about six-week intervals. From each plot, four quadrats 50 cm x 50 cm were cut at a height of 15 cm for recording purposes, and the remainder of the plot (size $10m^2$) was then cut back to the same height. All cut grass was carried off the plots. Samples were dried for 48 hours at 80°C and then weighed. Samples from each treatment, pooled over the four replications, were subsampled for nitrogen analysis by the Agricultural Chemistry Section.

Rainfall data for the first two periods are presented in *Table 3.* The second period was slightly wetter than the first. The third period was similar to the second but records are not available. All plots were flooded for three to seven days at least once each year when the nearby Markham River overflowed. At the end of the first period, small ditches were dug around each plot to prevent fertilizer washing from one plot onto another.

RESULTS AND DISCUSSION

DRYMATTER YIELDS

Yields, according to treatment, are presented in *Table 4* in the form of yearly totals. Effects of rates and frequencies of fertilizer application on yields at individual harvests are shown in *Figure 1.*

Table 2

Details of Soil pH, P, N and C/N Ratio, according to Treatment

		Am. Sulph.		Am. Nit.		Urea		MEAN
		F1	F2	F1	F2	F1	F2	
pH **1972**	No	—	—	—	—	—	—	7.6
	N100	7.7	7.6	7.5	7.6	7.5	7.6	7.6
	N200	7.7	7.6	7.4	7.5	7.6	7.6	7.6
	MEAN	7.7		7.5		7.6		
			F1—7.6		F2—7.6			
pH **1975**	No	—	—	—	—	—	—	8.0
	N100	8.1	7.6	7.9	8.0	7.7	7.6	7.8
	N200	7.8	7.8	7.6	7.8	8.0	7.6	7.8
	MEAN	7.8		7.8		7.7		
			F1—7.9		F2—7.7			
Olsen P ppm **1972**	No	—	—	—	—	—	—	32.3
	N100	47.0	32.5	32.5	27.5	29.0	29.0	32.9
	N200	31.0	23.5	35.5	33.5	33.0	38.5	32.5
	MEAN	33.5		32.3		32.4		
			F1—32.7		F2—30.8			
Olsen P ppm **1975**	No	—	—	—	—	—	—	12.3
	N100	5.0	6.5	6.5	5.0	6.0	6.0	5.8
	N200	5.0	5.0	4.5	4.5	4.5	5.0	4.8
	MEAN	5.3		5.1		5.4		
			F1—5.3		F2—5.3			
N% **1972**	No	—	—	—	—	—	—	0.17
	N100	0.19	0.18	0.19	0.17	0.17	0.17	0.18
	N200	0.17	0.17	0.20	0.20	0.13	0.17	0.17
	MEAN	0.18		0.19		0.16		
			F1—0.18		F2—0.18			
N% **1975**	No	—	—	—	—	—	—	0.23
	N100	0.26	0.25	0.27	0.24	0.21	0.23	0.24
	N200	0.24	0.23	0.25	0.28	0.22	0.25	0.21
	MEAN	0.25		0.26		0.23		
			F1—0.24		F2—0.21			
C:N Ratio **1972**	No	—	—	—	—	—	—	11.0
	N100	10	10	10	9	10	10	9.9
	N200	11	11	10	10	15	10	11.2
	MEAN	10.5		9.8		11.3		
			F1—11.0		F2—10.0			
C:N Ratio **1975**	No	—	—	—	—	—	—	8.2
	N100	7.7	12.4	8.7	6.8	6.7	7.0	8.2
	N200	12.4	7.1	6.7	6.1	7.7	8.0	8.2
	MEAN	9.9		7.1		7.4		
			F1—8.3		F2—7.9			

Table 3

Details of Fertilizer Treatments, and Intervals and Rainfall Recorded Between Fertilizer Application and Harvest

Fertilizer Application (kg N per ha)

Period 1: F_1N_1 = 100, F_1N_2 = 200 at harvest 0
F_2N_1 = 33, F_2N_2 = 66 at harvests 0, 2, 4*

Periods 2, 3: F_1N_1 = 25, F_1N_2 = 50 at harvests 0, 2, 4, 6
F_2N_1 = 12.5, F_2N_2 = 25 at harvests 0, 1, 2, 3, 4, 5, 6, 7

Intervals and Rainfall

Period		Harvest No. 1	2	3	4	5	6	7	8
1	F_1 (days)	53	108	149	197	303*	359	—	—
	F_2 (days)	53	108	41	89	47*	103	—	—
	Rain (mm)	86	318	67	99	81	246	—	—
2	F_1 (days)	43	83	46	84	43	82	42	85
	F_2 (days)	43	40	46	38	43	39	42	43
	Rain (mm)	58	116	221	332	262	157	225	406
3	F_1 (days)	42	80	47	89	42	84	41	83
	F_2 (days)	42	38	47	42	42	42	41	42

* The long interval between harvests 4 and 5 arose through cattle breaking in and gazing the plots; they were therefore cut back and fertilizer was reapplied to F_2 plots.

Table 4

Yields of Para Grass According to Type, Rate and Frequency of Fertilizer Application
Total drymatter yields (t per ha)

	Ammonium Sulphate F_1	Ammonium Sulphate F_2	Ammonium Nitrate F_1	Ammonium Nitrate F_2	Urea F_1	Urea F_2	Mean
Period 1							
No	—	—	—	—	—	—	7.2
N1	11.1	12.5	12.8	12.0	11.9	11.3	11.9
N2	13.9	16.3	14.6	15.5	12.8	14.3	14.6
MEAN	13.4		13.7		12.6		
		F_1—12.8		F_2—14.2			
	N_1F_1—11.9		N_1F_2—11.9	N_2F_1—13.8		N_2F_2—15.3	
Period 2							
No	—	—	—	—	—	—	13.5
N1	15.8	14.8	17.3	16.4	14.1	15.2	15.6
N2	17.6	19.5	18.5	20.1	18.0	18.5	18.7
MEAN	16.9		18.1		16.4		
		F_1—16.9		F_2—17.4			
	N_1F_1—15.8		N_1F_2—15.4	N_2F_1—18.1		N_2F_2—19.4	
Period 3							
No	—	—	—	—	—	—	7.8
N1	10.2	9.5	11.5	10.7	8.6	10.6	10.2
N2	12.3	11.9	14.7	14.2	12.0	12.2	12.9
MEAN	11.0		12.8		10.8		
		F_1—11.5		F_2—11.5			
	N_1F_1—10.1		N_1F_2—10.3	N_2F_1—13.0	N_2F_2—12.8		

Drymatter yield in the second period was higher than in the first and third possibly because of seasonal differences. Nitrogen application produced very highly significant yield increases in all years, averaging about 3,000 kg per ha from the first 100 kg N and a further 2,800 kg per ha from the second. This response of about 30 kg drymatter per kg N applied may be compared with such overseas results as 32.3 and 49.1 lb per lb N from 200 lb per acre at cutting intervals of 40 and 60 days respectively in Puerto Rico (Vicente-Chandler *et al*, 1959) and 37 kg per kg N from a single harvest six months after application of 200 kg N per ha in Northern Territory, Australia (Miller and Nobbs, 1976). Although the Northern Territory response and 60 day response in Puerto Rico were higher than the returns recorded at Narakapor, the longer growth intervals would have led to decline in quality of the herbage. It is also probable that N response at Narakapor was restricted by the declining P levels indicated by the 1975 soil analyses (*Table 2*).

Differences between sources of nitrogen were significant in the first year, non-significant in the second, and very highly significant in the third. Overall, ammonium nitrate produced the greatest response and urea the lowest, while ammonium sulphate was similar to ammonium nitrate in the first year but similar to urea in the second and third. On average, ammonium nitrate yielded about 1,000 kg drymatter per ha more than yield from ammonium sulphate and 1,500 kg more than from urea. At the current cost of K100/per tonne for sulphate of ammonia, K150 for urea and K180 for ammonium nitrate, the drymatter return per unit expenditure would be slightly greater for urea than for ammonium nitrate, which would be slightly greater again than that for sulphate of ammonia. In terms of efficiency of N utilization (kg drymatter per kg applied N) the figures were 36 for ammonium nitrate, 29 for sulphate of ammonia and 25 for urea. Gartner and Everett (1970) reported similar superiority of ammonium nitrate over urea on kikuyu grass but only at fairly high application rates (200 and 400 lb N per acre). Figarella *et al* (1972) reported a trial including comparison of ammonium sulphate, ammonium nitrate and urea on Pangola grass in Puerto Rico. Differences were non-significant but ammonium sulphate was generally the most efficient and urea least efficient source of N.

In the first year, the total yield from the split applications was 10 per cent greater than that from the single initial application. In the two later years, there was virtually no difference in overall yield between application at every harvest and application at alternate harvests. This, however, masks the fact that there were very big differences in response to application frequencies at individual harvests, as can be seen from *Figure 1*. The pattern of response is seen best when it is recognized that almost the whole of the nitrogen response was recorded in the growth between fertilizer application and the subsequent harvest (see *Table 5*).

Table 5

Yields at First and Second Harvests After Fertilizer Application

	First Harvest*		Second Harvest*	
	N_1	N_2	N_1	N_2
Period 1	194	268	125	133
Period 2	134	163	101	106
Period 3	158	222	99	110

* Based on mean drymatter yields from treatments where fertilizer was applied at alternate harvests, yield of fertilized plots being expressed as percentage of yield of unfertilized plots at the same harvests. Means of three harvests in Period 1, and four harvests each in Periods 2 and 3.

The residual response at the second harvest after each application was small in the first period, and in the second and third periods there was a small residual effect only at the higher application rate.

The short duration of the nitrogen response is also evident in *Figure 1*, where it may be seen that yield in the plots which received all fertilizer in one application reverted almost to the level of the unfertilized plots in the second and subsequent harvests. At the lower N rate, yield at the first harvest was 327% of the control yield but it was only 142% at the second and 124% for the total of harvests 2 to 6. At the higher N rate, figures were 460, 152 and 120% respectively.

As most of the fertilizer response was recorded in the first harvest after fertilizer application and there was little residual effect at subsequent harvests, the trial may also be viewed as covering a range of fertilizer rates from 12.5 to 200 kg per ha in a single application if a study is made of immediate post-fertilizer yields only. These are isolated in *Table* 6, which presents both dry matter yields and response expressed in terms of kg drymatter per kg N applied.

Table 6

Yields and Nitrogen Response in Harvests First after Fertilizer Application*

Nitrogen Rate (kg per ha)

Period 1		0	33		66		100		200	
Harvest	1	1486	2493	(31)	3197	(26)	4866	(34)	6840	(27)
Harvest	3	1092	2469	(42)	3866	(42)	—		—	
Harvest	5	1646	3251	(49)	4260	(40)	—		—	
Mean		1408	2738	(40)	3774	(36)	4866	(34)	6840	(27)
Period 2		0	125		25		25		50	
Harvest	1	975	1249	(22)	1480	(20)	1460	(19)	1687	(14)
	2	1339	1958	(50)	2734	(56)	—		—	
	3	2006	1864	(-11)	2317	(12)	2279	(11)	2907	(18)
	4	2285	2278	(-1)	2783	(20)	—		—	
	5	2233	2617	(31)	3235	(40)	3175	(38)	3700	(29)
	6	1267	1491	(18)	1899	(25)	—		—	
	7	1486	1806	(26)	2156	(27)	2056	(23)	2628	(23)
	8	1854	2151	(24)	2763	(36)	—		—	
Mean		1681	1927	(20)	2421	(30)	2243	(23)	2731	(21)
Period 3		0	12.5		25		25		50	
Harvest	1	919	1183	(21)	1541	(25)	1656	(29)	2119	(24)
	2	1026	1134	(9)	1217	(8)	—		—	
	3	1175	1814	(51)	2460	(51)	2080	(36)	3015	(37)
	4	799	949	(12)	1145	(14)	—		—	
	5	1326	1409	(7)	1368	(2)	1265	(-2)	1827	(10)
	6	1139	1569	(34)	2060	(37)	—		—	
	7	580	955	(30)	1228	(26)	1318	(30)	1903	(28)
	8	835	1189	(28)	1740	(36)	—		—	
Mean		975	1275	(24)	1595	(25)	1580	(23)	2216	(24)

* Figures in the body of the table are drymatter yields (kg per ha). For nitrogen rates above zero, figures in brackets show the nitrogen response in terms of the increase in drymatter yield expressed as kg drymatter per kg applied nitrogen.

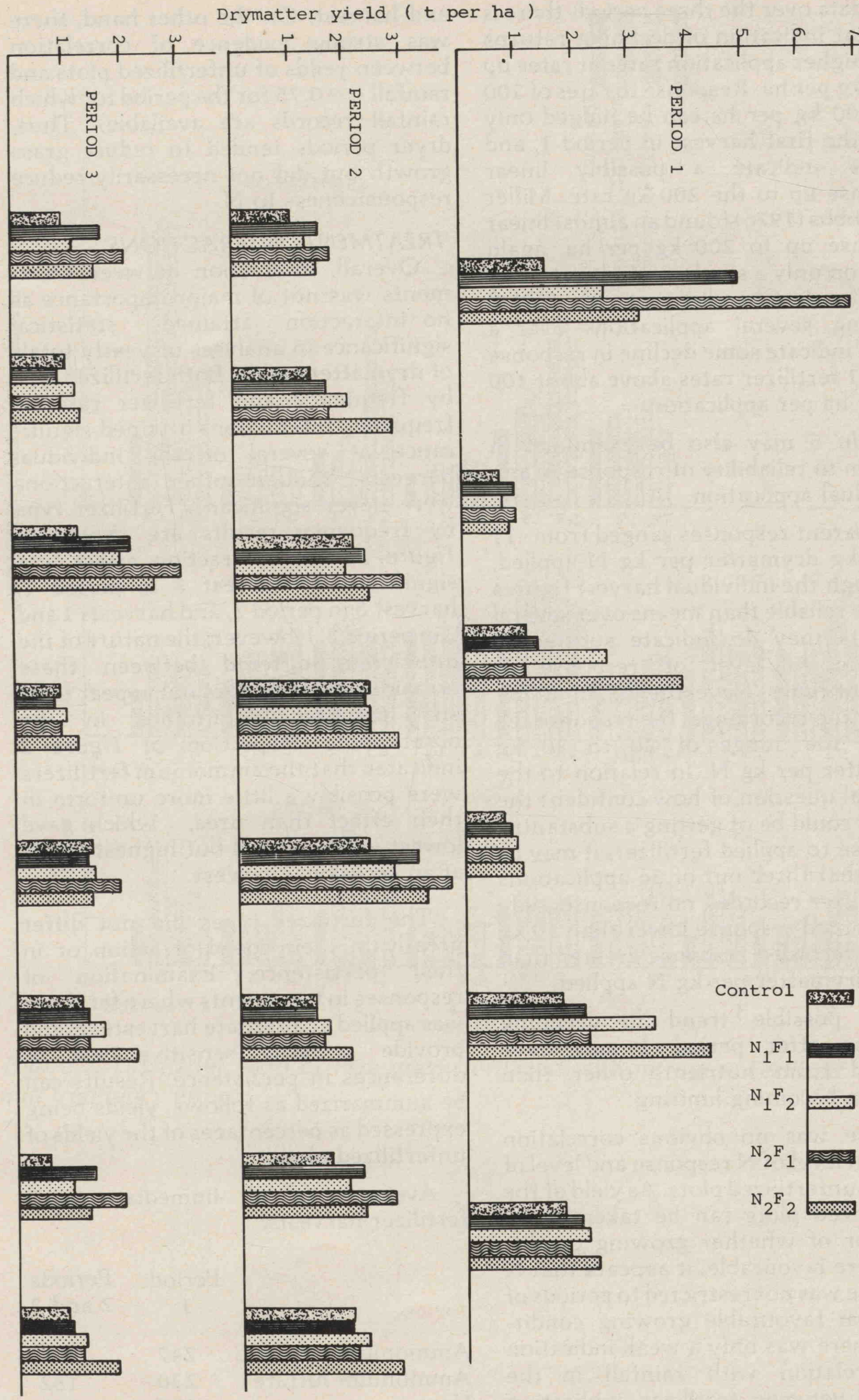

Figure 1 – Drymatter yield of Para grass fertilized with nitrogen. Fertilizer rate and frequency effects.

In data over the three periods there is no clear indication of declining returns with higher application rates at rates up to 50 kg per ha. Response to rates of 100 and 200 kg per ha can be judged only from the first harvest in period 1, and results indicate a possibly linear response up to the 200 kg rate. Miller and Nobbs (1976) found an almost linear response up to 200 kg per ha, again based on only a single application. Data of Vicente-Chandler *et al* (1959) covering several applications over a period indicate some decline in response level at fertilizer rates above about 100 kg per ha per application.

Table 6 may also be examined in relation to reliability of response to any individual application.

Apparent responses ranged from -11 to 56 kg drymatter per kg N applied. Although the individual harvest figures are less reliable than means over several harvests they do indicate substantial variation in level of response at different times. Nevertheless, in 60 per cent of the recordings, the response fell within the range of 20 to 40 kg drymatter per kg N. In relation to the practical question of how confident the grazier could be of getting a substantial response to applied fertilizer, it may be noted that three out of 56 applications of fertilizer recorded no response, only six recorded response lower than 10 kg and 40 recorded response greater than 20 kg drymatter per kg N applied.

The possible trend to declining response after period 1 may have resulted from nutrients other than nitrogen becoming limiting.

There was no obvious correlation between level of N response and level of yield of unfertilized plots. As yield of the unfertilized plots can be taken as an indicator of whether growing conditions were favourable, it appears that N response was not restricted to periods of the most favourable growing conditions. There was only a weak indication of correlation with rainfall in the interval between fertilizer application and harvest. On the other hand, there was strong evidence of correlation between yeilds of unfertilized plots and rainfall (r = 0.75 for the period for which rainfall records are available). Thus, dryer periods tended to reduce grass growth but did not necessarily reduce responsiveness to N.

TREATMENT INTERACTIONS

Overall, interaction between treatments was not of major importance as no interaction attained statistical significance in analyses of yearly totals of drymatter yields. Both fertilizer type by frequency and fertilizer rate by frequency interactions attained significance at several of the individual harvests, though other interactions were never significant. Fertilizer type by frequency results are shown in *Figure 2*. The interaction effect was significant at harvest 3 in period 1, harvest 5 in period 2, and harvests 1 and 3 in period 3. However, the nature of the interaction differed between these occasions so there does not appear to be any practical significance in the observation. Inspection of *Figure 2* indicates that the ammonium fertilizers were possibly a little more uniform in their effect than urea, which gave lowest yields overall but highest yields at an occasional harvest.

The fertilizer types did not differ greatly in their speed of action or in their persistence. Examination of responses in treatments where fertilizer was applied at alternate harvests should provide a fairly sensitive test of differences in persistence. Results can be summarized as follows, yields being expressed as percentages of the yields of unfertilized plots.

Averages of all immediate post-fertilizer harvests:

	Period 1	Periods 2 and 3
Ammonium sulphate	247	161
Ammonium nitrate	230	182
Urea	217	149

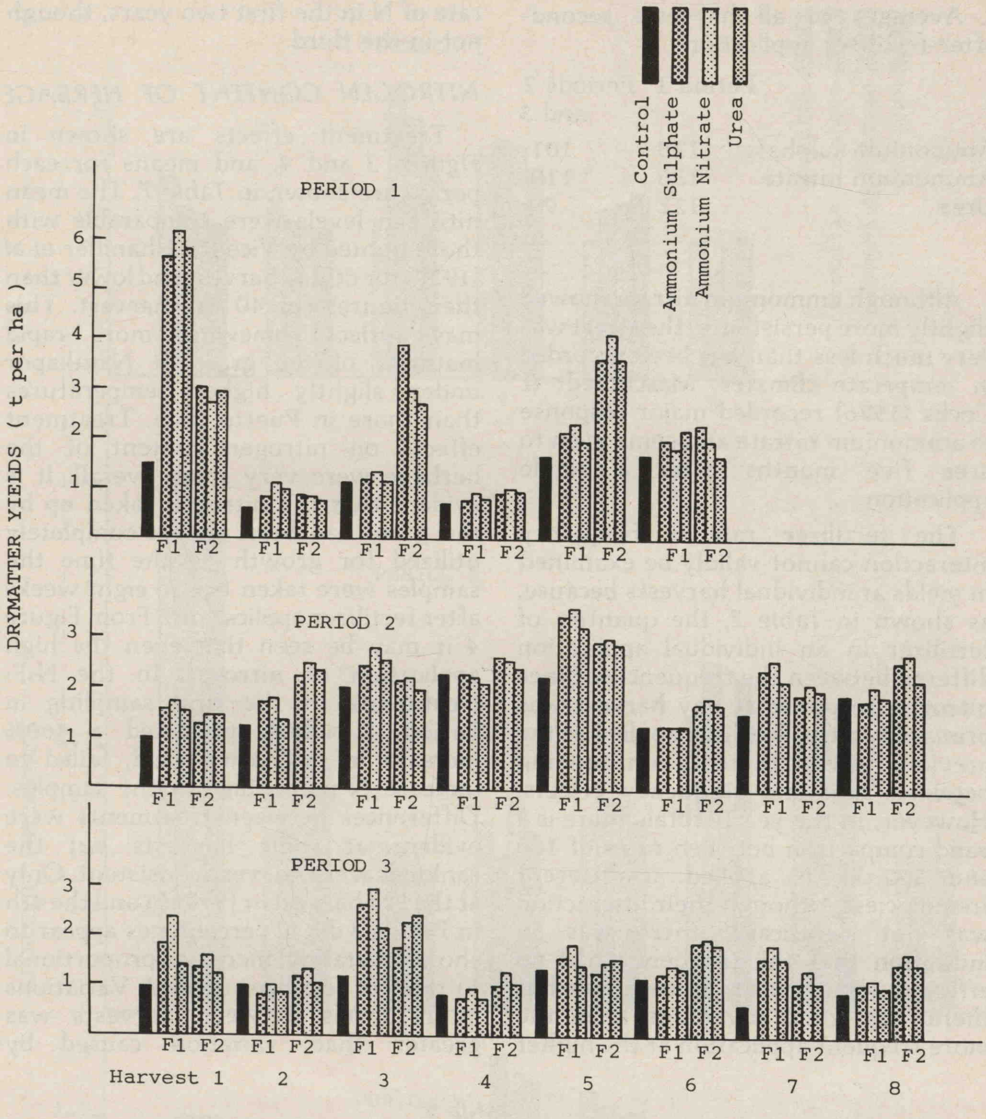

Figure 2.–Drymatter yield of Para grass fertilized with nitrogen. Fertilizer type and frequency effects.

Averages of all harvests second-after-fertilizer application:

	Period 1	Periods 2 and 3
Ammonium sulphate	128	101
Ammonium nitrate	136	110
Urea	122	99

Although ammonium nitrate showed slightly more persistence, the effect was very much less than has been recorded in temperate climates. Maschmedt & Cocks (1976) recorded major response to ammonium nitrate and some even to urea five months after a single application.

The fertilizer rate x frequency interaction cannot validly be examined in yields at individual harvests because, as shown in *Table 2*, the quantity of fertilizer in an individual application differed between the frequencies. Since nitrogen response at any harvest was primarily to the fertilizer applied at the previous harvest, there is a confounding between rate and frequency effects. However, in the yearly totals there is a valid comparison between rates of 100 and 200 kg N applied at different frequencies. Although their interaction was not significant, there was an indication that the frequency had no effect on total yield at the lower rate but there was some advantage from the more frequent application at the higher rate of N in the first two years, though not in the third.

NITROGEN CONTENT OF HERBAGE

Treatment effects are shown in *Figures 3* and *4*, and means for each period are shown in *Table 7*. The mean nitrogen levels were comparable with those quoted by Vicente-Chandler *et al* (1959) for 60 day harvest and lower than their figures for 40 day harvest. This may reflect somewhat more rapid maturity of the grass at Narakapor under slightly higher temperatures than those in Puerto Rico. Treatment effects on nitrogen content of the herbage were very small overall. It is evident that the nitrogen taken up by the grass had been almost completely utilized for growth by the time the samples were taken (six to eight weeks after fertilizer application). From Figure *4* it may be seen that even the high application of nitrogen in the N_2F_1 treatments in the first sampling in Period 1, which produced a 460% increase in drymatter yield, failed to increase N percentage in the samples. Differences between treatments were evident at some harvests but the rankings were not very consistent. Only at the 3rd harvest in Period 1 and the 4th in Period 3 did N percentages appear to show substantial increases proportional to rates of fertilizer applied. Variations in N levels between harvests was greater than variation caused by

Table 7
Mean Nitrogen Contents, According to Treatment
Annual Averages over Samples Taken at Each Harvest

	PERCENT NITROGEN IN DRYMATTER		
	Period 1	Period 2	Period 3
Control	0.92	1.09	1.04
N_1F_1	0.92	1.08	1.07
N_1F_2	0.96	1.07	1.06
N_2F_1	0.92	1.10	1.08
N_2F_2	1.00	1.11	1.10
Sulphate of Ammonia	0.96	1.10	1.08
Ammonium Nitrate	0.95	1.10	1.09
Urea	0.94	1.06	1.07

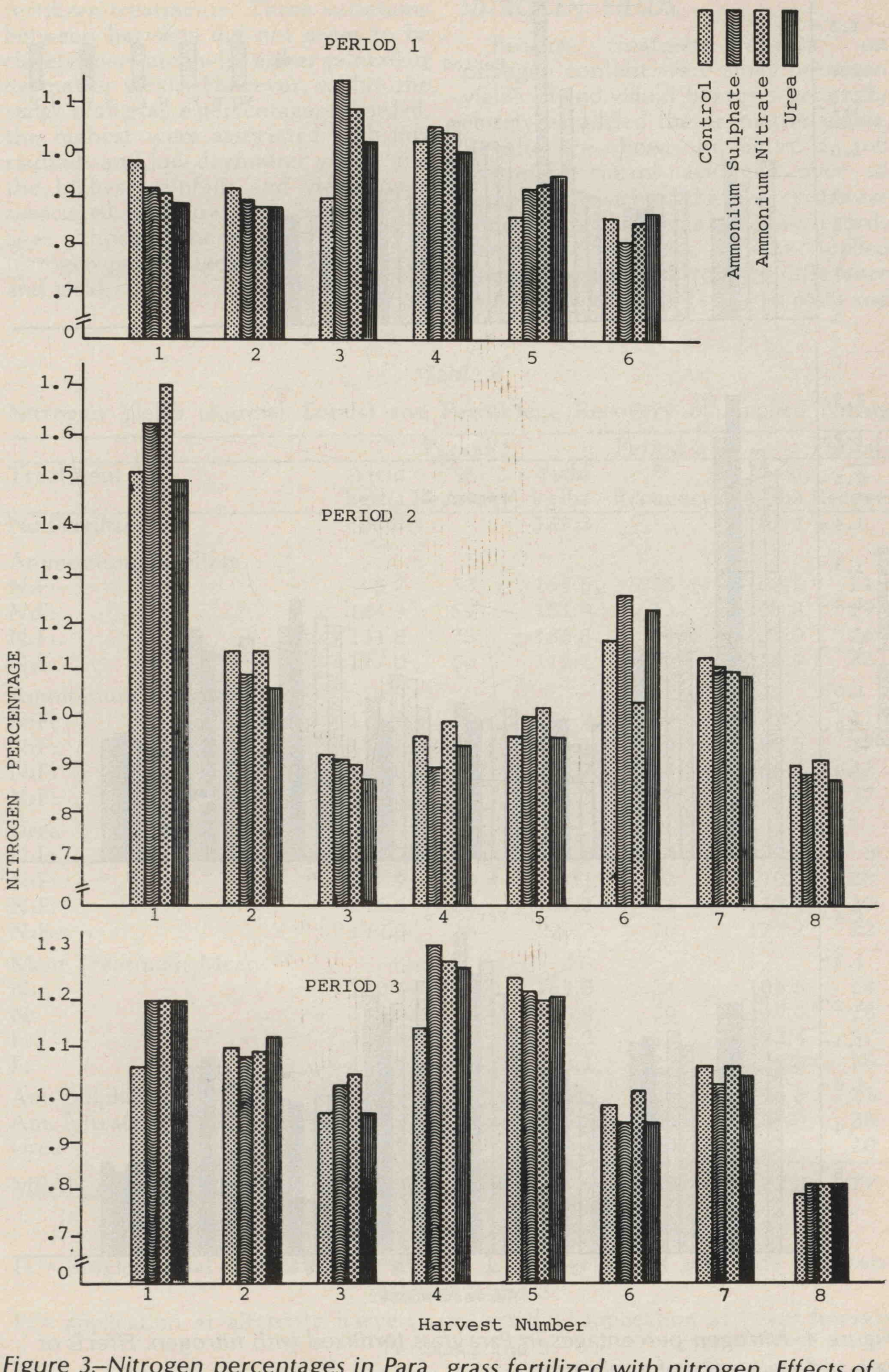

Figure 3.–Nitrogen percentages in Para grass fertilized with nitrogen. Effects of three different sources of nitrogen.

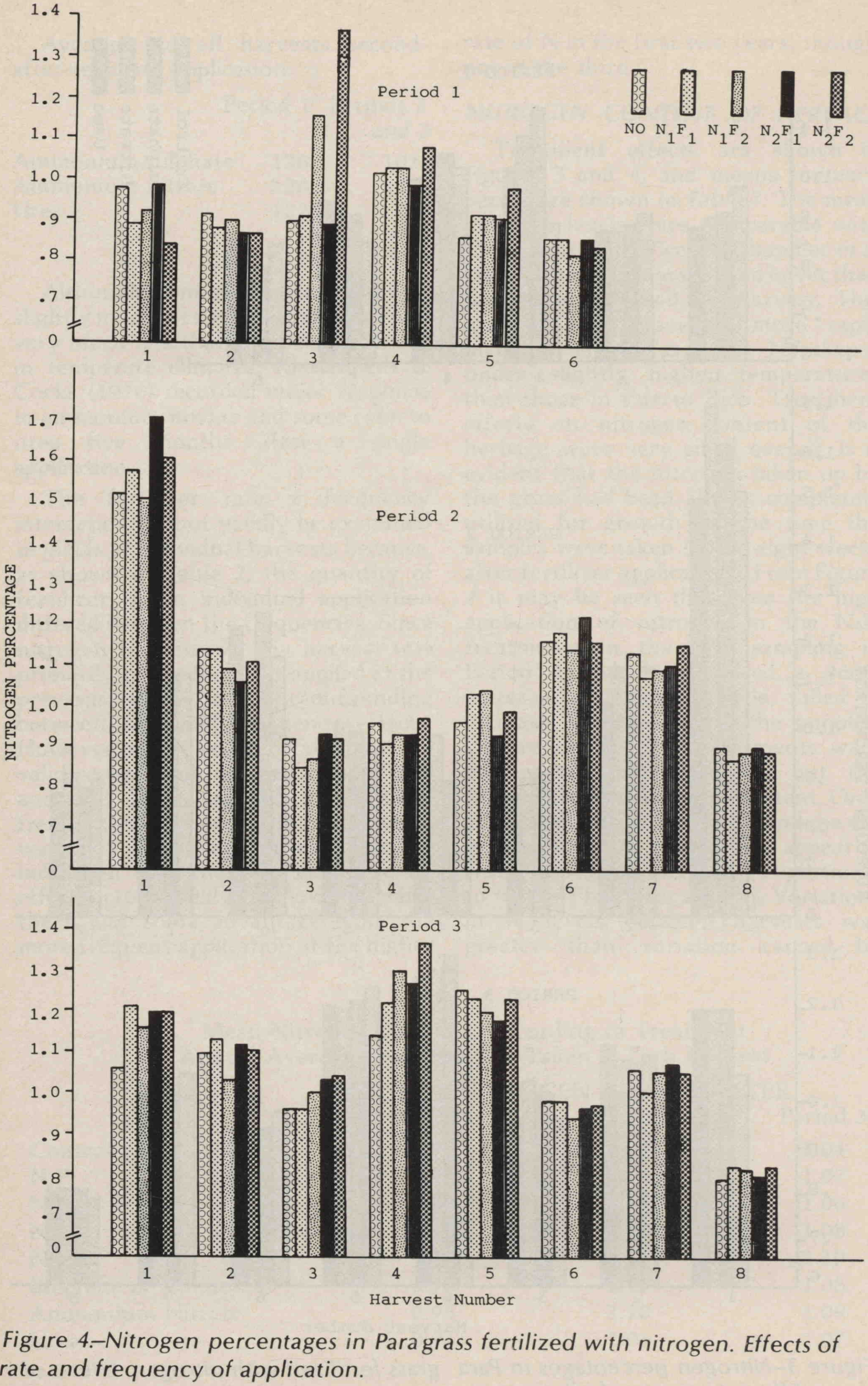

Figure 4.–Nitrogen percentages in Para grass fertilized with nitrogen. Effects of rate and frequency of application.

fertilizer treatments. These variations between harvests did not seem to be closely correlated with either rainfall or drymatter yields. However, within the range of nitrogen percentages recorded, the highest were associated with low rainfalls and low drymatter yields, and the highest rainfalls and yields were associated with low nitrogen percentages, though there were also low nitrogen percentages with low rainfall and yield.

NITROGEN YIELDS

Because treatment effects on nitrogen content were small, nitrogen yields at individual harvests generally closely paralleled the drymatter yields. Results are shown in *Figure 5*, and treatment means averaged over all samples for each of the three years are shown in *Table 8*. This table also records percentage recovery of the applied nitrogen, calculated from the difference in N yields between fertilized plots and

Table 8

Nitrogen Yields (Annual Totals) and Percentage Recovery of Applied Nitrogen

Treatment	Period 1 Yield kg/ha	Period 1 % Recovery	Period 2 Yield kg/ha	Period 2 % Recovery	Period 3 Yield kg/ha	Period 3 % Recovery
No Fertilizer	65.3		139.2		82.4	
Ammonium Sulphate						
N_1F_1	98.7	33	164.6	25	103.2	21
N_1F_2	124.3	59	151.9	13	101.0	19
N_2F_1	131.8	33	186.8	24	134.0	26
N_2F_2	177.0	56	212.1	36	126.9	22
Ammonium Nitrate						
N_1F_1	113.9	49	186.7	47	123.7	41
N_1F_2	117.7	46	168.1	29	109.5	27
N_2F_1	144.0	39	205.2	33	166.2	42
N_2F_2	159.6	47	214.7	38	156.6	37
Urea						
N_1F_1	106.2	41	144.6	6	90.5	8
N_1F_2	107.9	43	161.1	22	110.9	28
N_2F_1	115.6	25	181.3	21	123.1	20
N_2F_2	142.0	38	190.7	26	127.2	22
Main Treatment Means						
N_1	110.4	45	162.8	24	106.5	24
N_2	145.0	40	198.4	30	139.0	28
F_1	118.4	35	178.2	22	123.4	27
F_2	137.1	48	183.1	29	122.0	26
Am. Sulphate	132.9	45	178.8	26	116.3	23
Am. Nitrate	132.3	45	193.7	36	139.0	38
Urea	117.9	35	169.4	20	112.9	20
MEAN ALL FERTILIZED	127.7	42	180.6	28	122.8	27

N_1 = 100 kg N/ha N_2 = 200 kg N/ha

F_1 = single initial application in Period 1, application at alternate harvests in Periods 2 and 3.

F_2 = application at alternate harvests in Period 1, application at every harvest in Periods 2 and 3.

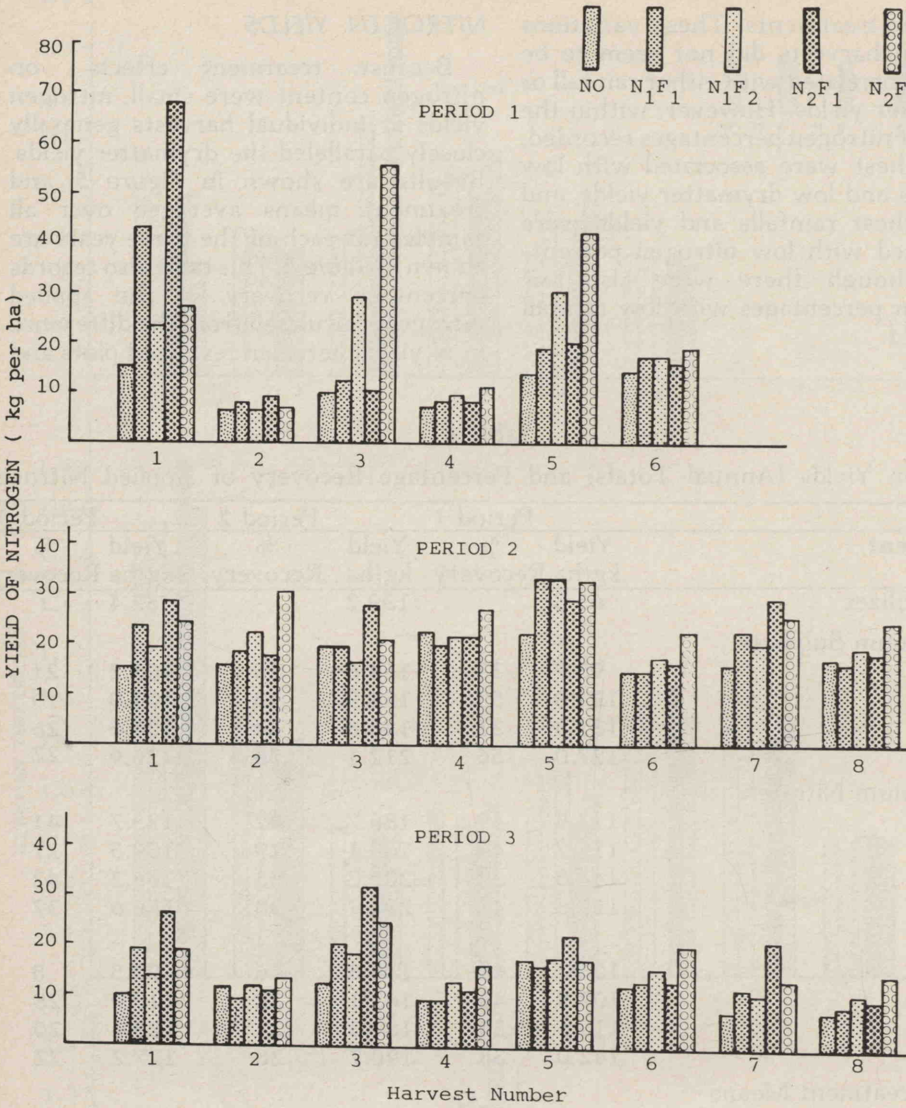

Figure 5. Nitrogen yields from Para grass fertilized with nitrogen. Effects of rate and frequency of application.

control plots receiving no nitrogen fertilizer.

Nitrogen yields were obviously increased by applied nitrogen, the increase being greater at the higher than at the lower level of nitrogen. Apart from those effects, results tended to be inconsistent. Recovery of N from urea was almost certainly lower than from ammonium nitrate, with ammonium sulphate intermediate.

Nitrogen recovered from the single initial application in Period 1 was less than that recovered from the same quantities of fertilizer in three split applications. In the following two periods, the comparison between application at every harvest and at alternate harvests did not give a clearcut result, though the overall trend was to higher recovery from the more frequent application. Recovery varied greatly from harvest to harvest, ranging from 0 to 56% where N was applied after every harvest and from 8 to 36% with application at alternate harvests. Although some of this variation was no doubt due to sampling error, there can be little doubt that there was much real variation also. This was not obviously correlated with rainfall.

There was no consistency as to whether percentage recovery of applied N was greater or less for higher application rates than for lower. The overall percentage recoveries of fertilizer N from nitrogen-treated plots, averaging 42, 28 and 27 percent respectively in the three successive periods, were relatively low, no doubt reflecting high leaching loss under tropical high rainfall conditions, and perhaps some volatilization loss also. Maschmedt and Cocks (1976) in a temperate climate recorded recovery of 44 per cent of N applied as a single dressing of urea at the start of the season and 87 to 92 per cent from ammonium nitrate or multiple dressings of ammonium nitrate or urea. Vicente-Chandler *et al* (1959) recorded recovery as high as 50% from 200 lb N per acre applied in six splits over a year in Puerto Rico. Miller and Nobbs (1976) recovered only 12% of N from fertilizer broadcast at 200 kg per ha in a single application.

ECONOMIC APPRAISAL

The trial demonstrated a substantial and fairly consistent response of Para grass to applied nitrogen. Evidence of similar results under comparable conditons overseas confirms the general indication that under wet lowlands conditions in Papua New Guinea a grazier could have a high level of confidence that he would get a return of about 30 kg drymatter from application of 1 kg N to Para grass pastures. This gives a cost of about 1.3 toea per kg of drymatter produced, at which rates the economic return would probably be marginal in terms of routine fertilizing. There is also some indication that persistent use of high levels of N would create a need for other fertilizers as well. It should be noted that in this trial the grass cuttings were removed from the plots whereas under grazing there would be some return to the plots in excreta. On the other hand, some of the additional growth might be lost through trampling and fouling of the pasture.

Although the economics of regular fertilizing may be doubtful, the rapidity of the response is such that nitrogenous fertilizer could be valuable as a management tool. At any time when there is a need for increased feed a grazier could apply fertilizer and increased herbage would be available within a few weeks. The response should be similar whether a heavy application rate were used on a small area of pasture or the same quantity of fertilizer were spread at a lower rate over a greater area.

CONCLUSIONS

1. Under equatorial lowland climatic conditions, Para grass responded

rapidly to applied nitrogenous fertilizer. Drymatter production increased linearly with increasing N rates up to 50 kg and possibly even to 200 kg N per ha per application.

2. N fertilizing had very little residual effect. By six weeks after application there was little effect on the N content of the herbage. There was little further response in drymatter production of regrowth after cutting the pasture at six weeks from fertilizer application.

3. The results obtained indicated that, at current fertilizer costs, profitability of fertilizing on a regular basis would be marginal. However, the ability to produce a large bulk of feed within a few weeks of N application could make it a useful management tool.

4. Ammonium nitrate proved more efficient than sulphate of ammonia or urea in terms of drymatter response per unit of N applied, but the lower price of urea in relation to its N content made it slightly more efficient than ammonium nitrate in terms of drymatter response per kina expended.

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