THE RESPONSE OF A PANGOLA GRASS PASTURE NEAR DARWIN TO THE WET SEASON APPLICATION OF NITROGEN

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ABSTRACT

The response of a pangola grass pasture to nitrogen fertilizer at 0, 100, 200, 400, 600 lb. nitrogen/acre in split applications during the wet season was measured near Darwin, N.T. There was a response in dry matter production up to the highest nitrogen level, but the differences in response occurred mainly during the early showers and not during the monsoonal rains of the wet season. Crude protein content and crude protein production per acre increased and the nitrogen recovery decreased with increasing levels of nitrogen fertilizer over the whole growing season. The phosphorus and potassium contents of the pasture were low.

INTRODUCTION

Pangola grass (*Digitaria decumbens*) has proved to be a valuable species for the Northern Territory's Top End area which extends to approximately 300 miles south of Darwin. Together with Townsville stylo (*Stylosanthes humilis*) it has formed a persistent, highly productive pasture (Hendy 1971). Under natural rainfall conditions, pangola grass commences growth after the opening rains. Growth increases to a maximum rate in February and March, then gradually diminishes as water becomes limiting, and the pasture remains in a hayed off condition over the dry season.

A severe feed shortage occurs in the late dry to early wet season period i.e. that time between the first showers and the monsoonal rains. Annual species have to become re-established, but perennial grasses, such as pangola, are already established, and able to make use of early showers to provide useful feed before the onset of the monsoonal rains. Since pangola grass is one of the most efficient nitrogen users of all the tropical grasses (Bryan and Sharpe 1965) its performance in this area at higher nitrogen levels needed to be assessed.

An experiment was carried out to measure the effect of the application of different levels of nitrogen fertilizer at intervals during the wet season on the pattern of response and yield of dry matter, crude protein production and efficiency of nitrogen utilization of a pangola grass pasture.

MATERIALS AND METHODS

The experiment site was a red lateritic soil at Berrimah Experiment Farm near Darwin, N.T. The pasture was a uniform, two year old pangola grass stand which had been lightly fertilized with nitrogen and superphosphate the previous year and cut for runners. The experiment was conducted during the 1970/71 wet season, when the rainfall was 76.7 in., of which 78% fell in five months, November-March. (The average rainfall for the area is 59 in. of which more than 90% usually falls in the November-March period). The annual average maximum temperature is 90.3°F. and average minimum is 74.5°F.

The experiment area was mown to a height of 3 in. above ground level before the commencement of the 1970/71 growing season in September and superphosphate at 4 cwt/acre and muriate of potash at 2 cwt/acre were applied to ensure

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that phosphorus and potassium deficiencies did not influence pasture growth. The design was a randomised complete block of 15 plots, each 40 x 40 sq ft with five levels of nitrogen and three replicates. Nitrogen levels were 0, 100, 200, 400 and 600 lb nitrogen/ac. (N_0, N_{100}, N_{200}, N_{400} and N_{600}), applied in the form of ammonium nitrate, containing 34% N. The fertilizer was split into four equal amounts and broadcast over the plots, so that each application period would include specific weather conditions. The experimental design is described in Table 1.

The plots were sampled to a height of 3 in. above ground level by taking five random quadrat cuts per plot using a 12 x 24 in. quadrat.

TABLE 1
Experimental Design

Period	Date	Treatment		Weather Conditions During Period
		Nitrogen Application	Sampling	
	16.x.70	Yes	(cut) No	
No. 1				After opening rains, showers
	10.xii.70	Yes	Yes	
No. 2				Heavy showers and monsoonal rains
	5.ii.71	Yes	Yes (cut)	
No. 3				Heavy monsoonal rains
	24.iii.71	Yes	Yes (cut)	
No. 4				After monsoons; final showers
	18.v.71	No	Yes	

The grass was mown to 3 in. after sampling and before nitrogen application on February 5, 1971 and March 24, 1971 but not after the December sampling as it was still short and actively growing.

All samples were wet weighed, then subsampled, oven dried and analysed for dry matter, nitrogen, phosphorus and potassium contents. Nitrogen was determined by the micro-Kjeldahl method and crude protein was calculated as N x 6.25.

RESULTS AND DISCUSSION

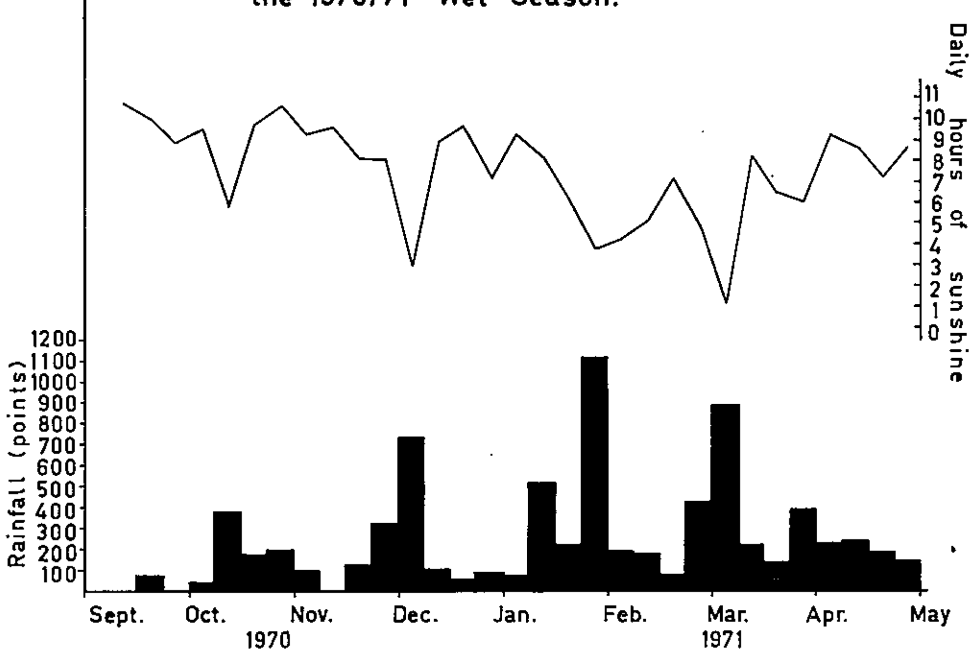
Dry Matter Production

The pangola grass began growing after the opening showers in mid September, and by the beginning of the experiment was 4-6 in. high. Growth continued throughout the wet season until mid May, a fortnight after the final showers, when the pasture dried and remained in a hayed off condition.

There was a response to the application of nitrogen fertilizer up to the 600 lb/ac level (Table 2). Total dry matter (DM) production increased from 14,400 lb/ac at N_0 up to 25, 400 lb/ac at N_{600}. However, this difference in total dry matter production was mainly due to the difference in response during the early showers and not during the monsoonal rains of the wet season.

It has been noted (Hendy 1971), that pangola grass is a useful grass in reducing the critical feed gap that occurs in the Top End of the Northern Territory in the late dry to early wet season (October-December). Its ability to take advantage of any showers during this period was demonstrated during this experiment.

Figure 1. Rainfall and daily hours of sunshine during the 1970/71 Wet Season.



N.B. Rainfall figures were taken on the site of the experiment and sunshine figures are those taken at Darwin by the Bureau of Meteorology.

TABLE 2

Dry Matter Production of Pangola Grass (lb/ac)

Sampling Date	Nitrogen Applied (lb N/ac) (Total of Four Equal Applications)				
	0	100	200	400	600
10.xii.70	1690^{a}	2480^{b}	3200^{c}	4040^{d}	4990^{e}
5.ii.71†	3750^{a}	4470^{b}	6610^{c}	4150^{b}	8180^{d}
24.iii.71	7030^{a}	10430^{bc}	10060^{b}	11400^{c}	10050^{b}
18.v.71	1900^{a}	2600^{c}	2480^{c}	2430^{c}	2150^{b}
Total Dry Matter Production	14370	19980	22350	22020	25370

Figures represent means for each treatment. Means followed by the same letter at any one sampling date are not significantly different at the 5% level, using Duncan's New Multiple Range Test.

†The figures for Period 2 are calculated by difference since the pasture was not mown after the first sampling.

There was regular rain from the beginning of October right through the wet season (Fig. 1) and greater than average rains for each month from October to January. Production till mid December was 1700 lb DM/ac for N_0 pasture, whereas in previous years with less favourable conditions, production was about 1000 lb DM/ac (Hendy 1971). With the application of nitrogen, during this critical period, production was significantly increased at each level. The N_{600} treatment (150 lb nitrogen/ac/application) produced 5000 lb DM/ac. Thus the feed gap could be considerably reduced by the application of nitrogen to pangola grass pastures.

At the February sampling, the N_0 pasture was a very pale, nitrogen-deficient, yellow-green colour, 1-2 ft high. However, there was a healthy legume component consisting of 5% Townsville stylo and 40% Buffalo Clover (*Alysicarpus vaginalis*). The N_{100} pasture still supported up to 15% Buffalo Clover, but at higher nitrogen levels the pasture was pure pangola grass, with a slight weed invasion at N_{600}, the weeds being *Hyptis suaveolens, Sida rhombifolia* and *Cassia obtusifolia.* In this treatment the pangola was up to 8 ft long, forming a very lush dark green, tangled mat. Growth during the second sampling period reflected the regular rainfall and there was a significant increase in production at each level except N_{400}. Growth of N_{400} pasture during this period was actually less than both N_{100} and N_{200} and this is completely inexplicable.

At the March sampling there was a general lack of response to nitrogen above the N_{100} level. This was the period of maximum rainfall and maximum growth (approx. 1000 lb DM/ac/week for N_0, which was twice the growth rate of the previous period). Application of nitrogen at N_{100} produced 49% increase in dry matter production. The lack of response to nitrogen above the N_{100} level indicated that factors other than nitrogen were limiting. There may have been a reduction of soil phosphorus and potassium, as well as reduced radiation. Figure 1 shows a decrease in the daily hours of sunshine during this period.

As the rainfall gradually decreased the pasture dried off, and had ceased growth by mid May, two weeks after the last shower. At the May sampling the N_0 treatment was 4-6 in. high with a very pale, nitrogen-deficient appearance, but the N_{100} was 6-12 in. high and healthy, with little or no burning of the leaves. At higher nitrogen levels, the grass was a dark blue green with increasing amounts of foliage burnt by the fertilizer. At N_{600} there were bare patches in the plots which had been invaded by weeds. During this last period when rainfall and growth were decreasing, there was a slight but significant ($P < .05$) response to nitrogen at N_{100}. Increasing nitrogen applications did not increase dry matter production and N_{600} actually decreased pasture growth due to burning of the foliage by the fertilizer. Thus growth cannot be greatly increased at the end of the wet season by the application of nitrogen, since moisture is apparently the limiting factor, and possibly phosphorus and potassium in this experiment.

The response of pangola grass to nitrogen fertilizer has varied widely in different parts of the world, depending on conditions. Most workers have achieved large increases in dry matter yield with applications up to 400 lb nitrogen/ac/yr. (Caro-Costas, Vincente-Chandler and Figarella 1960; Perez Infante 1970; Salette 1970; Vincente-Chandler 1966; Vincente-Chandler, Figarella and Silva 1961; Whitney and Green 1969), and reduced increases at higher applications up to a maximum of 1944 Kg nitrogen/ha (1730 lb nitrogen/ac) (Salette 1965). The highest yield from a pangola grass pasture seems to have been achieved by Salette (1970) at Guadeloupe when production was 54.6 tons DM/ha (44,200 lb DM/acre) with only 800 kg nitrogen/ha (712 lb nitrogen/ac) and a rainfall of 2,800 mm (approximately 110 in.).

Total dry matter yields obtained in this experiment compared favourably with those obtained by other workers, although there was a relatively small response above 200 lb nitrogen/ac.

Chemical Composition of the Pasture

Crude Protein and Nitrogen Recovery

Tables 3 and 4 show that, overall, crude protein content and crude protein production increased with increasing nitrogen application. This is in agreement with Caro-Costas, Vincente-Chandler and Figarella (1960), Whitney and Green (1969) and others. Crude protein percentages at the N_{600} level in this experiment were mostly higher than those quoted by other authors.

TABLE 3

Nitrogen Yield (lb/ac) in pasture and percent recovery during each period

Sampling Date	Total Nitrogen Application (lb/ac)									
	0		100		200		400		600	
	N. Yield	% Re-covery	N. Yield	% Re-covery	N. Yield	% Re-covery	N. Yield	% Re-covery	N. Yield	% Re-covery
10.xii.70	15	—	35	80	36	42	67	52	107	61
5.ii.71†	21	—	41	80	64	80	38	17	62	27
24.iii.71	62	—	98	144	118	112	192	130	222	107
18.v.71	15	—	22	28	28	26	56	41	52	25
Total yield and av. recovery	113	—	196	83	246	67	353	60	443	55

†Figure for 5.ii.71 obtained by difference of dry matter production between 5.ii.71 and 10.xii.71

N.B. The % recovery of N. was calculated as $\frac{\text{Treatment Yield Nn per cut} - \text{Yield } N_0}{\text{Applied Nn per cut}}$ per cut × 100%.

TABLE 4

Chemical Composition of the Pangola Grass Pasture (expressed as % of DM)

Sampling Date	Total Nitrogen Application (lb/ac)					
	N_0	N_{100}	N_{200}	N_{400}	N_{600}	Average
Crude Protein						
10.xii.70	5.7	8.8	7.0	10.3	13.4	
5.ii.71	3.5	5.7	6.1	5.8	4.7	
24.iii.71	5.5	5.9	7.3	10.5	13.8	
18.v.71	5.0	5.3	7.0	14.5	15.2	
24.vi.71	2.4	2.3	3.1	8.4	8.4	
22.vii.71	2.3	2.5	3.0	6.8	8.8	
20.viii.71	3.1	2.4	2.7	7.1	8.3	
Phosphorus						
10.xii.70	0.187	0.211	0.145	0.204	0.211	0.192
5.ii.71	0.158	0.144	0.138	0.098	0.106	0.129
24.iii.71	0.210	0.201	0.185	0.217	0.205	0.204
18.v.71	0.259	0.184	0.167	0.205	0.185	0.200
24.vi.71	0.148	0.110	0.112	0.115	0.092	0.115
22.vii.71	0.137	0.111	0.069	0.105	0.090	0.102
20.viii.71	0.126	0.093	0.081	0.106	0.093	0.100
Potassium						
10.xii.70	1.49	1.85	1.75	2.19	2.03	1.86
5.ii.71	0.91	1.12	0.94	0.51	1.04	0.90
24.iii.71	1.10	1.15	1.02	1.23	1.17	1.13
18.v.71	1.04	0.78	0.58	1.21	0.61	0.84
24.vi.71	0.50	0.39	0.27	0.36	0.43	0.39
22.vii.71	0.46	0.25	0.23	0.17	0.16	0.26
20.viii.71	0.31	0.15	0.15	0.19	0.20	0.20

Despite the low crude protein percentages, overall, nitrogen recovery was good. There was a decrease in nitrogen recovery with increasing nitrogen applications for the whole growing season, although nitrogen recovery differed in each period. This is in agreement with Little, Vicente and Abruna (1959) and Werner, Pedreira, and Caielli (1967) who obtained similar nitrogen recovery rates, and also with the lower rates of Bryan and Sharpe (1965). Oakes (1960), on the other hand, found that successive increments of fertilizer were used with the same efficiency. Whitney and Green (1969) and Salette (1965) concluded that nitrogen was less efficient at lower rates, and that the first increments of nitrogen essentially increased dry matter yields, and further increments increased the nitrogen content of the grass. Recovery may be good up to 800 kg/ha (710 lb/acre).

This pattern, modified by varying moisture conditions, was seen during this experiment. Under restricted to fair moisture conditions during Period 1, there was an approximately linear increase in dry matter production and crude protein percentage giving a 61% recovery at N_{600} level. The crude protein percentage for the N_{200} treatment was unexplainably low.

During the second period, values for crude protein percentage were very low, as was the crude protein production at higher N levels. With increasing rainfall and pasture growth, there was a significant increase in dry matter production for each nitrogen level (excluding N_{400}) and the low protein percentages were compensated by rapid growth giving an 80% recovery for N_{100} and N_{200}. It is possible that nitrogen was leached from the higher N treatments, since recovery was very low.

During the third period, with maximum growth in N_0 and very little response in dry matter production above N_{100} the crude protein percentage and crude protein production increased with each nitrogen increment from 5% up to 15% at the N_{600} level. Recovery rates were over 100%, indicating very little leaching.

At the final growth period, when decreasing rainfall only allowed a dry matter response up to N_{100}, the crude protein percentage and crude protein production increased with each increment of nitrogen up to N_{400} (N_{600} was reduced due to burning by the fertilizer). Nitrogen recovery was lower than at other times.

The crude protein content dropped sharply as the pasture dried off in May-June, but throughout the dry season it was greatly affected by the level of nitrogen fertilizer applied during the previous wet season. Table 4 shows that pasture receiving 400 and 600 lb nitrogen/ac during the wet season maintained a 7-8% crude protein level, whereas, in the other treatments, crude protein was only 2-3% during the dry season. Milford and Minson (1965) obtained a positive correlation between the voluntary intake of pangola grass and the crude protein content when less than approximately 7%. By nitrogen fertilization, Minson (1967) increased the voluntary intake and the apparent digestibility of the feed nitrogen of chopped, mature pangola grass when the crude protein content was increased from 3.7% to 7.2%. Thus animal production on the N_0, N_{100} and N_{200} treatments could be limited by low crude protein and the consequent decrease in voluntary intake of the pasture.

Phosphorus and Potassium contents

The phosphorus and potassium contents of the pasture are listed in Table 4. The phosphorus content during the growing season was generally low (0.098-0.259%), especially during the second growth period when the crude protein percentage was also very low. This may have been due to the lack of cutting after the December harvest, causing the material to be physiologically more mature in the second period than at other times.

There was not the same close relationship between the phosphorus and crude protein content of the pasture as found previously (Hendy 1971). No relationship was evident between phosphorus and sampling date during the growing season but as the pasture dried off, phosphorus levels dropped sharply to as low as 0.069%. A decrease in the phosphorus content of pangola grass with increasing levels of nitrogen fertilizer has been found by other workers, (Vicente-Chandler 1966; and Vicente-Chandler, Figarella and Silva 1961), but there was no trend in this experiment.

Apart from very low values during the second period, potassium gradually decreased during the growing season from 1.86% in December down to 0.84% in May. After the pasture hayed off, potassium level continued to fall through the dry season to 0.20% in August. Potassium levels were not affected by the application rate of nitrogen. Vicente-Chandler (1966) also found no effect.

Ahmad, Tulloch-Reid and Davis (1969) found that a potassium content of 2.23% was associated with the largest yield response (lb DM/acre) and recommended the application of potassium fertilizer every one to two months. Vicente-Chandler et al (1964) (cited in Ahmad, Tulloch-Reid and Davis 1969) concluded that a potassium content of less than 1.50% in 60 day old pangola grass indicated a deficiency of this element, and Whitney and Green (1969) suggested a potassium level of 1.0% of tissue dry matter as critical for normal plant growth. On that basis, the pangola grass pasture in this experiment could either be permanently potassium deficient or deficient at the end of the wet season.

CONCLUSION

The economics of nitrogen applications to pastures in the Top End area need to be closely studied. During the "critical feed period" of October-December, it is possible that nitrogen applications up to the N_{600} level on pangola grass may be economic, since it provides high quality grazing when feed is very scarce. Although there was a response to each level of nitrogen in the December-February period, there is an abundance of pasture at this time of the year, and it cannot be fully utilized. Nitrogen applications may be economic if the pasture can be conserved, such as hay (after conditioning or drying) or pellets, since it would provide high quality feed.

The economics and the effects of a single application of nitrogen before the final showers warrant further study. If it is able to increase the protein content of the pasture through the dry season and increase animal production by increasing pasture intake and digestibility, it could replace other forms of protein supplementation.

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