COMPARATIVE RESPONSES OF SOME TROPICAL GRASSES TO FERTILISER NITROGEN IN SARAWAK, E. MALAYSIA

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ABSTRACT

Forage production from four grass species were compared over a one-year period at five nitrogen levels: 0, 112, 224, 448 and 896 kg/ha/annum. Dry matter and crude protein yields of the species, ranked in their decreasing order, were: Brachiaria decumbens, *9887-19741 and 457-1217 kg/ha,* Digitaria decumbens, *5970-16993 and 298-1731 kg/ha,* Paspalum conjugatum, *2930-14012 and 174-1541 kg/ha,* Ischaemum aristatum, *3141-9299 and 192-940 kg/ha. Significant dry matter yield responses of up to 112 and 224 kg/ha N were obtained in* D. decumbens *and* B. decumbens *respectively, beyond which the efficiency of nitrogen utilization decreased markedly. Marked yield increases in* P. conjugatum *and* I. aristatum *occurred only at 448 kg/ha N. These indigenous species were comparatively less efficient in recovering nitrogen and utilizing it for forage and crude protein production than the introduced species. Nitrogen fertilisation generally resulted in higher forage crude protein content, lower dry matter content but increased removal of other macro-nutrients in all species. The percent crude protein decreased drastically when the regrowth interval exceeded 6 weeks.*

INTRODUCTION

Over the past few years, a collection of exotic forage grasses proven to be productive in the tropics has been introduced to Sarawak as potential species for improving local native pastures. *Digitaria decumbens* (Pangola grass) and *Brachiaria decumbens* (Signal grass) are among the more promising species that have emerged from preliminary evaluation by the Department of Agriculture, Sarawak (Dunsmore and Ong 1969). Both were introduced via Queensland, Australia.

Indigenous grasses belonging to the genera *Axonopus, Paspalum,* and *Ischaemum,* are found abundantly in sunny places which have been opened up by clearing. In the absence of established pastures, local cattle and buffalo depend upon these grasses for their sustenance. Although they are generally claimed to be of poorer agronomic value than introduced species in terms of feeding quality and response to fertilizer, there is a total lack of such comparative studies in Sarawak. Moreover, there remains a dearth of quantitative data on the yield response of pasture grasses to fertilizer nitrogen apart from those reported by Dunsmore and Ong (1969) and in the Department's Annual Reports (1967-70).

Presented in this paper are results of a cut-plot field experiment designed to compare the yield potential of two introduced and two native grasses and their response to nitrogen.

MATERIALS AND METHODS

The experimental site was located on a gentle slope at the Agricultural Research Station, Semongok (110° 20' E; 1° 24' N; elevation 152 m; average annual rainfall 400 cm or 160 inches; mean air temperature: day maximum = 31°C, night

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minimum = 22°C). The area had previously been used as a rubber nursery and prior to planting was dominated by *Imperata cylindrica*. Thus, although the soil was Red Yellow Podsolic belonging to the Semongok Series of Merit Family (Anon. 1966a), it was already a disturbed profile with much of its top soil removed. It is a residual soil of heavy texture generally low in plant nutrients (Table 1).

TABLE 1

Physical and chemical characteristics of soil (0-15 cm) from the experimental area

pH (1 : 2.5 H_2O)	Total N (% DW)	Total P (ppm)	Available P (ppm)	Exchangeable cations (m.e. %) Ca	Mg	K	Na	C.E.C. (m.e.%)	Clay %	Silt %	Sand %
4.6	0.16	273	19	1.44	0.44	0.26	0.04	12.94	38.30	35.47	26.23

The four grasses studied were *D. decumbens, B. decumbens, Ischaemum aristatum* (Batiki bluegrass), and *Paspalum conjugatum* (Buffalo or Sour grass).

A split plot design, replicated twice, was used in which grass species formed the main plots and N levels, 0, 112, 224, 448 and 896 kg/ha/annum, formed the subplots. The size of the subplot was 3.3 m x 3.3 m with 0.3 m guard drain separating the adjoining treatment plots. Nitrogen in the form of urea (46 percent N) was split into 6 equal amounts with the first application on November 9, 1970 and the rest after each subsequent sampling. A total of 375 kg/ha potassium chloride (50 percent K) and 250 kg/ha double superphosphate (9.6 percent P) were given as basal fertilizers to all plots. These were split twice, one week before planting and six months after.

Grasses were hand planted by rooted sprigs at 0.35 m x 0.35 m spacing on October 22-24. One hand weeding was carried out during the early establishment stage. The sward was first sampled on December 22-24 and subsequently at intervals of 6 to 14 weeks.

Six samplings were obtained during the experiment period from October 1970 to November 1971. No preliminary cut was made since the swards were established with proper spacing and their initial growth was uniform.

At each sampling forage of four random quadrats (0.6 m x 0.6 m) was clipped at 5-cm height from each plot using pasture clippers and its fresh weight determined. The perimeter area 0.3 m wide was excluded entirely from sampling to avoid border effects. A subsample was oven-dried for 48 hours at 70°C for dry matter (DM) yield estimate. Another subsample was hand separated into the sown species and 'others' (weeds and volunteers). After sampling, the remaining top growth was removed from the plot by either mowing with an 'Alpine' motorscythe or hand clipped, all adjusted at the 5-cm height. Four to eight days were required to complete sampling and mowing in all the cuts.

Oven-dried material was used for tissue analyses for total nitrogen and other macronutrients. To reduce analytical work, composite samples of replications of the 2nd, 3rd + 4th, 5th and 6th cuts were determined. The total nitrogen (N) was determined by the micro-Kjeldhal method and the crude protein (CP) content computed by multiplying the total N by 6.25. The total P was determined by the chlorostannous molybdate blue method in a sulphuric acid system, potassium (K) by the flame photometric method and magnesium (Mg) and calcium (Ca) by the colorimetric method using the Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Forage dry matter production

Accumulated DM yields from the six samplings are shown in Fig. 1. A gradation in total forage yield existed among the grass species at all levels of nitrogen fertilization, with *B. decumbens* ranking the highest and *I. aristatum* the lowest. Some weed invasion occurred in all the treatment plots but was more severe in those of *I. aristatum* and *P. conjugatum* especially in the later cuts. The component of the various sown species in the total pasture from the start to the end of the trial were: *D. decumbens,* 93-86%, *B. decumbens,* 99-84%, *I. aristatum,* 94-71%, *P. conjugatum,* 96-67%. The weed species consisted mainly of *Axonopus*

TABLE 2

Forage dry matter yields, nitrogen and dry matter contents and apparent nitrogen recovery of sown grasses at different levels of nitrogen fertilization

Treatments	DM yields (kg/ha/annum)	% DM	% N* (weighted means)	Apparent N† recovery (%)
B. decumbens kg/ha N				
0	9877 a	26.1 b	0.74 a	—
112	14023 b	27.2 b	0.84 ab	39.9
224	19741 c	24.9 b	0.94 ab	50.2
448	19627 c	25 0 b	0.92 ab	24 0
896	14748 b	22.3 a	1.32 b	13.6
Mean	15603	25.1	0.95	31.9
D. decumbens kg/ha N				
0	5970 a	26.6 c	0.80 a	—
112	12664 b	24.4 b	0.88 a	56.9
224	11636 b	24.7 b	0.92 a	26.5
448	14265 bc	24.4 b	1.15 ab	25.9
896	16993 c	21.7 a	1.63 b	25.6
Mean	12306	24.4	1.08	33.7
P. conjugatum kg/ha N				
0	2930 a	25.4 c	0.95 a	—
112	5731 ab	24.5 abc	0.95 a	23.7
224	6814 b	22.8 ab	1.12 a	21.6
448	12147 c	21.6 a	1.25 ab	27.7
896	14012 c	20.6 a	1.76 b	24.4
Mean	8327	23.0	1.21	24.4
I. aristatum kg/ha N				
0	3141 a	25.8 c	0.98 a	—
112	4997 a	22.9 b	1.15 a	23.8
224	4775 a	22.1 ab	1.23 ab	12.5
448	9299 b	21.8 ab	1.43 ab	22.8
896	8454 b	20.0 a	1.78 b	13.3
Mean	6133	22.5	1.31	18.1

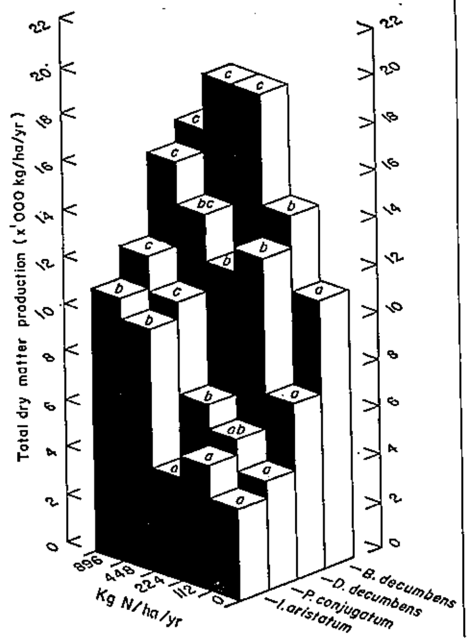
Figures not followed by the same letter differ ($P < 0.05$).
*Means of cuts 2, 3 and 4, 5 and 6.
†Estimated as $\frac{\text{Treatment annual yield Nn} - \text{annual yield No.}}{\text{Applied annual Nn}} \times 100\%$

compressus, Imperata cylindrica, Fimbristylis spp., *Cyperus* spp. and a few dicot spp. The pasture contributed by the sown species *per se* was, therefore, estimated separately to test its genuine rsponse to N fertilization (Table 2).

The overall response of species to N and N x species interaction were significant ($P < 0.001$; $P < 0.01$). In Pangola grass, a marked yield increase was obtained up to 112 kg/ha N ($P < 0.01$) beyond which no significant increases in the 2nd and 3rd N increments occurred. Forage productivity and N response were slightly lower than those of the 1969/70 trial on the same soil type when DM production ranging from 9584 to 21966 kg/ha and significant yield increases at 134 kg/ha N were recorded (Ann. Rept. 1970). The discrepancy was probably attributed in part to a greater number of samplings obtained previously. Yield figures were higher than those reported by Oakes and Skov (1962), comparable to data of Little, Vicente and Abruna (1959), Vicente-Chandler *et al.* (1964) and Whitney and Green (1969), but lower than those obtained in Trinidad (Adeniyi and Wilson 1960), Columbia (Crowder, Michelin and Bastidas 1964), Jamaica (Richards 1965), Queensland (Bryan and Sharp 1969) and Guadeloupe (Sallete 1970).

The forage DM content varied among the species ($P < 0.01$) and tended to decrease with increased N levels in all species ($P < 0.001$) (Table 2), which was in agreement with that observed by Ahmad *et al.* (1969) and Sallete (1970) for Pangola grass.

B. decumbens showed a dramatic yield response of up to 224 kg/ha N ($P < 0.01$), but its production was depressed at 896 kg/ha N. In Queensland, it



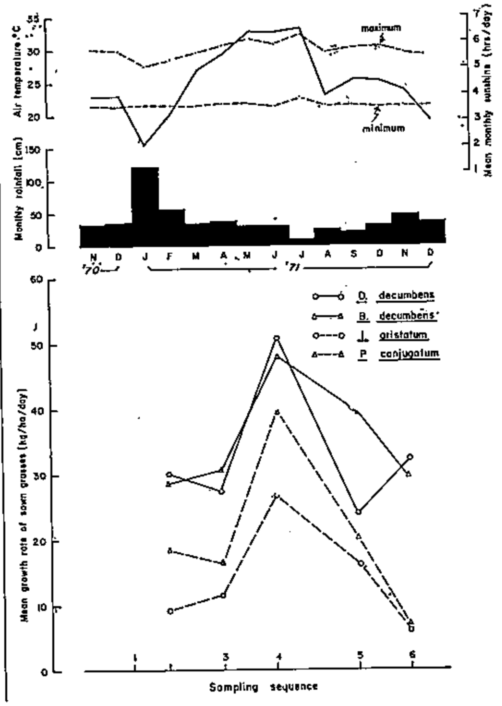


FIGURE 1 (left).
Total dry matter production of grass species at different rates of nitrogen application.
Blocks of each species not marked with the same letter differ ($p < 0.05$).

FIGURE 2 (right).
Mean herbage growth rate of sown grass species.

was reported to be highly responsive to N application (Anon. 1966b) and capable of achieving a much higher annual DM yield than the present figure.

The notable feature of *I. aristatum* and *P. conjugatum* was the marked increase in yield at 448 kg/ha N while their yield increments at lower N levels were not substantial. Such anomaly is not immediately explainable, but could be partly attributed to variability within the site and sampling errors. The greatest response to nitrogen occurred in cut 4. Maximum growth rates of the exotic species also occurred in this cut, apparently ascribed to high insolation that prevailed from April to June, hence favouring rapid growth (Figure 2). No relevant data are available from indigenous species for comparison with the results of this experiment.

It was noted that the yield response of the exotic species to N application was not as remarkable as that found in other tropical environments. In Pangola grass, a linear yield increase of up to 448 kg/ha N and beyond was normally obtained (e.g. Adeniyi and Wilson 1960; Riveria-Berenes, Torres-Mas and Arroyo 1961; Romney 1961; Crowder *et al.* 1964; Richards 1965; Ahmad, Tulloch-Reid and Davis 1969; Bryan and Sharp 1969; Whitney and Green 1969). Two possible explanations could be advanced for this. Firstly, inadequate supplies of other essential plant nutrients might be limiting the utilization of N, particularly K which is necessary for pastures subjected to frequent defoliation (e.g. Munson 1970, Sallete 1970). Yield response to K on this soil had actually been reported for two aromatic *Cymbopogon* spp. (Ng 1972). Secondly, in a tropical environment like Sarawak which is characterised by warm weather and high rainfall, losses of applied N by volatilization and leaching would be considerable. This was reflected at least in the relatively lower forage N content and much poorer N recovery of Pangola grass when compared to figures from elsewhere (e.g. Crowder *et al.* 1964; Whitney and Green 1969; Sallete 1970; Hendy 1972) (Table 2).

Forage nitrogen and crude protein contents

Although N fertilization generally resulted in increased forage N in all species, the increases were not substantial at lower N levels (Table 2). The highest crude protein content was recorded from regrowth of 6 weeks in cut 2 and the lowest from regrowth of about 14 weeks in cut 5 (Table 3) indicating increased physiological maturity of the forage. Thomas and McLaren (1971) suggested that to meet the maintenance and growth requirements of ruminants, crude protein (CP) content should not be less than 8% for Pangola grass. Although the grazing animal generally selects herbage which is higher in protein than cut herbage the results of this experiment emphasise the importance of utilizing the pasture at a regrowth interval of not more than 6 weeks in order to harvest the maximum CP and other digestible nutrients for animal production.

The exotic grasses had lower CP contents than the locals at all N levels especially in *B. decumbens* which might be explained by their greater DM accumulation of the top, hence a more rapid depletion of N and other nutrients. Such dilution effect caused by differing amounts of growth of the species as a confounding factor in comparing their tissue nutrient concentrations has been recognised (Wilson and Haydock 1971).

CP yield, obtained as the product of forage DM yield and mean CP content, showed a significant N species interaction ($P < 0.01$). A linear increase in CP yields resulting from N fertilization occurred in Pangola grass and *P. conjugatum*. In *B. decumbens*, it levelled off after 224 kg/ha N and in *I. aristatum*, the increase was linear up to 448 kg/ha N after which the increase was not significant (Table 3). Among the species, *B. decumbens* produced the greatest amount of CP without N application. In New Guinea, this species was also found to maintain high CP levels without fertilization (Hill, 1970). CP yields of the local grasses were comparatively low.

TABLE 3

Effect of nitrogen application on crude protein content and yield of grasses

Treatments	% CP 6 wks	% CP 8½-9 wks*	% CP 14 wks	Weighted means	CP yields (kg/ha/annum)
B. decumbens kg/ha N					
0	6.12	4.50	3.31	5.01 a	457 a
112	7.94	4.50	4.06	5.50 a	736 b
224	10.12	4.81	3.69	5.76 a	1160 c
448	8.44	5.53	3.50	7.22 ab	1128 c
896	10.31	8.93	4.94	10.17 b	1217 c
Mean	8.59	5.65	3.90	6.73	940
D. decumbens kg/ha N					
0	6.19	4.62	4.62	4.61 a	298 a
112	7.56	5.40	3.62	5.25 a	696 b
224	8.31	5.12	4.50	5.86 c	669 b
448	10.81	6.53	5.00	5.75 c	1025 c
896	15.56	9.21	6.69	8.28 c	1731 d
Mean	9.69	6.18	4.89	5.95	884
P. conjugatum kg/ha N					
0	6.00	5.99	5.75	5.93 a	174 a
112	7.69	5.37	5.31	5.94 a	340 ab
224	9.75	6.43	5.50	7.03 a	477 b
448	9.25	8.15	5.62	7.79 ab	949 c
896	16.06	10.90	6.19	11.01 b	1541 d
Mean	9.75	7.37	5.67	7.54	696
I. aristatum kg/ha N					
0	7.25	6.25	4.87	6.15 a	192 a
112	9.62	6.75	5.62	7.18 a	359 a
224	11.19	7.12	5.37	7.70 ab	367 a
448	13.75	8.37	5.25	8.94 ab	831 b
896	15.75	11.06	6.69	11.14 b	940 b
Mean	11.51	7.91	5.56	8.22	538

*Means of cuts 3, 4 and 6.
Figures not followed by the same letter differ ($P < 0.05$).

Efficiency of nitrogen utilization

Introduced species were more efficient than the local species in utillizing N as measured by their greatest N recovery (Table 2). In Pangola grass, the average recovery was highest at 112 kg/ha N (approximately 57%) which declined to about 26 percent at higher N levels. In *B. decumbens,* the maximum recovery of about 50 percent occurred at 224 kg/ha N beyond which there was a dramatic decrease. The efficiency of recovery of the indigenous grasses decreased beyond 112 kg/ha N, but the trend was somewhat erratic.

Mineral composition of forage and nutrient removal

In general, increased quantities of all the macronutrients were removed by the forage with increased N rates ($P < 0.001$), except for K which tended to decrease at 896 kg/ha N in most of the species. Species difference in nutrient removal followed closely that in DM production. The concentration of P, K, Mg and Ca were not significantly affected by N application. Hendy (1972) obtained a similar result in his work, although Vicente-Chandler (1966) and Vicente-Chandler *et al.* (1961) reported that P content of Pangola grass decreased with increased N levels.

CONCLUSION

Although the results from this herbage cutting trial were obtained in only one season they emphasize that research should be concentrated on exotic grasses which are capable of producing greater quantities of forage and crude protein, more efficient in utilizing applied nitrogen and generally better in controlling weed invasion than indigenous grasses.

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