COMPARATIVE PRODUCTIVITY OF TWO TROPICAL GRASSES AS INFLUENCED BY FERTILIZER NITROGEN AND PASTURE LEGUMES

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ABSTRACT

Cutting trials in Sarawak, Malaysia, compared the influence of fertilizer nitrogen and various tropical legumes on pasture productivity of two tropical grasses, Ischaemun magnum *and* Brachiaria decumbens. *Pasture dry matter production, botanical composition and crude protein yield were recorded for three years.*

Centrosema pubescens *together with* Stylosanthes guyanensis *formed the best mixture with* I. magnum, *yielding nearly as much dry forage as grass alone fertilized with 224 kg N/ha/annum. Association of these legumes with* B. decumbens, *however, was significantly less productive than grass plus nitrogen. The crude protein yield of satisfactory grass-legume mixtures was significantly higher than N-fertilized pasture. The major contribution came from Stylo because of its vigour and persistence in the mixture. Centro and also other trailing legumes decreased in proportion in the pasture over time and disappeared eventually. Pasture productivity decreased over time, generally at a faster rate in grass plus N than in grass-legume mixtures. Experimental results substantiated the value of growing tropical grass-legume mixture and also demonstrated that* I. magnum *was comparable to* B. decumbens *in productivity and other agronomic attributes.*

INTRODUCTION

There are numerous studies in the literature comparing nitrogen fertilized and legume-based tropical pastures (e.g. Nuthall and Whiteman 1972; Kretschmer 1974). The general conclusion was that unless increased cost is justified by higher return, legume-based pasture provided a more profitable system for beef production than nitrogen-grass pasture (Nuthall and Whiteman 1972). However, there have been relatively few published reports comparing N-fertilized grass production with grass-legume production in the lowland equatorial tropics with annual rainfall of 3000-4000 mm. In view of the Malaysian Government's determined effort in recent years to establish tropical pasture for large-scale beef cattle production, it becomes increasingly important to have more local knowledge about grassland production. Research in this area has been initiated both in the Sarawak Department of Agriculture (Anon. 1970, 71, 72, 73, 74) and the Malaysian Agricultural Research and Development Institute.

This paper reports two experiments with two tropical grasses, *Ischaemum magnum* and *Brachiaria decumbens*, in which the productivity of N-fertilized grass was compared with that of various grass-legume mixtures. *B. decumbens* is one of the best pasture grasses introduced to the Malaysian State of Sarawak. Field evaluation by this Department has shown that its dry matter production ranges from 10-20 tonnes/ha/annum depending on the input of nutrients (Ng 1972; Anon. 1974). In an earlier experiment, it combined quite well with *Stylosanthes guyanensis* cv. Schofield alone producing 16 tonnes/ha/annum of dry matter (Ng 1976).

I. magnum is an indigenous grass of wide occurrence in Malaysia (Gilliland 1971). Whereas most of the indigenous grasses are low producing (Ng 1972), *I. magnum* is observed to be a productive grass in natural stands. It is a very persistent perennial bunch grass, producing abundant viable seeds (Ng and Wong unpublished). One of our experiments showed that its response to cutting interval and the mineral composition of its forage were comparable to a number of introduced grasses (Anon. 1974). More agronomic studies on this grass is therefore considered worthwhile.

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MATERIALS AND METHODS

The two experiments, contiguous to each other, were conducted at the Agricultural Research Centre, Semongok (110° 20'E, 1° 24'N; elevation 152 m) on the same soil type as reported in other previous studies (Ng 1972, 1976). The environment is extremely humid and wet, with annual rainfall averaging *c.* 4000 mm. There are little duirnal or seasonal fluctuations in ambient temperature, the average maximum and minimum being 30/24°C. The mean relative humidity is high, averaging 84%.

In each experiment, six pasture types were compared—grass fertilized with 224 kg N/ha/annum, grass grown in association with *Macroptilium atropurpureum* (Siratro), Siratro + *Stylosanthes guyanensis* cv. Schofield (Stylo), *Centrosema pubescens* (Centro) + Stylo, *Calopogonium mucunoides* (Calopo) + *Pueraria phaseoloides* (Puero) and Calopo + Stylo respectively. These treatments were laid out in randomised complete block design with four replicates.

Pasture was established in 3.9 × 3.9 m plots. The soil was disc harrowed and rotavated before planting. Legume seeds, inoculated with commercial rhizobium peat culture were drilled in by hand on April 4, 1972 in a 30 cm × 30 cm pattern. Stem cuttings of the grass were planted in between from April 25 to 30.

The soil was limed with 224 kg/ha dolomite because grasses responded to liming on this soil (Anon. 1974). Annually, 448 kg/ha double superphosphate (17% P) and 448 kg/ha muriate of potash (50% K) were given as basal dressing to each plot. Half portion of these fertilizers was applied prior to planting (March 30, 1972) and the remaining portion given six months later. In the subsequent years, these fertilizers were also split and applied every 6 months. In the establishment year, each plot also received 89.6 kg/ha kieserite (15.6% Mg), 22.4 kg/ha sodium sulphate, 2.24 kg/ha sodium molybdate, 5.6 kg/ha borax, 5.6 kg/ha copper sulphate and 5.6 kg/ha zinc sulphate. For the grass plus nitrogen treatment, an equally split portion of nitrogen as urea was given after each sampling.

Pasture was clipped every eight weeks at 10 cm height from the central area of the plot measuring 5.92 m^2. Samples were taken for the estimate of dry matter (DM) yield and botanical composition while the remaining forage was removed. Sampling started on June 23, 1972 for the *Brachiaria* experiment and July 19, 1972 for the *Ischaemum* experiment. In the former, six samplings were taken annually whereas in the latter five samplings were recorded in 1972/73, seven samplings in 1973/74 and 6 samplings in 1974/75.

Oven-dried (80°C for 48 h) material of grasses and legumes were analysed separately for total nitrogen content in nearly every sampling. Crude protein content (CP) was computed as % N × 6.25.

RESULTS

Pasture dry matter yield

Table 1 shows three-year mean and also individual-year breakdown of dry matter production of different pasture types. In the *Ischaemum* experiment, the overall mean total pasture yield of *Ischaemum*-Centro-Stylo was not significantly different from that of *Ischaemum* plus nitrogen. Among the grass-legume mixtures, Siratro and Calopo-Puero mixtures had the lowest DM production but highest weed yield. The two other mixtures showed no difference in total pasture yield. Legume was the major yield component, averaging 58%, in all the mixtures containing Stylo.

In the *Brachiaria* experiment, grass + N produced more dry matter than all the grass-legume mixtures ($P < 0.05$). Again, Siratro and Calopo-Puero mixtures had the lowest total yield but highest weed yield. There was no significant difference in yield among the three mixtures containing Stylo as a component.

In all the treatments, there was a consistent decrease in total pasture production with time (Table 1). The rate of decrease generally tended to be more rapid in grass

TABLE 1

Yield of different pasture types

Pasture types		Grass	3-year mean		Total Pasture	Total pasture		
			Legume	Weed		1972/73	1973/74	1974/75
		kg DM/ha/annum						
I. magnum	+ 224 kg N/ha/annum	13740 a	—	330 b	14070 a	17291 a	15868 a	9051 a
	+ Siratro	8038 b	926 c	917 a	9881 c	11629 c	11013 c	7001 b
	+ Centro + Stylo	5560 c	7584 a	310 b	13454 a	16507 a	14525 a	9331 a
	+ Siratro + Stylo	4143 c	7332 a	326 b	11801 b	14094 b	13271 b	8037 ab
	+ Calopo + Puero	8044 b	2337 b	431 b	10812 bc	13425 b	11516 c	7496 b
	+ Calopo + Stylo	4613 c	6733 a	516 b	11862 b	13574 b	12570 b	9442 a
	Mean	7356	4152	472	11980	14420	13127	8393
B. decumbens	+ 224 kg N/ha/annum	13816 a	—	225 b	14041 a	19529 a	13258 a	9337 bc
	+ Siratro	8142 b	755 c	557 a	9454 c	12720 c	8391 b	7252 d
	+ Centro + Stylo	5856 c	5691 a	188 b	11735 b	15072 b	10350 ab	9782 abc
	+ Siratro + Stylo	6009 c	5411 a	344 ab	11764 b	13583 bc	10987 ab	10721 ab
	+ Calopo + Puero	7322 b	2630 b	257 b	10209 bc	12631 c	9450 b	8547 cd
	+ Calopo + Stylo	5792 c	5659 c	364 ab	11815 b	13036 bc	11328 ab	11080 a
	Mean	7823	3358	322	11503	14428	10627	9453

For each experiment, figures in each column not followed by the same letter differ significantly ($P < 0{\cdot}05$) by Duncan's Multiple Range Test.

+ N than in grass-legume mixtures. In the establishment year, grass + N had higher DM yield than all grass-legume mixtures although by the third year it yielded either equally as (in *Ischaemum* experiment) or even less (in *Brachiaria* experiment) than mixtures consisting of Stylo.

Botanical composition of pasture

Figure 1 shows changes in the proportion of various legumes over time in different pasture mixtures of both experiments. Species difference in persistence was obvious. Starting with 30-65% in the pasture, the percentage of Siratro decreased with each sampling continuously until it disappeared completely by the end of second year. This was partly due to the infestation of *Rhizoctonia solani*, prevalent under warm and humid conditions. Calopo and Puero behaved almost similarly. The percentage of Centro (*c.* 8%) was originally low in the pasture mainly due to poor germination and it also disappeared from the pasture by the end of the second year. Stylo was the most vigorous and persistent legume of all, maintaining 50-70% on the average in the *Ischaemum* experiment than in the *Brachiaria* experiment although the starting percentage was about the same.

Weed content was generally low and therefore its changes with time were not depicted. Pasture mixtures containing Stylo were almost weed-free by the second year.

Forage crude protein

There was little difference between *B. decumbens* and *I. magnum* in their CP content which averaged 5.8% and 6.0% respectively. Percentage CP of the associate grass in the mixtures was, in general, slightly lower than that of grass + N. All the legumes had CP content at least twice that of grasses. Stylo had lower CP content (*c.* 12%) than other trailing legumes (*c.* 14%).

In terms of total CP yield, all the *Ischaemum* treatments were consistently higher than the *Brachiaria* treatments (Table 2). Also, the mixtures containing Stylo produced significantly more CP than N-fertilized pasture ($P < 0.05$). Siratro and Calopo-Puero mixtures had the lowest CP yield except that in the establishment year they even yielded slightly more than the nitrogen treatment. Like DM yield, there was a decline in CP yield over time. The rate of decrease was even more marked in Siratro and Calopo-Puero mixtures than in grass + N treatments, reflecting a rapid disappearance of these legumes as depicted in Figure 1.

TABLE 2

Mean annual total crude protein yield of pasture

	Pasture type	1972/73	1973/74	1974/75	Mean
			Kg/ha/annum		
I. magnum	+ 224 Kg N/ha/annum	1061 d	909 c	567 c	846 c
	+ Siratro	1139 cd	624 d	392 d	718 d
	+ Centro + Stylo	1666 a	1493 a	964 a	1374 a
	+ Siratro + Stylo	1591 a	1371 ab	825 b	1262 ab
	+ Calopo + Puero	1391 b	888 c	441 d	907 c
	+ Calopo + Stylo	1288 bc	1235 b	966 a	1163 b
	Mean	1356	1087	693	1045
B. decumbens	+ 224 Kg N/ha/annum	916 d	814 ab	554 c	761 b
	+ Siratro	1026 cd	415 c	292 d	578 c
	+ Centro + Stylo	1494 a	861 ab	750 b	1035 a
	+ Siratro + Stylo	1197 bc	893 ab	873 a	988 a
	+ Calopo + Puero	1369 ab	684 b	458 c	837 b
	+ Calopo + Stylo	1298 ab	938 a	885 a	1040 a
	Mean	1217	768	635	873

For each experiment, figures in each column not followed by the same letter differ significantly ($P < 0{\cdot}05$) by Duncan's Multiple Range Test.

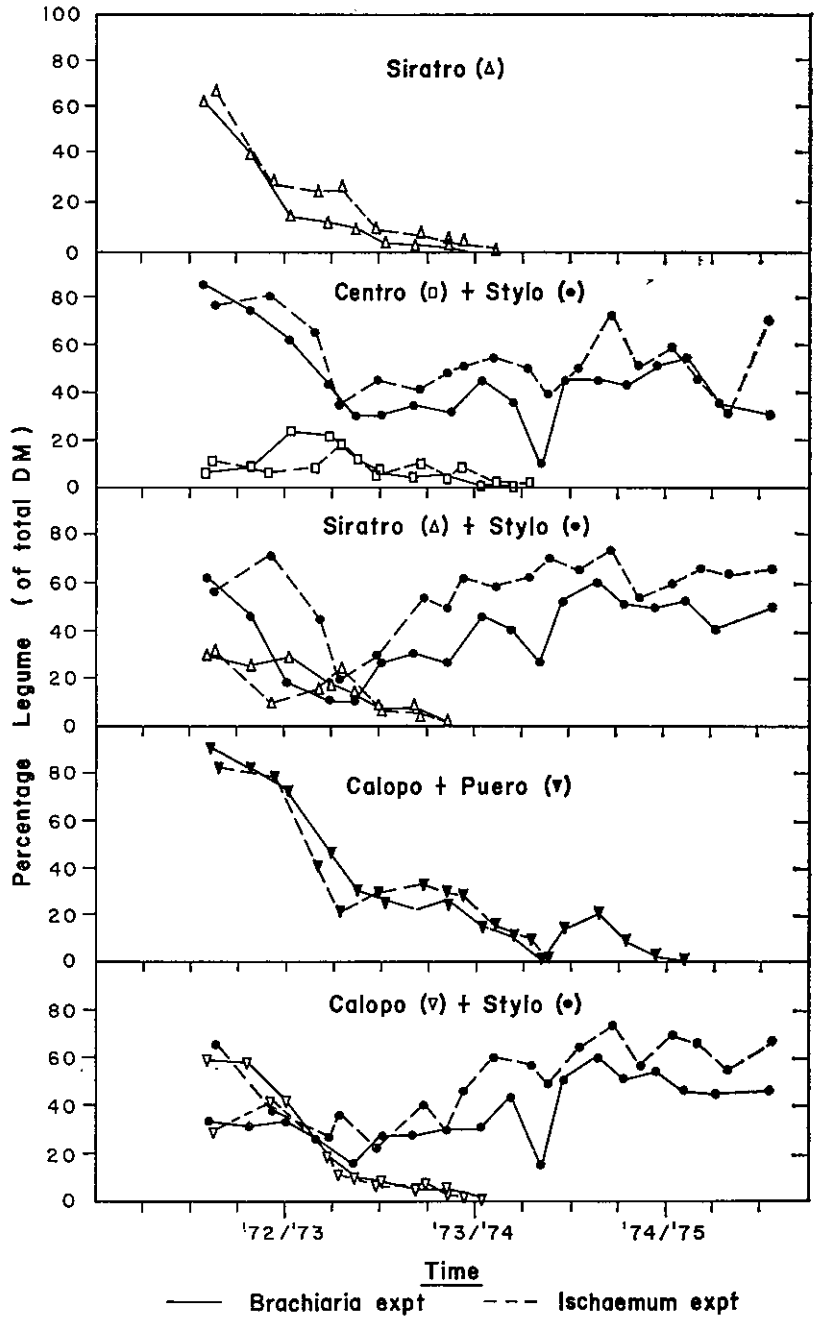

FIGURE 1
Changes in the proportion of legume species in different pasture mixtures over time.

DISCUSSION

Basic to a successful tropical grass-legume association is that the legume component must be maintained at a reasonably high level in the pasture to ensure an adequate supply of nitrogen to the system. This requires the search for legumes which are vigorous, persistent and compatible with the associate grass. Results of the present study indicated clearly that Stylo was the most suitable legume for combining with either *B. decumbens* or *I. magnum* and thus confirmed the previous observation with *B. decumbens* (Ng 1976). All the trailing legumes could not withstand repeated cutting. Siratro was definitely ruled out because of disease problems.

In both experiments, mixtures containing Stylo were very similar in total pasture dry matter yield, averaging 12 tonnes/ha/annum. This figure agrees well with the mean yield potential of a wide range of tropical grass-legume mixtures (cf. Kretschmer 1974) but was lower than that of *Brachiaria*-Stylo mixture recorded previously (Ng 1976), possibly caused by cutting at 10 cm as compared to 5 cm in the former experiment. Also, a higher level of total phosphate and potassium was applied in the previous than the present experiment.

The mixture with Centro and Stylo had the highest yield among all the *Ischaemum* mixtures and was almost equivalent to that of *Ischaemum* fertilized with 224 kg N/ha/annum. Centro and Stylo grown in association with *B. decumbens* was, however, statistically ($P = 0.05$) less productive than *Brachiaria* plus nitrogen. The difference was due to a lower legume component (largely Stylo) in the *Brachiaria* mixture than in *Ischaemum* mixture because the grass and weed yields were rather similar. Likewise, in other mixtures containing Stylo, there tended to be more Stylo in *Ischaemum* than in *Brachiaria* swards. This could suggest that *B. decumbens* is a more aggressive companion grass than *I. magnum* for combining with Stylo.

Both in the +N and grass-legume mixtures, there was little difference in the CP percentage of the grass. It was lower than the critical level (7%) at which feed intake of the animal is depressed (Milford and Minson 1965). However, the significance of CP content of pasture in cutting experiments should not be over-emphasized particularly when the forage was cut at averagely 8-week interval and the bulk of cut material, not young leaves, was analysed for % N. In grazing situation, cattle have preferential selection for young leaves obviously of much higher CP content. Despite such necessary qualification, it is clear that the overall CP level of the pasture had been considerably improved by the inclusion of pasture legumes. In terms of CP yield, all the mixtures containing Stylo were *c.* 45% higher than grass + N pasture.

A point worth commenting upon is that the CP percentage of legumes recorded appeared to be lower than usual. In MARDI Malaysia, % N of Stylo recorded is usually above 2.5 and that of other trailing legumes above 3.0% (P. C. Kerridge pers. comm.). It therefore suggests that the nitrogen fixation process of legumes in the present experiments was probably limited by certain nutrient deficiencies. This is difficult to ascertain because foliar analyses of other nutrients were not carried out. Sulphur deficiency was suspected because the supply of this element from double super and kieserite was probably too low. Magnesium was definitely far below the requirement for optimal plant growth. Soil analysis at the conclusion of the experiments found that exchangeable Mg^{++} was only 0.02 m.e. %.

Such possible nutrient deficiencies could be responsible for the general decline in DM and CP with time in these experiments. In a previous study (Ng 1976) there was in fact an increase in pasture productivity after the first year. This could be due to higher input of potassium (693 kg/ha KCL) and phosphate (658 kg/ha double super) in the second and third years as compared to 448 kg/ha of each of the fertilizers applied annually in the present study.

Overall, two major conclusions can be drawn from the present study. First, it has demonstrated once again the value of incorporating legumes, especially Stylo, into tropical grass pature. It contributed a significant proportion of dry matter and in

particular crude protein yield to the pasture. However, this needs to be further substantiated under actual grazing conditions because the dynamics of Stylo in the pasture would be very much influenced by the animal. Furthermore, the persistence of Schofield Stylo over the long term is not exactly known. Local experience finds that unlike other cultivars (e.g. Cook or Endeavour) it rarely flowers and sets seeds in the equatorial tropics and thus it may have self-generation problems.

The second conclusion is that *I. magnum* is comparable to *B. decumbens* in terms of pasture productivity and other agronomic attributes. Although more studies are needed to understand other agronomic aspects of this grass, the few experiments carried out so far have revealed that it is a promising forage grass deserving a wider recognition. Being an indigenous grass, its planting material either by seeds or vegetative propagation is readily available. This has a definite advantage over introduced grasses, the seeds of which are costly to import .

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