MARDI Res. Bull., 8, 2 : (163—173)

PRODUCTIVITY AND CHEMICAL COMPOSITION OF TWENTY IMPROVED TROPICAL GRASSES IN THE HUMID TROPICS

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Keywords: Grasses, Productivity, Chemical composition, Dry matter, Mineral, Protein.

RINGKASAN

Penilaian kesan terhadap 20 jenis rumput terpilih dengan kadar pembajaan sebanyak 400 kg N sehektar setahun, dan pembuangan daun pada jarak tiap-tiap 5–6 minggu telah dibuat di Serdang, Malaysia, selama 2 tahun. Ini termasuklah menyabit semasa di tahun pertama dan ragutan berselang oleh lembu-lembu di tahun kedua.

Penghasilan bahan kering kesemua 20 jenis rumput ini berbeza dari 6.100 ke 27,700 kg sehektar setahun dan hasil "protin kasar" pula berbeza di antara 730 ke 2,900 kg sehektar setahun. Jenis-jenis yang mengeluarkan hasil tertinggi ialah Tanganyika guinea, *B. decumbens* dan Gori guinea diikuti oleh *Setaria splendida* dan *Paspalum plicatulum* cv. Rodd's Bay. Hasil bahan kering rumput-rumput tersebut didapati berhubung secara positif dan bermakna ($p<0.05$) (significantly correlated, $p<0.05$) dengan pertambahan hujan kecuali pada empat jenis. Peratus bahan kering rumput-rumput tersebut berbeza daripada 16 hingga 33% dengan *C. plectostachyus* yang tertinggi dan jenis-jenis *Setaria* yang terendah.

Kandungan nitrogen daripada jumlah herba mempunyai kaitan yang negatif terhadap penghasilan bahan kering dan kandungan "protin kasar" pula berbeza dari 10.5 hingga 13.5%. Kandungan natriam dan kalsiam pada amnya adalah lebih tinggi bagi jenis-jenis *Setaria* sementara kandungan magnesiam adalah tinggi bagi jenis-jenis *Paspalum* dan *Digitaria*. Kandungan garam-garam galian (mineral) dan nitrogen terhadap 20 jenis rumput dibincangkan dari segi hubungannya dengan keperluan-keperluan pemakanan binatang.

INTRODUCTION

The majority of cattle in Malaysia relies almost entirely upon native grasses from fallow padi fields, road-side verges and plantation holdings as their feed. Such natural pastures as reported by LIM (1968) and NG (1972) are low in nutritive quality and productivity.

Studies on the evaluation of introduced grasses (KEEPING, 1951; HENDERSON, 1955; JAMIL, 1956; URE and JAMIL, 1957) indicate that this country is favourable for improved tropical pasture production. However, there are few reports available on the comparative productivity and chemical composition of the different introduced tropical pasture species under similar cultural and management conditions.

The objectives of the study were to evaluate the performance and chemical composition of 20 improved tropical grasses which have shown high productive potential in the plant introduction nursery at Serdang, and to select from these, the more promising species for grazing assessment.

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MATERIALS AND METHODS

Environment

The experiment, conducted in Serdang, was on a well-drained Serdang soil series (LEAMY and PANTON, 1966) that had been under rubber cultivation until 1971. The soil chemical properties of the site has been previously described by THAM *et al.,* 1978.

The mean total annual rainfall (15 year mean) was 2448 mm with the driest months of the year falling between June and September *(Figure 1).*

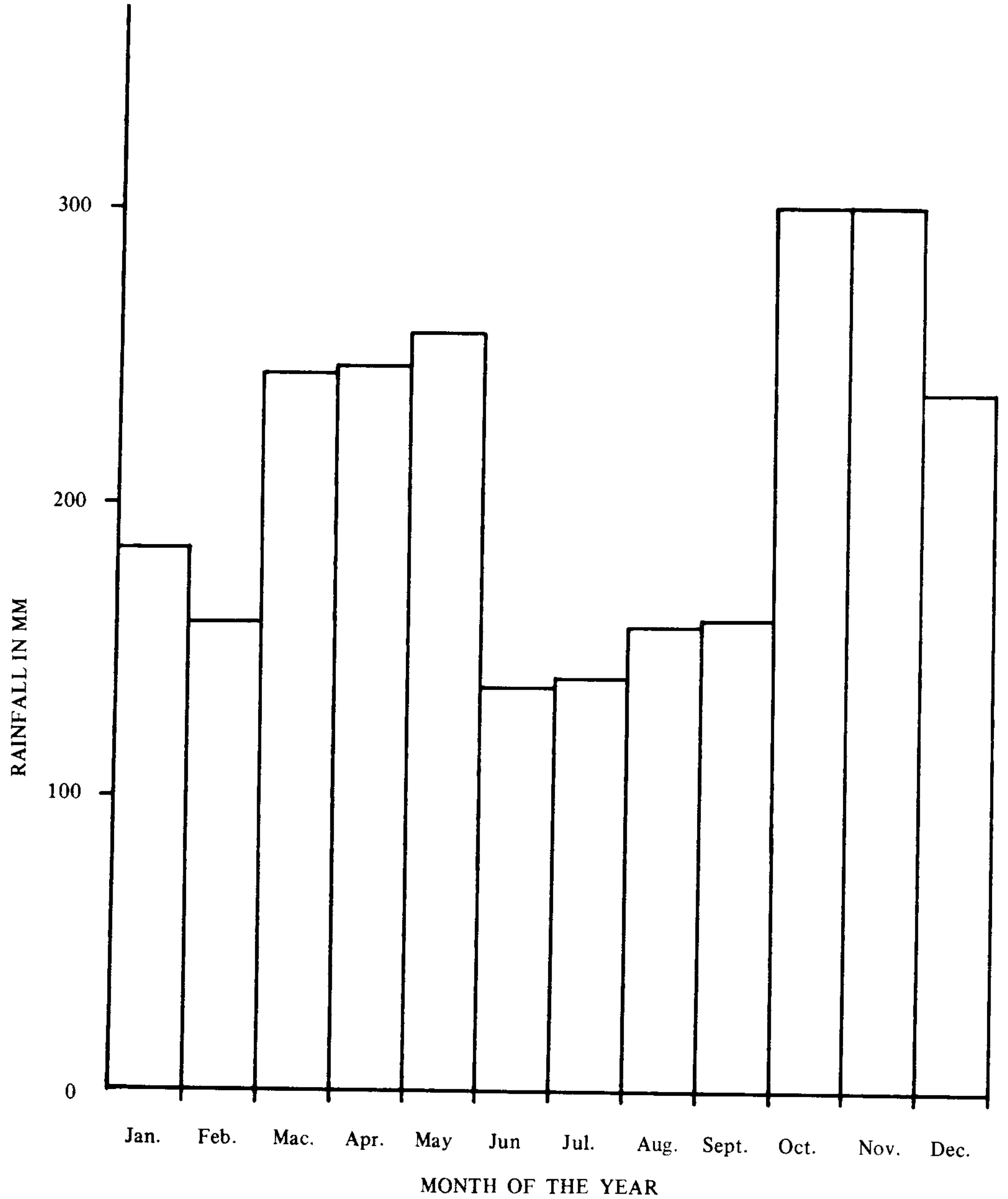

Figure 1. Mean monthly rainfall for Serdang from 1958–1972.

The mean daily maximum and minimum temperatures were 32 and 21°C respectively with no distinct seasonal fluctuations.

Treatment and design

The 20 grasses selected are listed in *Table 1* together with some notes on their habits.

TABLE 1. IDENTIFICATION OF 20 GRASSES EVALUATED AT SERDANG, MALAYSIA

Grass Species	*Common Name*	*Habit*
Brachiaria brizantha (Hochst) Stapf.	–	Stoloniferous
Brachiaria decumbens Stapf.	Signal grass	Stoloniferous
Brachiaria ruziziensis (Germain et Everard)	Ruzi grass	Stoloniferous
Cynodon plectostachyus	African Stargrass	Stoloniferous
Digitaria sp. (USDA PI H–10)[1]	–	Stoloniferous
Digitaria sp. (Slenderstem)[1]	–	Stoloniferous
Digitaria sp. (USDA PI x 125–1)[1]	–	Stoloniferous
Digitaria sp. (USDA PI x 46–2)[1]	–	Stoloniferous
Digitaria setivalva Stent (USDA PI 299892)[1]	–	Stoloniferous
Panicum maximum cv. Coloniao	Coloniao guinea	Erect
Panicum maximum cv. Gori	Gori guinea	Erect
Panicum maximum cv. Hamil	Hamil guinea	Erect
Panicum maximum cv. Sigor (K 52530)[2]	Sigor guinea	Erect
Panicum maximum cv. Tanganyika	Tanganyika guinea	Erect
Paspalum dilatatum	Common paspalum	Erect
Paspalum plicatulum cv. Rodd's Bay	–	Erect
Paspalum plicatulum cv. Hartley	–	Erect
Setaria anceps cv. Kazungula	Kazungula setaria	Erect
Setaria anceps cv. Nandi	Nandi setaria	Erect
Setaria splendida (CPI 15899)[3]	–	Erect

1 United States Department of Agriculture Plant Introduction Number.
2 Kitale Plant Introductuon Number.
3 Commonwealth Plant Introduction Number.

All the grasses were established from cuttings in March 1973, supplied with 15 kg N, 30 kg P and 15 kg K ha^{-1}. They received a uniform defoliation in June 1973 prior to the commencement of the experiment.

The grasses were evaluated at a 5–6 weekly defoliation interval over two consecutive years using a 4 x 5 rectangular lattice design with 3 replications. The fertilizer rate was 400 kg N, 50 kg P and 300 kg K ha^{-1} ann^{-1}, split applied after each cut.

Harvesting sampling

In the first year, the grasses were hand-cut, weighed and sub-sampled. The sub-samples were sorted into grass and other species and dried overnight in an air-forced drought dehydrator at about 70°C and weighed. In the second year, the grasses were further evaluated under rapid intermittent grazing by 20–25 cattle at 5–6 weekly intervals. Prior to each grazing, three quadrat samples of 0.5m x 0.5m each were taken from each plot at pre-determined random positions for dry matter (D.M) yield estimation.

Chemical analysis

All dried samples were ground to pass through a 1 mm screen, bulked by replicates, and in proportion to the D.M. yields over all harvests. These were sub-sampled for analysis of nitrogen, phosphorus, potassium, calcium and magnesium by emission spectroscopy (JOHNSON and SIMONS, 1972). Crude protein of the herbage was determined as Kjeldahl nitrogen x 6.25.

Other observations

In addition, observations were made on palatability, persistence, pests and diseases of the grasses. Rainfall was recorded throughout the experimental period.

RESULTS AND DISCUSSION

Annual Productivity

Total herbage yield varied among the 20 grasses but yield trends were similar in both hand-cutting and grazing although the former showed a higher production. The D.M. yields of the grasses averaged over the two years are shown in *Figure 2.*

Throughout the duration of the experiment, Tanganyika guinea gave significantly ($P<0.05$) higher yields (27,700 kg ha^{-1} ann^{-1}) than the other grasses except *B. decumbens* (24,700 kg ha^{-1} ann^{-1}) and Gori guinea (25,400 kg ha^{-1} ann^{-1}).

The three best yielding grasses compared favourably with the yields obtained by other researchers in similar improved species (URE and JAMIL, 1957; DUNSMORE and ONG, 1969; COLMAN, 1971; TAN *et al.*, 1973). NG (1972) obtained 19,740 kg D.M. ha^{-1} ann^{-1} at 224 kg N ha^{-1} ann^{-1} from *B. decumbens.* In the tropical areas of Australia, GROF and HARDING (1970) also reported *B. decumbens* as the highest yielder, followed by the high-yielding Hamil, Common and Coloniao guinea. The annual D.M. yield of the ten guinea grass varieties reported by them ranged from 15,700 to 28,000 kg ha^{-1} ann^{-1}. In contrast, Hamil and Coloniao guinea in this trial performed rather poorly and this was probably due to viral-like infection of the grasses.

Cynodon plectostachyus gave the lowest yield but FLINT *et el.*, (1971) obtained a high yield (30,900 kg D.M. ha^{-1} ann^{-1}) with a fertiliser rate of 67 kg ha^{-1} of NPK at each 6–weekly cut. The low grass yield in this experiment could be attributed to the poor sward formation resulting from slow establishment.

The *Digitarias, P. plicatulum* cultivars and *Setarias* produced high D.M. yields over the two years. However, under grazing, increased yields from Hartley paspalum and Kazungula setaria were noted. JONES (1966) also reported increased yield in Kazungula setaria under grazing. The better performance of the grasses under grazing was probably due to their greater persistence.

Dry matter content

D.M. percentage of herbage is an important factor for consideration in forage meal production. The average percentages of D.M. of the 20 grasses are shown in *Figure 2.* The three highest yielding grasses did not differ significantly in D.M. content from each other. *C. plectostachyus* gave the highest D.M. content, significant at $P<0.01$. OYENUGA (1957) also reported a high D.M. percentage in this grass (36.6% at 6 weekly cut). Unfortunately, *C. plectostachyus* was the lowest yielder of the 20 grasses.

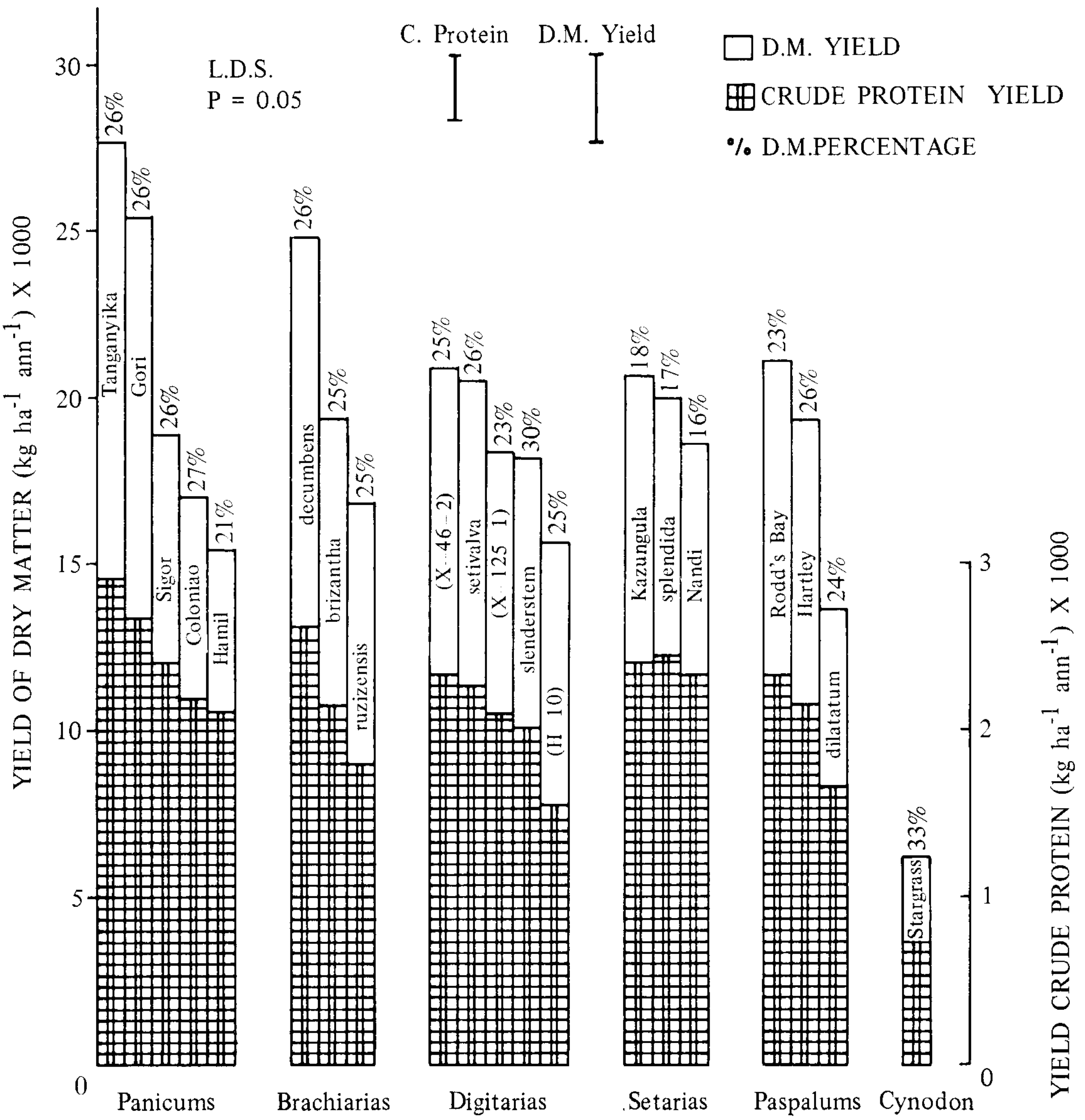

Figure 2: Mean dry matter yield, crude protein yield and dry matter percentage of 20 grasses defoliated every 5-6 weekly interval over a 2-year period

The *Setarias,* although the highest in fresh yield (data not shown) exhibited the lowest D.M. content, significantly lower ($P<0.01$) than the other grasses. The *Digitarias* and the Guineas had similar D.M. content except for Digitaria sp. (Slenderstem) and Hamil guinea.

The D.M. percentages obtained in this study were generally higher than those reported by other investigators (LIM, 1968; NG, 1972 and TAN *et al.,* 1973). This could be attributed to different drying temperatures adopted.

Rainfall effect

Monthly rainfall data at Serdang for the experimental period are given in *Figure 3.*

The first year of the experiment was slightly wetter than the long term mean total annual rainfall (2520 mm compared with an average of 2448 mm) but the second year was drier (1600 mm) due to a long dry spell from June to October in 1974.

The D.M. yield of the 20 grasses was positively correlated to the quantity of rainfall received during the regrowth period *(Table 2)* except for Sigor guinea, Coloniao guinea, *S. splendida* and *D. setivalva.*

The positive relationship of rainfall to the mean D.M. yield of the 20 grasses is well illustrated in *Figure 3.* Unfortunately the water status of the grasses was not determined and differences in drought tolerance amongst the grasses were less obvious. In view of the generally reduced yield during periods of low rainfall, further investigation is needed to determine the degree of the adverse effect of water stress on the growth of these grasses as has been done by NG *et al.,* (1975) on green panic guinea.

Nitrogen and protein yield

There was a negative relationship between nitrogen concentration and D.M. yield. Coloniao, Sigor and Hamil guinea, *P. dilatatum,* Nandi setaria and *S. splendida* were significantly higher ($P<0.05$) in nitrogen concentration but their crude protein yields were low due to low D.M. production except for *S. splendida (Figure 2).*

Conversely, Tanganyika and Gori guinea and *B. decumbens* gave the highest crude protein yield (2620 – 2905 kg ha^{-1} ann^{-1}) in spite of their low nitrogen concentrations and crude protein percentages.

Low nitrogen concentration has often been reported in tropical grasses (FRENCH, 1957). The critical level of nitrogen concentration below which voluntary intake of D.M. is depressed is about 1% N. (MILFORD and MINSON, 1966). In this experiment, the nitrogen concentrations of all the grasses were well above this critical level. MINSON *et al.,* (1976) indicated that the recommended dietary content of nitrogen for finishing cattle weighing 300 to 500 kg was 1.8% in D.M. of diet. Gori and Tanganyika guinea, *C. plectostachyus* and all species of *Digitaria, Paspalum* and *Brachiaria* except *B. ruziziensis* and *Digitaria sp.* (x-125-1) were marginally below this recommended level. This could lead to a possibility of nitrogen deficiency potential in these forages for animal production. However, the low nitrogen concentrations or crude protein percentages of these grasses were analysed from total herbage but under grazing, selection of the younger and leafy tissues by animals could result in a higher nitrogen intake.

TAN and PILLAR (1975) have indicated the requirement of a nitrogen concentration of 2.4–2.7% N for high quality forage meal production. Under the present management, such high nitrogen levels could not be obtained from these grasses but a higher level of nitrogen application and a shorter cutting interval could help to achieve the required level of nitrogen as has been shown by VICENTE-CANDLER *et al.,* (1959) and SOTOMAYOR-RIOS et al., (1974).

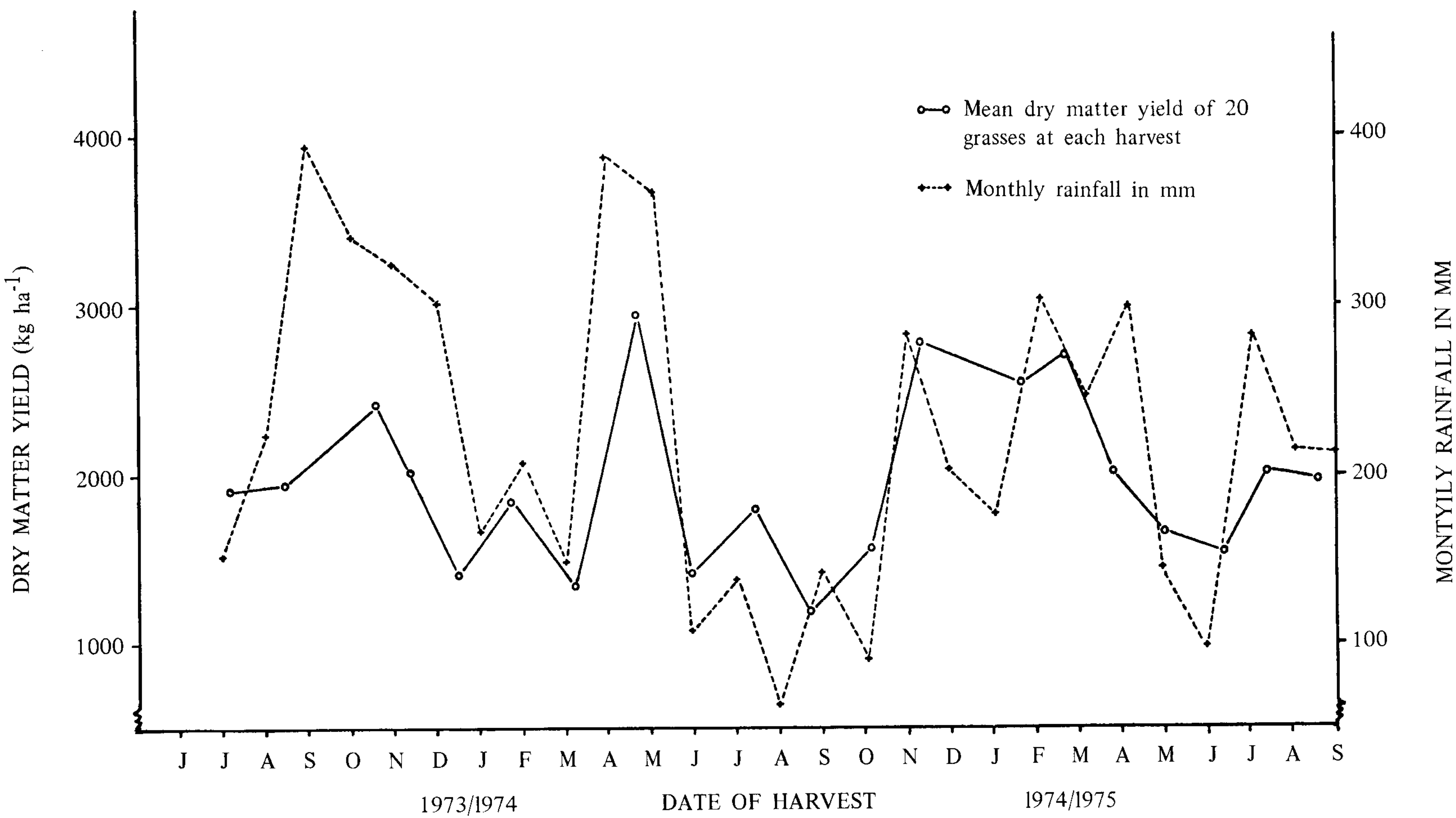

Figure 3: The effect of rainfall on mean dry matter yields of 20 grasses under cutting in the first year and intermittent grazing in the second year at Serdang

TABLE 2: THE COEFFICIENTS OF CORRELATION OF RAINFALL WITH DRY MATTER YIELDS OF 20 GRASSES OVER A TWO-YEAR PERIOD IN SERDANG

Grass species	Coefficients of correlation
Brachiaria brizantha	0.67*
Brachiaria decumbens	0.55*
Brachiaria ruziziensis	0.62**
Cynodon plectostachyus	0.52*
Digitaria sp. (H–10)	0.67**
Digitaria sp. (Slenderstem)	0.62**
Digitaria sp. (x–125–1)	0.58**
Digitaria sp. (x–46–2)	0.58**
Digitaria setivalva	0.34 N.S.
Panicum maximum cv. Coloniao	0.31 N.S.
Panicum maximum cv. Gori	0.57*
Panicum maximum cv. Hamil	0.51*
Panicum maximum cv. Sigor	0.37 N.S.
Panicum maximum cv. Tanganyika	0.47*
Paspalum dilatatum	0.53*
Paspalum plicatulum cv. Rodd's Bay	0.81**
Paspalum plicatulum cv. Hartley	0.50*
Setaria anceps cv. Kazungula	0.53*
Setaria anceps cv. Nandi	0.61**
Setaria splendida	0.43 N.S.

* Significant at 5%
** Significant at 1%
N.S. Not significant.

Mineral Composition

The average mineral composition of the herbage above stubble height from the 20 grasses (*Table 3*) seemed to be more than adequate to meet the recommended dietary requirements for beef cattle weighing 300–500 kg per head (MINSON *et al.*, 1976) except for the phosphorus and sodium contents. Since the mineral contents were based on total herbage, a higher concentration of the two elements would have been obtained if younger tissues were sampled.

An inverse relationship between the mineral percentages and D.M. yield was also observed as with nitrogen concentration in the grasses. The highest yielding grasses (*B. decumbens*, Gori and Tanganyika guinea) had the lowest concentrations of phosphorus, potassium and magnesium. Phosphorus concentration did not vary much among the grasses but tended to be lower in the Hartley paspalum. The *Digitarias* and the *Paspalums* had higher magnesium levels than the other genera. Tanganyika guinea and the *Digitarias* and *Paspalums* had higher calcium content ($P<0.05$) than the other grasses. The sodium concentration in all grasses was generally lower than normal herbage except in the *Setarias* which also had high concentrations of potassium. HACKER (1969) also reported high potassium and sodium concentrations in *Setarias*. The low sodium in most of the grasses could be due to the higher potassium uptake (HENKENS, 1965) or the low sodium status of the soil (PLAYNE, 1970).

TABLE 3: AVERAGE MINERAL COMPOSITION NITROGEN AND CRUDE PROTEIN (as % dry matter) OF 20 GRASSES EVALUATED AT SERDANG.

Grass species	% Crude protein	% N	% Ca	% P	% Mg	% K	% Na
Brachiaria brizantha	10.8	1.73	0.26	0.16	0.18	1.41	0.02
Brachiaria decumbens	10.6	1.69	0.30	0.15	0.19	1.35	0.02
Brachiaria ruziziensis	11.6	1.86	0.31	0.16	0.20	1.80	0.02
Cynodon plectostachyus	10.9	1.74	0.16	0.14	0.10	1.45	0.02
Digitaria sp. (H–10)	10.7	1.71	0.37	0.17	0.23	1.55	0.02
Digitaria sp. (x–125–1)	11.5	1.84	0.38	0.14	0.23	1.61	0.04
Digitaria sp. (x–46–2)	11.1	1.77	0.36	0.16	0.22	1.51	0.03
Digitaria sp. (Slenderstem)	11.1	1.78	0.27	0.15	0.21	1.55	0.06
Digitaria setivalva	11.0	1.76	0.39	0.15	0.26	1.54	0.03
Panicum maximum cv. Coloniao	12.9	2.07	0.29	0.16	0.18	1.63	0.02
Panicum maximum cv. Gori	10.5	1.68	0.23	0.13	0.14	1.25	0.02
Panicum maximum cv. Hamil	13.5	2.16	0.27	0.15	0.15	1.88	0.02
Panicum maximum cv. Sigor	13.4	2.15	0.26	0.14	0.18	1.69	0.03
Panicum maximum cv. Tanganyika	10.5	1.68	0.36	0.13	1.17	1.38	0.02
Paspalum dilatatum	12.3	1.97	0.29	0.18	0.24	1.75	0.03
Paspalum plicatulum cv. Rodd's Bay	11.1	1.78	0.43	0.13	0.25	1.55	0.02
Paspalum plicatulum cv. Hartley	11.1	1.78	0.44	0.13	0.25	1.25	0.02
Setaria anceps cv. Kazungula	11.7	1.88	0.25	0.15	0.22	1.79	0.08
Setaria anceps cv. Nandi	12.6	2.01	0.24	0.15	0.16	1.76	0.09
Setaria splendida	12.4	1.99	0.21	0.15	0.21	1.73	0.06
Recommended values+		1.80	0.22–0.35	0.22	0.12	0.31–0.44	0.05
L.S.D. 5%	1.2	0.20	0.27	0.02	0.09	0.20	0.01
L.S.D. 1%	1.7	0.27	0.09	0.02	0.12	0.28	0.02

\+ Recommended dietary content of mineral elements and nitrogen for finishing cattle weighing 300 – 500 kg (Minson *et al.*, 1976)

Other observations

Persistence exceeded 90% (% of plant surviving) in all grasses except *C. plectostachyus* which was slow in establishment. Weed invasion of the plot was dense. There was no obvious relationship between the dry spell and plant mortality.

Pests and diseases in all the grasses were negligible except for Coloniao and Hamil guinea which suffered from a viral-like infection after the initial harvest. The infected plants were stunted in regrowth and young leaves were chlorotic with necrosis of leaf tips and marigns. Attempts to isolate the pathogens were not successful.

On palatability, the cattle showed a distinct preference for the *Setarias* and the Guineas. However, Tanganyika guinea seemed to be less acceptable than the others. The least palatable species were the *Brachiarias* and the *Paspalums*.

CONCLUSION

While the D.M. yield and chemical composition of the 20 grasses were discussed in relation to animal production requirements, their true feeding values can best be assessed only through grazing (HUTTON and MINSON, 1974). Further studies are needed to evaluate the high yielding grasses identified with reference to drought tolerance and animal productivity.

ACKNOWLEDGEMENTS

The author wishes to thank En. Jalil b. Sulaiman for assistance in running the experiment, En. A.D. Johnson of CSIRO for chemical analysis of plant material and En. Ahmad Shukri for the statistical analyses.

SUMMARY

The response of 20 improved grasses fertilised at 400 kg N ha^{-1} ann^{-1} and defoliated at 5–6 weekly intervals was evaluated in Serdang, Malaysia for a two year period, involving hand-cutting during the first year and intermittent grazing by cattle in the second year.

The dry matter yields of the 20 grasses ranged from 6,100 to 27,700 kg ha^{-1} ann^{-1} and crude protein yield from 730 to 2,900 kg ha^{-1} ann^{-1}. The highest productive species were Tanganyika guinea, *B. decumbens* and Gori guinea followed by *Setaria splendida* and *Paspalum plicatulum* cv. Rodd's Bay. The dry matter yields of the grasses were positively and significantly ($P<0.05$) correlated with increased rainfall except for 4 species. The dry matter percentage of the grasses ranged from 16 to 33% with *C. plectostachyus* the highest and the *Setarias* the lowest.

The nitrogen concentration of the total herbage was negatively related to dry matter production. Crude protein content varied from 10.5 to 13.5%. Sodium and potassium levels were generally higher in the *Setarias* while calcium and magnesium contents were high in the *Paspalums* and *Digitarias*. The nitrogen and mineral contents of the 20 grasses were discussed in relation to animal nutritional requirements.

REFERENCES

COLMAN, R.L. (1971). Quantity of pasture and forage crops for dairy production in the tropical regions of Australia. I Review of the Literature. *Trop. Grassld. 5:* 181–94.

DUNSMORE, J.R., and ONG, C.B. (1969). Preliminary work on pasture species and beef production in Sarawak, Malaysia. *Trop. Grassld. 3:* 117–21.

FLINT, B., KASSIM ISMAIL, RAJOB, M.H.H., and MAMAT EMBONG (1971). Yield moisture and protein content of selected forage grasses in Malaysia. *Research Publ.* No. 5, Anim. Sci. Series No. 2, College of Agriculture, Malaya.

FRENCH, M.H. (1957). Nutritional value of tropical grasses and fodders. *Herb. Abstr. 27:* 1–9.

GROF, B., and HARDING, W.A.T. (1970). Dry matter yields and animal production of guinea grass *(Panicum maximum)* on the humid tropical Coast of North Queensland. *Trop. Grassld. 1:* 85–95.

HACKER, J.B., and JONES, R.J. (1969). The *Setaria sphacelata* complex – a review. *Trop. Grasslдd. 3:* 13–34.

HENDERSON, R. (1955). The cultivation of fodder grasses in Malaya. Part III. The time and frequency of application of fertiliser. *Malays. agric. J. 38:* 250–255.

HENKENS, C.H. (1965). Factors influencing the sodium content of meadow grass. *Neth. J. Agric. Sci. 13:* 21–47.

HUTTON, E.M., and MINSON, D.J. (1974). Selecting and breeding tropical pasture plants for increased cattle production. *Proc. 12th Int. Grassld. Congr., Moscow 1974, 1:* 210–22.

JAMIL, M. (1956). A study of some cultural effects on protein content of guinea grass. *Malays. agric. J. 39:* 121–32.

JOHNSON, A.D., and SIMONS, J.G. (1972). Direct reading emission spectroscopy's analysis of plant tissue using a briquetting technique. *Comm. in Soil Sci. and Plant Analysis. 3:* 1–9.

JONES, R.J. (1966). CSIRO Division of Tropical Pasture. *Annual Rpt. 1965–66.*

KEEPING, G.S. (1951). A review of fodder grasses investigation. *Malays agric. J. 34:* 65–75.

LEAMY, M.L. and PANTON, W.P. (1966). Soil survey manual for Malaysian conditions. *Div. of Agric. Bul. No. 119.*

LIM, H.K. (1968). Animal feeding stuffs – Part 4: Compositional data of grasses and fodders. *Malays. agric. J. 46:* 405–20.

MILFORD, R., and MINSON, D.J. (1966). Intake of tropical pasture species. *Proc. 9th. Int. Grassld. Congr., Sao Paulo, Brazil. 1964.* pp. 815–22.

MINSON, D.J., STOBBS, T.H., HEGARTY, M.P., and PLAYNE, M.J. (1976). Measuring the nutritive value of pasture plants. In 'Tropical Pasture Research – Principles and Methods'. *Bul. Commonw. Bur. Past. Fld. Crop No. 51* pp. 308–37. (Eds. N.H. Shaw and W.W. Bryan).

NG, T.T. (1972). Comparative responses of some tropical grasses to fertiliser nitrogen in Sarawak, East Malaysia. *Trop. Grassld. 6:* 229–36.

NG, T.T., WILSON, J.R., and LUDLOW, M.M. (1975). Influence of water stress on water relations and growth of a tropical C_4 grass, *Panicum maximum* var. *trichoglume. Aust. J. plant Physiol. 2:* 581–95.

OYENUGA. V.A. (1957). The composition and nutritional value of certain feeding stuffs in Nigeria. *Emp. J. exp. agric. 25:* 237–55.

PLAGNE, M.J. (1970). The· sodium concentration in some tropical pasture species with reference to animal requirements. *Aust. J. exp. agric. anim. Husb. 10:* 32–5.

SOTOMAYOR-RIOS A., JULIA, J.J., and ARROYO-AGUILU J.A. (1974). Effect of harvest intervals on the yield and composition of 10 forage grasses. *J. agric. Univ. Puerto Rico. 58:* 448–55.

TAN, H.T., and PILLAI, K.R. (1975). Production of high quality grass in the tropics. *Paper presented at 'Conf. on Malaysian food self-sufficiency', 1975.*

TAN, H.T., YEOW, K.H., and PILLAI, K.R. (1973). Potential pasture production and development. *Proc. of the Sym. on 'National utilisation of land resources in Malaysia' Serdang 1973* pp. 23–39.

THAM, K.C., WONG, C.C. and AJIT, S.S. (1978). Establishement of *Leucaena leucocephala* on the Acidic Inland Soils of Peninsular Malaysia. 1. Effects of lime, inoculation, pelleting and phosphorus on the establishment of *L. leucocephala. MARDI Res. Bull. 5:* 1–20.

URE, J.S. and JAMIL, M. (1957). Fodder grass cultivation – A manual and varietal trial at the Federal Experimental Station, Serdang. *Malays. agric. J. 40:* 206–16.

VINCENTE-CHANDLER, J., SILVA, S. and FIGARELLA, J. (1959). The effect of nitrogen fertilization and frequency of cutting on the yield and composition of three tropical grasses. *Agron. J. 51:* 202–206.