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PRODUCTIVITY OF FIVE SUBTROPICAL GRASSES ON A BLACK EARTH OF THE EASTERN DARLING DOWNS OF QUEENSLAND

J. MACKENZIE, [1] R. MAYER[2] and W. J. BISSET[3]

1. Queensland Wheat Research Institute, P.O. Box 5282, Toowoomba, Qld 4350.
2. Biometry Branch, Queensland Department of Primary Industries, Box 102, Toowoomba, Qld 4350.
3. Agriculture Branch, Department of Primary Industries, Box 46, Brisbane, Qld 4001.
Present address—1 Gable St., Stafford Heights, Qld 4053.

ABSTRACT

Four subtropical perennial grass species and a perennial forage sorghum were compared for dry matter production and herbage nitrogen concentration at three levels of *nitrogen fertilizer in a cutting trial on a cracking clay soil of the eastern Darling Downs.*

At 3 months after sowing, Sorghum *spp. hybrid cv. Silk had considerably outstripped the perennial grasses in dry matter yield while* Chloris gayana *cv. Pioneer outyielded* Panicum coloratum *var.* makarikariense *cv. Pollock,* Bothriochloa insculpta *cv. Hatch and* Dichanthium aristatum. *Over the next 5 years Silk and* B. insculpta *were the best dry matter producers at each rate of fertilizer;* D. aristatum *was the lowest producer and had the shortest growing season.*

Although inferior to Silk, C. gayana *and* P. coloratum *in spring growth,* B. insculpta *exceeded all these in autumn growth.* B. insculpta *requires less nitrogen for growth than* C. gayana *and* P. coloratum; *Silk requires more nitrogen and in the nil fertilizer treatment suffered a reduction of stand. The high dry matter yields of* B. insculpta *were accompanied by a low herbage nitrogen concentration.*

In a comparison of cutting frequencies in the fifth year, Silk consistently outyielded the others at the 8-weekly frequency whereas C. gayana *tended to produce most dry matter at the 4-weekly frequency.* D. aristatum *was excluded from this comparison.*

INTRODUCTION

The Darling Downs (Lloyd 1970) is a plateau region of predominantly self-mulching clay soils (vertisols) lying between the latitudes 26° 30'S and 28° 30'S in south-eastern Queensland. Annual rainfall ranges between 625 and 750 mm with two thirds falling between October and March. Summer droughts are common and frosts occur between May and September. The eastern portion consists of uplands (450–600 m elevation) with relatively shallow soils on which the chief land use is forage cropping (mainly oats and annual sorghums with some lucerne) for beef and dairy cattle. The main reasons for not using sown pastures on these cracking clay soils are poor establishment reliability of conventional small seeded sub-tropical sown grasses (Leslie 1965) and poor persistence. A sown pasture phase in the cropping system would reduce cultivation costs and provide year-round soil protection in this erosion-prone region. Thus, there is a continuing need to test new grass species.

The currently recommended grass species for the heavier soil phases are *Sorghum almum* cv. Crooble (Columbus grass), *Panicum coloratum* var. *makarikariense* (Makarikari grass) and *Chloris gayana* (Rhodes grass) (Lloyd 1970, Cull 1974). Columbus grass has a large seed and does not have any establishment problem but persistence is limited to 2–3 years. Makarikari grass is the best small-seeded grass in regard to establishment reliability and general adaptation, but seedling growth is slow. The strength of Rhodes grass lies in its stoloniferous habit, which enables it to overcome poor establishment.

In recent years experiments have shown *Bothriochloa insculpta* cv. Hatch (creeping bluegrass) and *Dichanthium aristatum* (angleton grass) to establish more reliably on the heavy clay soils of Queensland's Central Highlands than *P. coloratum* var. *makarikariense* cv. Pollock (Younger and Gilmore 1978). Since nothing was known of the productivity of these two new grasses on the Darling Downs, this experiment was undertaken to compare their dry matter production with that of *P. coloratum*, *C. gayana* and a new perennial sorghum, *S. spp.* hybrid cv. Silk (Anon. 1978). The comparisons were made with various rates of application of nitrogen fertilizer.

MATERIALS AND METHODS

The experiment was conducted at Wellcamp, 8 km west of Toowoomba on a gently sloping site that had previously been cultivated for about 20 years. The sedentary soil (Ug5.12 Northcote 1974) was a Charlton clay (Thompson and Beckmann 1959) of c. 800 mm depth to weathered basalt. Characteristics of this soil type are: reaction neutral at the surface becoming alkaline with depth; very good supplies of phosphorus and adequate potassium; total nitrogen low to moderate and declining with cropping.

The following species and cultivars were used: *Chloris gayana* cv. Pioneer, *Panicum coloratum* var. *makarikariense* cv. Pollock, *Bothriochloa insculpta* cv. Hatch, *Dichanthium aristatum* (commercial seed ex Bloomsbury), and *Sorghum* spp. hybrid cv. Silk.

The five grasses received three rates of nitrogen fertilizer, giving a total of fifteen treatments. Plot size was 6 x 3 m with a 0.9 m border between plots. Seed of all species was hand-broadcast at a high seeding rate (20 kg ha^{-1}) and covered by harrowing. The experiment was sown February 9, 1972 and favourable rainfall conditions resulted in an acceptable stand of all species.

Nitrogen was applied at 0, 60 and 120 kg N ha^{-1}, as urea, in October of 1972 and for each of the next three years. An additional dressing of nitrogen was applied in December 1972 (giving total applications of 0, 120 and 240 kg N ha^{-1} for that year) to offset the effect of a very wet season.

Previous experience in a similar soil on the Darling Downs indicated that yield of pasture responded to sulphur (Loader 1974) and in some instances to phosphorus, despite a high soil phosphorus status (Lloyd 1970). These two elements were topdressed to all plots as single superphosphate (225 kg ha^{-1}) in December 1972, 'superphosphate with sulphur' (26% S) in July 1973 (225 kg ha^{-1}) and single superphosphate (350 kg ha^{-1}) in October 1975.

Yields were measured from a strip 0.8 × 4.0 m cut within each plot using a flail mower set to cut at 2 cm-height. The harvested material was dried in a forced draught oven at 80 °C and weighed. At each harvest the remainder of each plot was mown and the residue raked off. The first harvest was taken on May 31, 1972. Subsequent harvests (four each year) were taken at approximately 8-weekly intervals between October and May until 1976. Actual harvest dates were: October 23, December 14, February 15, April 12, 1972–73; October 3, November 29, January 22, March 18, 1973–74; October 21, December 18, February 17, April 8, 1974–75; October 28, December 18, March 11, May 31, 1975–76. The nitrogen fertilizer was applied immediately after the first harvest in each year.

On October 27, 1976 a clearing cut was made and nitrogen fertilizer applied at rates of 0, 120 and 240 kg ha^{-1}. Each plot was divided into two sub-plots to accommodate a comparison of 4-weekly and 8-weekly cutting for the 1976–77 season. Three 8-weekly cuts were made on all plots (December 21, February 15 and April 15); plots harvested 4-weekly were also cut on November 23, January 18 and March 16. Poor productivity during the first four years caused *D. aristatum* to be excluded from the experiment in 1976–77.

Nitrogen concentrations were determined for all harvests except the first (May 1972), after Kjeldahl digestion. Yields of nitrogen were estimated from these concentrations and plot yields. Percent recovery of applied nitrogen was calculated by dividing the accumulated increase in nitrogen yield, compared with the nil nitrogen treatment over the 4-year period, by the total amount of nitrogen applied at each rate.

Statistical analysis of the data was carried out using analysis of variance across years. The results for the period October 1976–April 1977 were analysed separately to compare cutting frequencies.

Broadleaf weeds, *Datura stramonium* (thornapple) and *Rapistrum rugosum* (turnip weed), were controlled by spraying in March 1972, July 1973 and May 1975 with a picloram-2, 4-D herbicide at commercial rates. For the first 4 years the headlands and interplot laneways were rotary hoed annually for weed control.

Monthly rainfalls recorded at the site during the experimental period are shown in Table 1, together with the long term averages for Westbrook, the nearest recording station with a similar rainfall (*c.* 650 mm annual mean). Growing season (October–March) rainfall was good in 1972–73 and poor in 1973–74, when first and last harvests were early. After 8 months of drought, growing season rainfall in 1974–75 was good and adequate rain fell throughout 1975–76. In 1976–77 spring rainfall was good but December-February rainfall was poor.

TABLE 1

Monthly and annual rainfalls (mm) at Wellcamp from May 1972 to April 1977, together with 70-year average for Westbrook Boys' Farm (10 km S.S.W.)

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Totals
1972—73	22*	9*	1	0	10	175	69	65	128	170	37	0	686
1973—74	16	19	52	15	8	14	17	33	136	0	7	0	317
1974—75	15	2	0	0	0	59	153	60	126	168	36	0	619
1975—76	15	19	44	39	70	126	84	139	127	152	69	0	884
1976—77	63	10	54*	0*	63*	61	82	22	51	47	64	24	541
70-year average	31	41	37	29	32	62	69	89	93	68	62	31	644

* from Westbrook Boys' Farm.

RESULTS

Annual and total dry matter production

At the initial harvest in May 1972 dry matter yields (t ha^{-1}) for the various species were: *Sorghum* spp. hybrid 7.45; *C. gayana* 4.02; *B. insculpta* 2.31; *D. aristatum* 2.05; and *P. coloratum* 1.57 (L.S.D. (P = 0.05) = 0.83). *Sorghum* spp. hybrid and *C. gayana* therefore yielded significantly more than the other three grasses, and *Sorghum* spp. hybrid significantly outyielded *C. gayana* at this time.

Total yields over the following 5 years (Table 2) showed that at each nitrogen rate *B. insculpta* and *Sorghum* spp. hybrid produced the highest yields, with *C. gayana* and *P. coloratum* in the middle range and *D. aristatum* giving the lowest yield.

Table 3 shows the dry matter yields for each year x nitrogen rate averaged over all species. Without nitrogen fertilizer, dry matter production decreased sharply in the second year and thereafter remained at 20 to 35% of its first year level. Production declined relatively less with each rate of nitrogen. Yields improved in the wet year 1975–76 (see Table 1) but declined in 1976–77.

TABLE 2

Total dry matter production (t ha^{-1}) over 5 years for the five grasses at three nitrogen rates

Total N applied (kg ha^{-1})	*Chloris gayana*	*Panicum coloratum*	*Bothriochloa insculpta*	*Dichanthium aristatum*†	*Sorghum* spp. hybrid
0	15.72	17.01	25.13	11.63	20.76
420	32.07	33.12	46.48	24.32	43.04
840	48.76	51.42	55.33	36.45	60.93

LSD (P = 0.05) = 4.53.

† Estimates of *D. aristatum* production in 1976—77 were calculated at 1.25, 3.79 and 6.22 t ha^{-1} for the 3 N rates.

Figure 1 shows the yields of the individual species according to nitrogen rates and years. In the first year *B. insculpta* and *D. aristatum* responded least to nitrogen. The pattern of declining yield in the second and third years, modified by nitrogen fertilizer, with recovery in the fourth year as shown in Table 2, is common to all species. *B. insculpta* and *D. aristatum* improved most in the fourth year, with fertilized *B. insculpta* exceeding its first year yield. In the fifth year, *C. gayana* and *Sorghum* continued to improve with nitrogen fertilizer, whereas *P. coloratum* did not and *B. insculpta* declined sharply. In all years *B. insculpta* differed from all other species in showing little extra benefit from the higher rate of nitrogen.

Nitrogen concentration of dry matter

Overall, mean nitrogen concentrations of the herbage were low (Table 4). The higher rate of nitrogen fertilizer significantly increased concentrations in the first,

TABLE 3

Mean dry matter production (t ha^{-1}) for each year x nitrogen rate, averaged over the five grasses

N-rate* ($kg\ ha^{-1}\ yr^{-1}$)	Year				
	1972—73	1973—74	1974—75	1975—76	1976—77**†
0	8.54	2.98	1.64	3.00	1.88
60	11.64	6.61	4.25	7.22	6.09
120	12.96	9.34	7.25	11.34	9.69

L.S.D. (P = 0.05) for comparing means with the same rate of N = 0.68.
L.S.D. (P = 0.05) for comparing means with different rates of N = 0.73.
* In years 1972—73 and 1976—77, twice the specified N-rate was applied.
** Estimates of *D. aristatum* yield for 1976—77 have been used.
† The October cut was excluded in 1976—77.

TABLE 4

Mean nitrogen percentage of dry matter over the five grasses for the three nitrogen rates in the 5 years

N rate* ($kg\ ha^{-1}\ yr^{-1}$)	1972—73	1973—74	1974—75	1975—76	1976—77**
0	1.04	1.06	1.08	0.82	0.89
60	1.16	1.16	0.96	0.66	0.94
120	1.45	1.42	1.09	0.66	1.21

LSD (P = 0.05) = 0.15
* In years 1972—73 and 1976—77 twice the specified rates of nitrogen were applied.
** Estimates of N% of *D. aristatum* for 1976—77 were used.

second and fifth years, but had no effect in the third year and resulted in a reduced concentration in year 4. The nitrogen concentration of unfertilized grass declined in the fourth and fifth years. Mean nitrogen concentrations for the five species averaged over all nitrogen rates and years were: *D. aristatum* (estimated for 1976–77) 1.22; *P. coloratum* 1.04; *Sorghum* 1.02; *C. gayana* 1.00; *B. insculpta* 0.92%, (L.S.D. (P = 0.05) = 0.09).

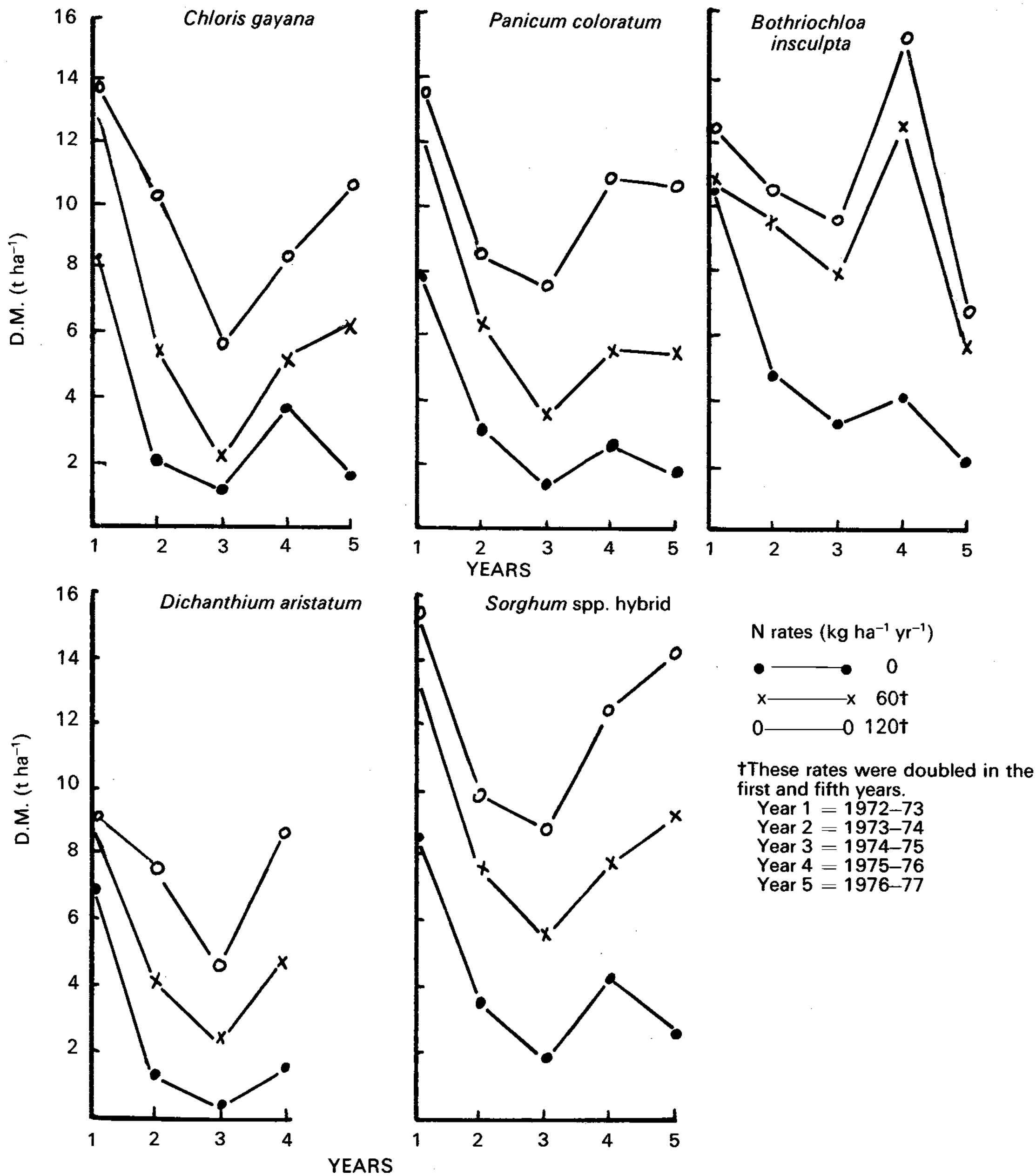
Seasonal dry matter production and nitrogen concentration

In general, dry matter yields peaked at the February harvest (Figure 2). With applied nitrogen *C. gayana* and *Sorghum* spp. hybrid reached a plateau at the December harvest which was maintained at the February harvest. Nitrogen also substantially increased the November-December growth of *P. coloratum*, but had little effect at this time on either *B. insculpta* or *D. aristatum*. Yields of all species declined sharply at the April harvest, *B. insculpta* giving highest yields irrespective of applied nitrogen.

In the absence of nitrogen fertilizer the nitrogen concentrations were generally highest at the October harvest, declining sharply to reach a trough at the February harvest, and rising at the April harvest (Figure 3). The higher rate of applied nitrogen had a marked effect on nitrogen concentrations at the December harvest, producing a maximum at that time in several species with the response generally decreasing as the season progressed. The pattern was different for *D. aristatum*; with this species nitrogen concentration was more uniform throughout the season, at each nitrogen rate; applied nitrogen increased concentration even at the October harvest and the effect was well sustained.

Efficiency of nitrogen recovery

Significant differences were recorded in percentage nitrogen recoveries (Table 5). With 60 kg N ha^{-1}, recovery by *Sorghum* was greater than that by *C. gayana* and *D.*



L.S.D. (P = 0.05) for comparing between years for each grass x N rate = 1.53
L.S.D. (P = 0.05) for comparing means involving different grasses and/or different N rates = 1.64.

FIGURE 1

Yearly DM production of five grasses at three nitrogen fertilizer rates over 5 years (4 years with *Dichanthium aristatum*).

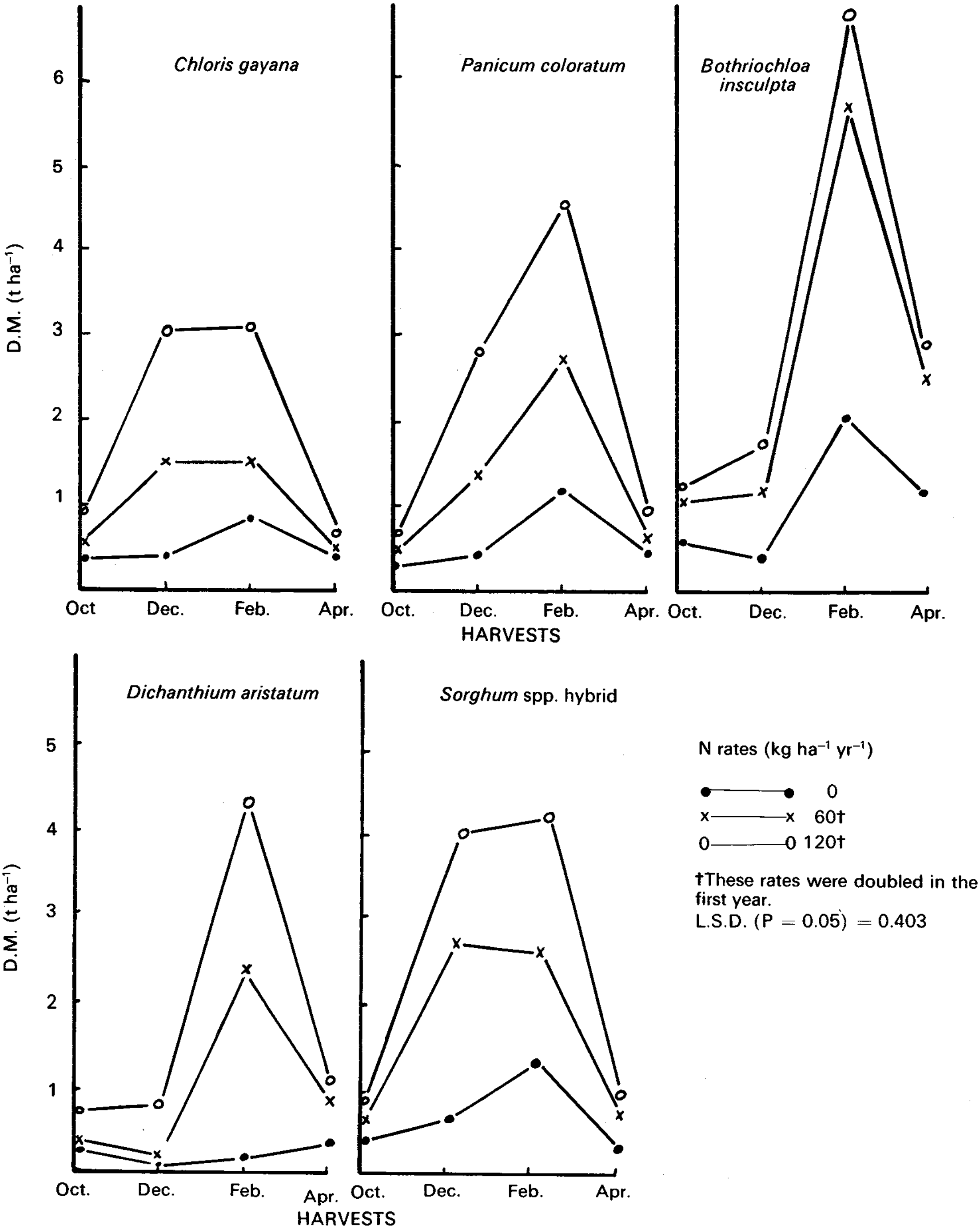


FIGURE 2

Seasonal DM production of five grasses at three nitrogen fertilizer rates measured at four harvests (means of 4 years).

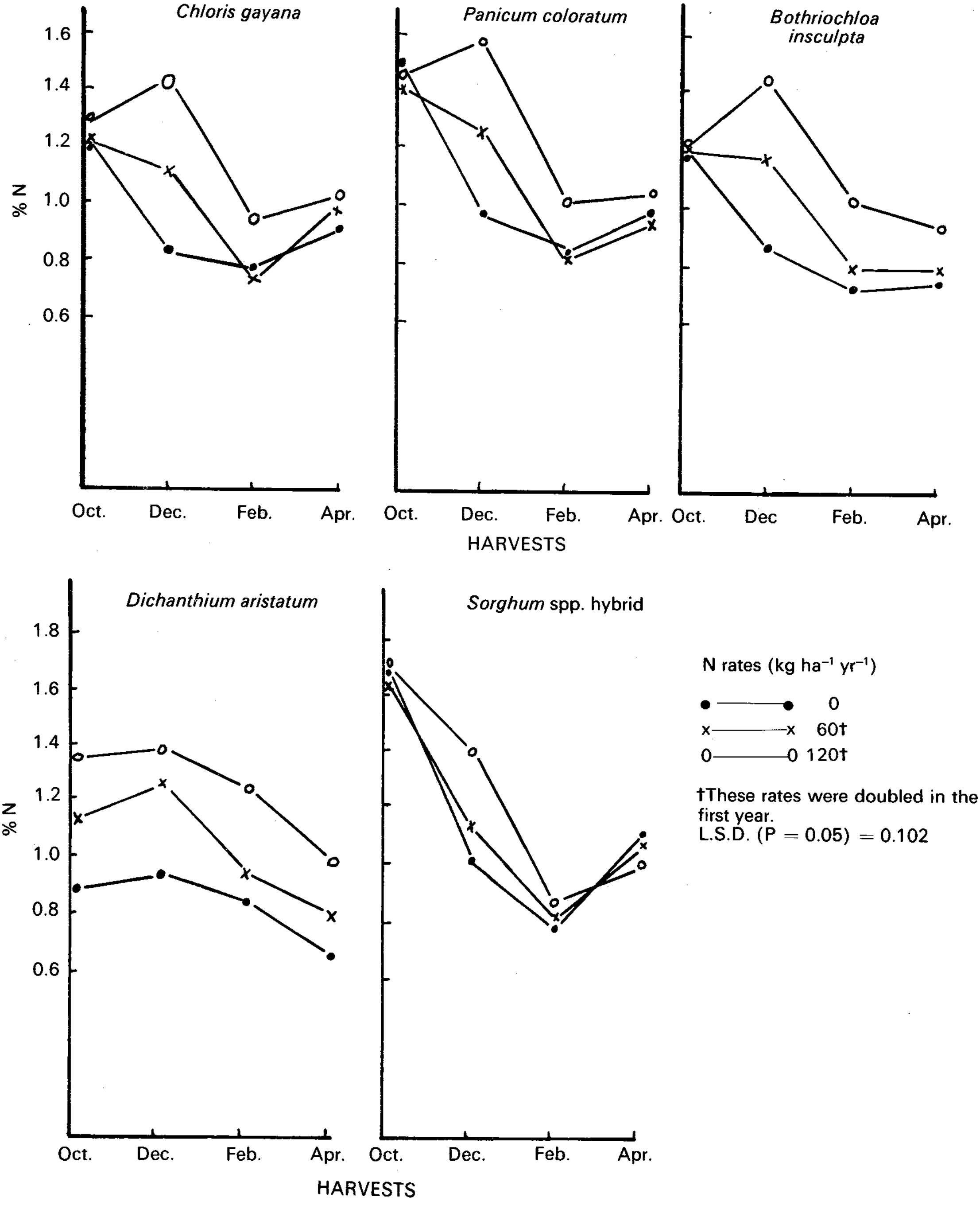


FIGURE 3

Seasonal nitrogen percentage of five grasses at three nitrogen fertilizer rates measured at four harvests (means of 4 years).

aristatum, whereas with 120 kg N ha^{-1} the recovery by *C. gayana* and *P. coloratum* increased to match that by *Sorghum*.

Effect of harvest frequency on dry matter production and nitrogen concentration

Increasing the cutting frequency to 4-weekly reduced the annual dry matter production of all species except unfertilized *C. gayana* (Table 6). At the 8-weekly interval *Sorghum* consistently outyielded the other species at each rate of applied nitrogen, whereas at the 4-weekly interval *C. gayana* tended to produce most dry matter.

Cutting more frequently resulted in higher nitrogen percentages in the dry matter of all species at all rates of applied nitrogen (Table 7). In many instances the increases in concentration were substantial. Applied nitrogen increased nitrogen concentration under both cutting frequencies.

TABLE 5

Per cent recovery of nitrogen applied as urea in tops of five grasses over 4 years

Annual N rate (kg ha^{-1})	*Chloris gayana*	*Panicum coloratum*	*Bothriochloa insculpta*	*Dichanthium aristatum**	*Sorghum* spp. hybrid
60†	38.3	45.0	49.2	38.8	54.1
120†	55.3	56.1	47.8	44.2	55.3

LSD (P = 0.05) = 11.5.
† These rates were doubled in the first year.

TABLE 6

Dry matter yields (t ha^{-1}) of four grasses fertilized at three nitrogen (N) rates and harvested at two frequencies between October 1976 and April 1977

N rate (kg ha^{-1})	Harvest Frequency (weeks)	*Chloris gayana*	*Panicum coloratum*	*Bothriochloa insculpta*	*Sorghum* spp. hybrid
0	4	1.83	1.28	0.93	1.28
0	8	1.64	1.90	2.07	2.55
120	4	4.11	2.89	3.21	2.83
120	8	6.35	5.50	5.62	9.19
240	4	4.89	4.33	4.01	4.02
240	8	10.62	10.65	6.75	14.18

LSD (P = 0.05) for comparing between harvest frequencies for each grass N rate = 0.72.
LSD (P = 0.05) for comparing means involving different grasses and/or different N rates = 0.75.

TABLE 7

Nitrogen percentage of dry matter of four grasses fertilized at three nitrogen (N) rates and harvested at two frequencies between October 1976 and April 1977

N rate (kg ha^{-1})	Harvest frequency (weeks)	*Chloris gayana*	*Panicum coloratum*	*Bothriochloa insculpta*	*Sorghum* spp. hybrid
0	4	0.92	1.12	1.00	1.40
0	8	0.83	0.79	0.72	0.90
120	4	1.41	1.71	1.40	1.62
120	8	0.93	0.87	0.90	0.82
240	4	1.97	2.15	1.99	2.22
240	8	1.20	1.22	1.31	1.00

LSD (P = 0.05) = 0.19 (from a randomized block design analysis, since split plot analysis proved non-monotonic).

Persistence and invasion

No stand counts were made of the four perennial grasses but there was no obvious loss of stand in any grass at the end of the experiment. Since persistence was of special interest with *Sorghum* spp. hybrid, its stand was measured in October 1973 and September 1976 by recording the number of hits from 80 point-quadrat throws per plot. These showed a significant (P = 0.05) decline in stand in the nil nitrogen treatment only.

In the fifth year (1976–77), following the cessation of rotary hoeing, there was considerable colonization of the headlands and interplot laneways by seedlings of *D. aristatum*. The only cross invasion observed was by seedlings of this species in the *Sorghum* plots in the fifth year.

DISCUSSION

First year dry matter yields of all species reflected excellent rainfall and the doubling of the nitrogen fertilizer rates. The marked decline in the second year probably reflected the very low rainfall of that year, since herbage nitrogen concentrations were maintained (Table 4). The further decline in dry matter yields in the third year, when rainfall improved, plus the failure of nitrogen concentrations to respond to nitrogen fertilizer, suggested a run-down in available nitrogen. In the fourth year, yields responded to both excellent rainfall and nitrogen fertilizer, but nitrogen concentrations declined further and were actually reduced by fertilizer, suggesting a dilution of plant nitrogen by the abundant growth. In the fifth year, when nitrogen rates were doubled, fertilized *C. gayana* and *Sorghum* spp. hybrid exceeded their fourth year yields despite a deficient rainfall, and *P. coloratum* maintained its yield; nitrogen concentration (mean of the four species) improved at the 240 kg ha^{-1} N fertilizer rate but was still significantly below that of the first and second years. The marked decline in yield of *B. insculpta* in the fifth year may have been caused by a deficiency of moisture during its peak growth period; the better spring growth potential of other species resulted in their being less disadvantaged by the low December-February rainfall.

The slow seedling growth, poor yields and short growing season of *D. aristatum* make this grass unattractive for pasture in this environment. The seasonal nitrogen concentrations show that it had not exhausted the nitrogen supply at the end of the growing season. This, plus poor nitrogen recovery, suggests poor local adaptation. Adaptation to the soil type, as evidenced by prolific seedling colonization, is not questioned. Results obtained in central Queensland (Younger and Gilmore 1978) suggest that high dry matter yields of *D. aristatum* require wetter and warmer conditions than those prevailing on the Darling Downs.

Throughout our experiment *Sorghum* spp. hybrid and *B. insculpta* produced the highest yields, and *Sorghum* considerably outyielded all other grasses 3 months after sowing, when all except *C. gayana* produced poorly. Although inferior to *Sorghum, C. gayana* and *P. coloratum* in spring growth, *B. insculpta* was superior to all these in autumn growth. The superior yield responses and low recovery of applied nitrogen exhibited by *B. insculpta* suggest that this species needs less nitrogen for growth than the others. An accompanying weakness is its low herbage nitrogen content. The seasonal nitrogen levels indicate that *Sorghum* has a higher nitrogen requirement than *C. gayana* and *P. coloratum*. There is also a suggestion that the low autumn yields of these three species might have been improved by a further application of fertilizer in January.

The lower yield of *Sorghum* spp. hybrid compared to *C. gayana* under the 4-weekly cutting interval suggests that *Sorghum* would be less well adapted to continuous grazing. Over the 5 years of our experiment *Sorghum* maintained its stand in the nitrogen fertilized treatments.

Our experiment has shown both *Sorghum* spp. hybrid cv. Silk and *B. insulpta* to be promising species for ley pastures on the eastern Darling Downs. Further work involving a wider range of nitrogen treatments, and using grazing animals, would be required to assess their value in a grazing situation. In evaluation trials at the CSIRO Narayen Research Station in south-eastern Queensland Silk has shown a number of advantages over the standard perennial *S. almum* cv. Crooble (Anon. 1978).

More recently the newly released *Setaria porphyrantha* cv. Inverell has shown considerable promise on black earths of north-western New South Wales and southern Queensland (Anon. 1977). We consider that this cultivar should be included in future experiments.

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LITTER MEASUREMENTS IN TWO GRAZED PASTURES IN SOUTH EAST QUEENSLAND

R. C. BRUCE[A] and J. P. EBERSOHN[B]

A. Agricultural Chemistry Branch, Department of Primary Industries, Meiers Road, Indooroopilly, Queensland, 4068.

B. Coolum Research Station, Department of Primary Industries, Coolum Beach, Queensland, 4573. Present Address: Department of Primary Industries, Nambour, Queensland, 4560.

ABSTRACT

Litter was measured in two grazed pastures in coastal south-east Queensland. The pastures were pangola grass (Digitaria decumbens) *which was medium-heavily and continuously grazed and tropical species* (Panicum maximum *var.* trichoglume, Setaria sphacelata *var.* sericea, Desmodium intortum *and* Macroptilium atropurpureum) *which were lightly and intermittently grazed. Sampling was done at 28-day intervals over 112 days (from January to May) and 2 years respectively.*

The amount of litter under pangola varied from 81 to 209 g m^{-2}*. Under mixed tropical species it varies from 284 to 902 g* m^{-2} *being highest in spring and lowest in early autumn.*

For pangola, litter accumulation during a 28-day period ranged from 59 to 76 g m^{-2} *28* d^{-1}*, or, assuming uniform accumulation rates, 3 to 6 mg* g^{-1} d^{-1} *relative to the amount of standing crop. For tropical species accumulation varied from 66 to 452 g* m^{-2} *28* d^{-1} *with the highest amounts in spring.*

Pangola litter disappeared at rates from 9 to 54 gm^{-2} *28* d^{-1} *or 3 to 10 mg* g^{-1} d^{-1} *relative to litter on the ground, if a uniform disappearance rate is assumed over 28 days. For tropical species the corresponding figures were 12 to 422 g* m^{-2} *28* d^{-1} *and 1 to 20 mg* g^{-1} d^{-1}*. The highest rates of disappearance were in summer and lowest in winter. Sampling errors were high in all litter measurements, especially in pangola.*