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Chemical composition, *in vitro* digestibility, leaf:stem ratio, HCN potential and dry matter production of forage sorghums in south-east Queensland

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Abstract

Quality and dry matter production data are presented for 13 forage sorghum cultivars grown in a two-year trial on the Darling Downs of southern Queensland. Dry matter production ranged from 10.8 to 16.5 t/ha. Generally, forage hybrids (*Sorghum bicolor*×*S. sudanense*) produced more digestible dry matter than cultivars from the sweet sorghum group. There was a wide range in leaf:stem ratio; the highest were the late maturing cultivars Magic (2.12) and Jumbo (1.36) and the lowest the sudangrasses Trudan (0.57) and Piper (0.43). This was not strongly reflected in *in vitro* dry matter digestibility (55.7 to 62.5%) or crude protein (9.2 to 12.1%) although the correlation between leaf:stem ratio and crude protein was high (r=0.7). Sodium contents were consistently low and varied little from 0.01%. The HCN potential of sample leaves of sweet sorghums averaged 745 ppm compared to 485 ppm for all other cultivars.

INTRODUCTION

Forage sorghum is a popular annual summer forage in eastern Australia. In the three years 1979–80 to 1981–82 an average of 86 000 ha was grown of which 25% was in NSW and 72% in Queensland (ABS pers. comm. 1983). Sorghum is sown to provide summer forage because of its tolerance to heat and moisture stress and its capacity to produce large quantities of dry matter per unit area (Wheeler 1980).

The forage sorghums available in Australia are either sudangrasses (*Sorghum sudanense*) or sweet sorghums (*Sorghum bicolor*) or crosses. Late maturing cultivars that remain vegetative until the onset of short days stimulates flowering were introduced in the late 1970s. This variety of material has led to the marketing of a confusing array of cultivars which, in most cases, have been selected and are promoted only on the basis of their yield of green (fresh) forage and resistance to disease. The present study was done to provide comparative data on dry matter production, *in vitro* digestibility, N, S, and Na content and potential for release of hydrogen cyanide (HCNp). The site used was representative of the topography and soil of the central Darling Downs.

MATERIALS AND METHODS

Site

The experiment was established in two successive years on an area of black self-mulching soil 55 km west of Toowoomba with an immediate pre-experimental history of fallow–wheat–fallow. Rainfall was approximately 450 mm for the six months spanning sowing and harvesting in both years. No irrigation was provided and uneven rainfall distribution resulted in some moisture stress. However, the mean rainfall and its irregular distribution are characteristic of an extensive area of the Darling Downs.

Design and cultural details

Twelve sorghum cultivars detailed in Table 1 were sown at 8 kg/ha in a randomised block with four replications on 11 November 1980. This was repeated on 15 October 1981 but included an additional cultivar, Rising Fast, which was unavailable in 1980. In both years, the seedlings were hand thinned to obtain 10 plants/m of row. Individual plots were six rows wide and 8 m long with a row spacing of 760 mm in year 1 and 1010 mm in year 2. Buffer rows were sown around the entire site. Anhydrous ammonia was applied before sowing at the rate of 140 kg N/ha in year 1 and 60 kg N/ha in year 2.

Table 1. Forage sorghums used in experiments 1980–81

Species or hybrid	Cultivar	Source
Sudangrasses		
Sorghum sudanense	Piper	Public variety
S. sudanense hybrid	Trudan	Northrup King Pty Ltd
Sweet sorghums		
S. bicolor	Sugardrip	Public variety
Sweet sorghum × sudan grass hybrids	*Honeydrip	Northrup King Pty Ltd
	Magic	Pioneer Hi Bred Seed Co. Pty Ltd
Forage hybrids		
S. bicolor×*S. sudanense*	Speedfeed	Pacific Seeds
	*Jumbo	Pacific Seeds
	Cow Chow	Pioneer Hi Bred Seed Co. Pty Ltd
	Lush	Hylan Seed Co.
	Zulu	Hylan Seed Co.
	Sudax 6	DeKalb Shand Seed Co. Pty Ltd
	Yates Forage Arthur Yates and Co. Pty Ltd	
	Rising Fast	Cargill Seeds

* Late maturing cultivars bred to remain vegetative until short days stimulate flowering.

Harvesting and measurements

Harvesting was carried out on three occasions each year. In the two years the growing periods in days were 62 and 64 for initial growth, 43 and 41 for first regrowth and 53 and 54 for second regrowth. Samples were cut to a height of 150 mm from the central 6 m of the inner two rows of each plot and were weighed fresh. From each sample ten whole plants were divided into leaf and stem to estimate leaf:stem ratio (dry matter basis). A 2 kg subsample, taken to determine dry matter content, was placed in a forced-air dryer for 10 days. As the dryer could only be operated at 30°C this did not result in complete drying in year 1 and consequently no data on dry matter or leaf:stem ratio are available for this year. In year 2 complete drying was achieved by crushing the stems before drying.

Digestibility and chemical analyses

At the first and third harvests representative samples of the material dried at 30°C were ground and passed through a 1 mm sieve, dried to constant weight at 80°C and used for the following determinations. Dry matter *in vitro* digestibility (Tilley and Terry 1963), sodium (Williams and Twine 1967), sulphur (Rocks *et al.* 1973) and nitrogen (McKenzie and Wallace 1954). The youngest emerging leaf was collected at the first and third harvests from six plants in each plot for the determination of cyanide potential (Anderson 1960). Determinations of HCNp were on fresh material but results are expressed on an oven-dry basis.

RESULTS AND DISCUSSION

Dry matter production

Total dry matter production over the three harvests in year 2 was fairly typical for dry land sorghum (Table 2). Grouping the cultivars into genetic units shows that the sweet sorghums gave significantly lower yields than the forage hybrids and sudangrasses ($P<0.01$) (Table 3). At the third harvest DM production of the sweet sorghums was only 67% of the DM production of the forage hybrids.

This trend has also been found by Muldoon (1985) who showed further that sweet sorghums cut once at the end of a season gave a higher DM yield than those subjected to a sequence of cuts. The cultivars Rising Fast and Speedfeed had significantly higher DM yields than all sweet sorghums and sudangrasses except Trudan ($P<0.05$).

Table 2. Effect of cultivar on production and nutritive value of forage sorghum

Cultivar/ species	Fresh yield (t/ha)†		DM (t/ha)†	IVDMD (%)‡		DDM (t/ha)†	Leaf:stem ratio§	Crude protein(%)‡	
group*	year 1	year 2	year 2	year 1	year 2	year 2	year 2	year 1	year 2
Rising Fast FH	n.a.	87	16.5	n.a.	58.4	9.6	0.90	n.a.	9.4
Speedfeed FH	56	84	15.9	52.7	55.7	8.8	0.82	8.3	10.1
Lush FH	62	84	15.1	52.5	60.8	9.1	1.09	7.7	11.2
Sudax 6 FH	58	80	15.0	48.0	56.8	8.5	1.24	8.7	10.7
Cow Chow FH	58	74	14.8	49.0	62.5	9.2	1.03	7.6	11.0
Trudan SG	54	71	14.7	48.7	58.3	8.5	0.57	8.1	9.2
Yates Forage FH	50	71	13.8	48.1	60.4	8.3	1.02	7.6	10.8
Honeydrip SS	64	83	13.5	53.2	61.1	8.3	1.09	9.3	10.9
Jumbo FH	64	84	13.1	49.6	59.3	7.7	1.36	8.7	10.9
Piper SG	38	48	12.7	51.4	59.8	7.5	0.43	8.7	10.1
Zulu FH	56	64	12.4	50.2	58.8	7.3	1.08	8.2	11.0
Magic SS	45	62	12.0	51.6	62.2	7.5	2.12	9.8	12.1
Sugardrip SS	58	67	10.8	51.7	61.3	6.6	1.34	8.8	11.9
Probability¶			<0.001	<0.05		<0.001	<0.001	n.s.	
LSD P=0.05			1.9	3.1		1.5	0.31		

* FH=Forage hybrid SG=Sudangrass SS=Sweet sorghum.

†Totals of three harvests.

‡Means of first and third harvests.

§Means of three harvests.

¶Probabilities of overall differences between cultivars.

n.a.=not available.

Table 3. Effect of forage type on dry matter production (t/ha) in year 2

Genetic group	Harvest 1	Harvest 2	Harvest 3	Total
Forage hybrids	3.5	6.8	4.3	14.6
Sudangrasses	3.1	6.7	3.9	13.7
Sweet sorghums	2.8	6.4	2.9	12.1

Digestibility

The overall variation between cultivars in *in vitro* dry matter digestibility (IVDMD) was less than seven percentage units, yet the sweet sorghums were significantly higher ($P<0.01$), possibly due in part to their relatively later maturity and the higher soluble carbohydrate content of their stems (Table 4). This did not compensate for their lower DM yields when yield of digestible dry matter was considered. Sugardrip was still the lowest in digestible dry matter production with Magic the next lowest apart from Zulu (Table 2). IVDMD was not correlated with leaf:stem ratio ($r=-0.04$).

Table 4. Effect of forage type on *in vitro* dry matter digestibility (%)

Genetic group	Year 1		Year 2		Mean
	Harvest 1	Harvest 3	Harvest 1	Harvest 3	
Sweet sorghums	51.6	52.7	62.4	60.5	56.8
Forage hybrids	49.9	49.9	61.4	56.7	54.5
Sudangrasses	50.2	49.8	62.7	55.4	54.5

In year 1 the values obtained for IVDMD were very low, on average 9.2 percentage units lower than for year 2 ($P<0.01$). Two factors would have contributed to this difference:

•Sowing was a month earlier in the second year so that material harvested at the first cut was not exposed to midsummer temperatures as in the first year. The depression of digestibility by high temperatures is well recognised, for example Struik *et al.* 1985.

•Slow drying, as in year 1, results in substantial losses of non-structural carbohydrates from respiration and fermentation. This draws attention to the importance of controlled oven drying in forage crop evaluation to obtain reliable data not only on dry matter production but also on composition and nutritive value.

Leaf:stem ratio

There were significant variations in leaf:stem ratio among cultivars and genetic groups (Table 2). The forage hybrids fell in the middle of the range, being more leafy than the sudangrasses but less leafy than the sweet sorghums ($P<0.01$). (Table 5).

The late maturing cultivar Magic had a higher leaf:stem ratio than all other cultivars ($P<0.01$).

Table 5. Effect of forage type on leaf:stem ratio in sorghum

Genetic group	Harvest 1	Harvest 2	Harvest 3	Mean
Sweet sorghums	2.2	1.2	1.2	1.5
Forage hybrids	1.6	0.8	0.8	1.1
Sudangrasses	0.8	0.4	0.4	0.5

Crude protein

Crude protein was much lower for regrowth than for initial growth ($P<0.01$). In year 2 the average for initial growth was 14.6% compared to 7.0% for the third harvest. Year 1 values averaged 2.4% lower than for year 2 ($P<0.01$) despite the heavier N application in the first year. The plants would appear to have been relatively more mature at harvest in year 1. Although the range in crude protein was less than three percentage units, there was a highly significant correlation between crude protein and leaf:stem ratio ($r=0.7$, $P<0.001$, $n=26$), the more leafy cultivars being higher in crude protein (Table 2).

Sodium and sulphur

Differences between cultivars in sodium and sulphur content were small and non-significant. The values were however typical of forage sorghum with sodium about 0.01% and sulphur between 0.123 and 0.137%. Stock receiving a diet consisting solely of any of these cultivars should be given a salt supplement (Wheeler and Hedges 1979).

Cyanide potential

Significant differences in HCNp were found among cultivars and species groups (Table 6). The sweet sorghum types were consistently higher in HCNp and averaged 745 ppm compared to a mean of 485 ppm for all other cultivars ($P<0.01$). Jumbo was the highest of the forage hybrids but lower than the other later maturing cultivars Honeydrip and Magic. The values for Piper were considerably higher than expected. Many reports in the literature rank Piper consistently lower than forage hybrids and generally below 250 ppm (Burger and Hittle 1967; Gray *et al.* 1981; Hedges *et al.* 1978; Rabas, *et al.* 1970), although higher concentrations were reported by Loyd and Gray (1970).

The values for HCNp reported in Table 6 are for sample leaves and not whole plants. Whole plant values are lower than young leaf values because of dilution with stem that is normally lower in HCNp. Nonetheless the leaf values were sufficiently high to suggest that none of the cultivars could be considered completely safe for livestock without suitable grazing management. Gray *et al.* (1968) suggest 600 ppm as the maximum safe level of HCNp. In theory maintenance of an adequate level of sulphur in the diet by provision of S supplements would reduce the risk of HCN poisoning but this has yet to be demonstrated in practice (Wheeler 1980).

Table 6. Effect of cultivar and harvest on leaf HCNp (ppm dry matter basis)

Cultivar	Year 1		Year 2		Mean
	Harvest 1	Harvest 3	Harvest 1	Harvest 3	
Speedfeed	397	680	315	186	395*a**
Piper	427	704	224	298	413*ab*
Lush	255	685	436	306	421*ab*
Zulu	362	697	362	285	427*ab*
Trudan	530	997	191	235	488*abc*
Cow Chow	455	730	422	362	492*abc*
Yates Forage	492	732	453	329	502*bc*
Sudax 6	560	740	392	643	584*cd*
Jumbo	810	880	462	433	646*de*
Sugardrip	560	1062	536	532	673*de*
Honeydrip	785	895	616	641	734*ef*
Magic	967	969	674	701	828*f*
Rising Fast	n.a.†	n.a.	329	280	n.a.
Mean	550	814	416	402	
LSD P=0.05	202	202	280	180	104

* Entries linked by a common letter are not significantly different at P=0.05.

† n.a.=not available.

In years 1 and 2 respectively, the overall HCNp means, excluding Rising Fast, were 682 and 409 ppm ($P<0.001$). The years×harvests interaction was also significant ($P<0.001$).

The significant increase in HCNp at the third harvest in year 1, 814 ppm compared to 550 ppm for the first harvest, was probably largely due to moisture stress noted at the third harvest (Benson *et al.* 1969). The higher N application of 140 kg/ha in year 1 compared to 60 kg/ha in year 2 was probably another factor contributing to the significantly higher HCNp in year 1 (Wheeler *et al.* 1980).

CONCLUSION

For grazing, the forage hybrids (*Sorghum bicolor*×*S. sudanense*) have two advantages over the sweet sorghum forages; they produce more DM regrowth and have a lower risk of HCN poisoning. These differences are less evident when the crops are used for standing winter feed or are cut at boot or early bloom stages for fodder conservation. DM production of the sweet sorghums increases when they are allowed to grow continuously (Muldoon 1985) and HCNp drops considerably as the plants approach maturity (Benson *et al.* 1969). Even so, stock losses from HCN poisoning after the ingestion of sorghum hay have occurred in recent drought years in both Queensland and NSW. Caution is especially required where cultivars of high HCNp are grown under conditions of moisture stress.

The later maturing cultivars Jumbo and Magic were the most leafy, but this was not reflected in any significant advantage in crude protein or digestibility and their dry matter yields were below most of the forage hybrids.

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