VARIATION IN YIELD, CANOPY STRUCTURE, CHEMICAL COMPOSITION AND *IN VITRO* DIGESTIBILITY WITHIN AND BETWEEN TWO *DESMODIUM* SPECIES AND INTERSPECIFIC HYBRIDS

T. H. STOBBS* AND B. C. IMRIE*

ABSTRACT

Variation in yield, canopy structure, chemical composition and in vitro *digestibility was assessed in two* Desmodium intortum *accessions (CPI* 18009 *and CPI* 17916), *two* Desmodium sandwicense *accessions (CPI* 40146 *and CPI* 19677) *and two* D. intortum × D. sandwicense *hybrids (CPI* 40146 × *CPI* 18009) *by sampling four 6-week regrowths in* 10 *cm layers.*

CPI 17916, *one of the components of the cultivar Greenleaf, was the highest yielding* (7600 *kg* ha^{-1} *compared with a mean yield of* 6800 *kg* ha^{-1}), *had the longest growing season, and had the highest leaf yield* (4670 *kg* ha^{-1}) *of the lines tested. Although mean sward and leaf densities of all lines were low, averaging* 52 *and* 32 *kg* ha^{-1} cm^{-1}, *CPI* 17916 *had the highest averaging* 61 *and* 38 *kg* ha^{-1} cm^{-1} *respectively.*

D. sandwicense *lines were generally lower than* D. intortum *in digestibility, nitrogen, phosphorus, calcium and potassium. These elements, except potassium, were also higher in leaf than stem and higher in the top than the base of the swards. Sodium content in all fractions in all lines was low (mean* 0.03%).

The performance of one hybrid line, 247, indicated that it is possible to combine the desirable features of D. intortum *and* D. sandwicense *in interspecific hybrids.*

INTRODUCTION

Whereas intake and digestibility of chaffed *Desmodium intortum* herbage fed to sheep in metabolism cages are high (Milford and Minson 1966; Thornton and Minson 1973), low milk yields have been obtained from cows grazing pure stands of this legume (Stobbs 1971) apparently due to a low intake of digestible energy. Recent experiments (Stobbs 1973) suggest that low intakes of digestible energy under grazing may be due to the inability of cows to harvest adequate quantities of feed from some trailing legumes because of sward structure. Since animals prefer to graze leaf from the uppermost layers of the sward (Stobbs 1973) variation in nutritive value from the top to the bottom of a sward can influence the nutritive value of the diet selected and thus animal production (Stobbs 1975). No data are available on leaf, stem and nutrient distribution within and between desmodium species so a cutting experiment was conducted to investigate variation in a set of lines selected as being representative of present and potential future cultivars. Two lines each of *D. intortum* and *D. sandwicense* and two selections from an interspecific hybrid between the species were chosen from material included in a breeding programme designed to incorporate early maturity and large seed size from *D. sandwicense* into the higher yielding *D. intortum* (Imrie 1973). Seasonal variation in morphology and nutritive value were measured by sampling sward components at intervals throughout the growing season.

*C.S.I.R.O., Division of Tropical Agronomy, Mill Road, St. Lucia, Qld. 4067.

MATERIALS AND METHODS

Site

The experiment was conducted on a hill slope site at the C.S.I.R.O., Pasture Research Station, Samford, south-east Queensland. The soil on the trial area is a solodized solonetz on granodiorite with a sandy loam A horizon 20-30 cm deep (pH 6.1) overlaying a mottled clay B horizon (Northcote classification DY3.42).

Materials

Two accessions each of *D. intortum* (CPI 17916 and CPI 18009) and *D. sandwicense* (CPI 19677 and CPI 40146), and two interspecific hybrids were grown. The hybrid lines were designated 208-2, an F_4 selection from CPI 40146 × CPI 18009, and 247, an F_5 selection from the same cross.

Cultural and sampling procedures

Two replicates of the six lines were grown in pure stand on an area which had received a preplanting application of 375 kg ha^{1-} of superphosphate. Seed was germinated in peat pellets and single row plots established in December 1971 with seedlings spaced at 0.5 m between plants and 2.5 m between rows. Pure stands developed by February 1972 with plot area maintained at 5 m × 2 m. Plots were cut during late summer and autumn 1972 and a clearing cut made in September 1972 prior to commencement of this experiment.

Two quadrats, each 0.5 m^2 in area, were cut at random from each plot every six weeks throughout the 1972-1973 growing season. Herbage was harvested in 10 cm thick layers, 5-15 cm, 15-25 cm, > 25 cm above ground level, using a hedge trimmer fitted with catcher attachment. Following quadrat sampling the remainder of the plots was cut back to 5 cm and the cut material removed.

Layer samples were separated into their leaf and stem fractions, inflorescence being included with stem. Inflorescences were present in the *D. sandwicense* lines from January onwards, in the hybrid lines in April, and not at all in the *D. intortum* lines. The small amounts of weed and dead material obtained were discarded before assessing yield which was estimated for samples of leaf and stem oven dried (70°C) to a constant weight. Twenty measurements of sward height were taken with a ruler to allow sward bulk density and leaf bulk density to be calculated (kg ha^{1-} cm^{-1}).

Measurement of nutritive value

Samples of leaf and stem from each layer were ground through a 1 mm aperture screen and analysed for dry matter digestibility using the *in vitro* technique standardised with whole plants and plucked leaf *D. intortum* samples of known *in vivo* digestibility (Minson and McLeod 1972). Nitrogen content was determined after Kjeldahl digestion and P, Ca, Na, K and Mg by atomic absorption.

RESULTS

Yield and sward structure

Cumulative dry matter yields from the four harvests, which constituted the whole grazing season, averaged 6827 kg ha^{1-} (Table 1). Variation within the species was as great as variation between species. The hybrid line 208-2 was the lowest yielding entry whereas the other hybrid, 247, was one of the highest yielders. All lines had highest yields at the first sampling (a mean of 37 per cent of annual yield) and lowest yields at the autumn sampling (a mean of 11 per cent of annual yield). Analysis by season showed that CPI 17916, 208-2 and 247 produced higher yields ($P < 0.05$) in the spring than CPI 18009 and the *D. sandwicense* lines, 208-2 was inferior to the other lines in subsequent samplings ($P < 0.05$) and CPI 18009 was also low yielding in autumn.

TABLE 1

Total yield of leaf and stem and mean leaf:stem ratio, sward and leaf bulk densities of four 6 week regrowth cuts of Desmodium species and hybrids.

Characteristic	*D. intortum*		*D. intortum* × *D. sandwicense*		*D. sandwicense*		Significance Level	L.S.D. $P = 0{\cdot}05$
	CPI 18009	CPI 17916	208–2	247	CPI 40146	CPI 19677		
Leaf yield (kg ha^{-1} D.M.)	4139	4668	3509	4249	3753	4244	*	508
Stem yield (kg ha^{-1} D.M.)	2510	2975	2201	3288	2513	2912	†	
Total yield (kg ha^{-1} D.M.)	6649	7643	5710	7537	6266	7156	*	762
Leaf : stem ratio	1·65	1·57	1·59	1·29	1·49	1·46	*	0·12
Mean leaf bulk density (kg ha^{-1} cm^{-1})	32·0	38·0	30·9	31·3	28·5	30·8	*	3·4
Mean sward bulk density (kg ha^{-1} cm^{-1})	50·7	61·1	50·1	55·5	47·8	51·3	n.s.	

n.s. = $P > 0{\cdot}05$ † = $P < 0{\cdot}10$ * = $P < 0{\cdot}05$

The proportion of leaf to stem varied from the top to bottom of the swards (Figure 1) and between samplings with a low leaf to stem ratio occurring in the third sampling period. The hybrid 247 consistently had a higher proportion of stem to leaf than the other lines but had a high leaf yield in the top layer which is most accessible to the grazing animal. The *D. intortum* accessions were characterised by high yields of leaf in the basal layer.

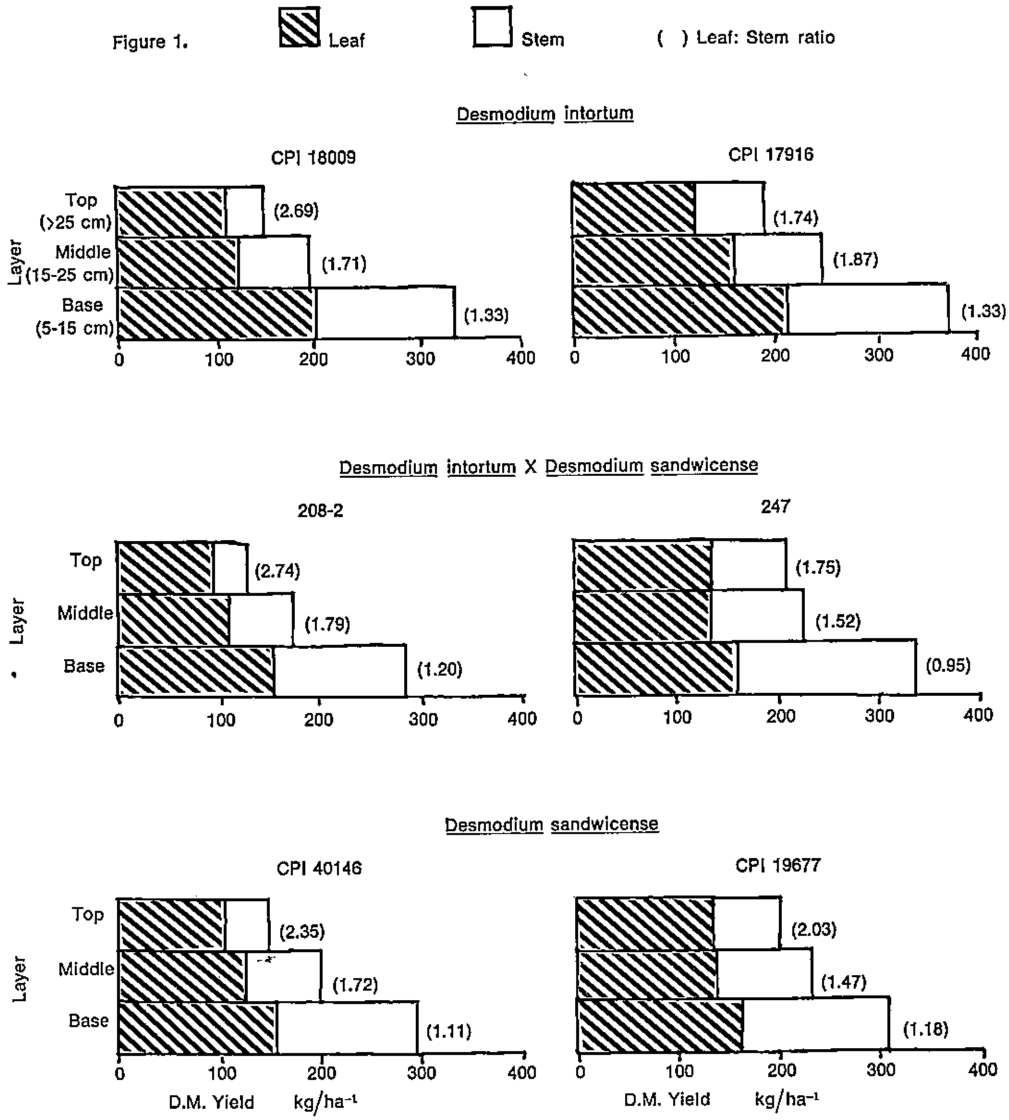

FIGURE 1

Mean cumulative dry matter yields of leaf and stem together with leaf to stem ratios in each strata within the swards of 6 week regrowths of *Desmodium* lines.

Overall bulk densities were low averaging 31.8 kg ha^{-1} cm^{-1} and 52.4 kg ha^{-1} cm^{-1} for leaf and sward bulk densities respectively. CPI 17916 had the highest bulk density and leaf bulk density ($P < 0.05$ Table 1). Herbage in the base of the sward was the most tightly packed (72.1 kg ha^{-1} cm^{-1}) compared with the middle (45.8 kg ha^{-1} cm^{-1}) and the top (38.7 kg ha^{-1} cm^{-1}) of the swards.

Digestibility

Mean digestibility of the desmodiums varied ($P < 0.01$) with the *D. sandwicense* accessions being lower, particularly after they had commenced flowering in January (Table 2). Mean digestibility of herbage was highest in the top of the sward (58.2%) and lowest in the bottom (54.0%) (Table 2). Stem digestibility was higher than leaf digestibility (Table 3), this difference being significant in all but the November harvest. When plants suffered drought stress in February, differences in digestibility between stem and leaf were greatest ($P < 0.001$).

TABLE 2

Seasonal variation in in vitro *digestibility of six week regrowths of Desmodium species and hybrids together with variation in the base, middle and top of the swards*

Line	Sampling date			
	Nov. 1972	Jan. 1973	Feb. 1973	Apr. 1973
CPI 18009	60·2	56·5	50·1	54·7
CPI 17916	63·5	60·1	51·7	58·2
hybrid 208–2	61·5	59·0	49·4	53·0
hybrid 247	63·5	58·7	51·0	55·6
CPI 40146	63·5	55·6	47·1	53·6
CPI 19677	63·3	55·8	47·0	52·9
All lines	62·6	57·6	49·4	54·7
L.S.D. (P = 0·05)	2·4	2·7	2·6	N.S.
Top (>25 cm)	66·5	60·1	50·7	58·8
Middle (15·25 cm)	61·6	57·3	48·9	54·8
Base (5–15 cm)	59·6	55·3	48·5	52·9
L.S.D. (P = 0·05)	2·3	2·0	1·8	2·2

TABLE 3

Variation in in vitro *digestibility between leaf and stem fractions of Desmodium species and hybrids*

Line	Mean over four harvests			Weighted mean* over four harvests		
	leaf	stem	mean	leaf	stem	mean
CPI 18009	54·2	56·6	55·4	54·4	58·1	55·8
CPI 17916	57·6	59·2	58·4	58·9	59·4	59·0
hybrid 208–2	53·7	57·7	55·7	54·7	58·8	56·3
hybrid 247	57·0	57·5	57·2	58·6	58·0	58·3
CPI 40146	52·7	57·3	55·0	53·9	58·0	56·6
CPI 19677	52·8	56·7	54·8	54·1	56·0	54·9
LSD (P = 0·05)			2·5			2·6

*Weighted for variation in dry matter yield between harvests.

Nitrogen and mineral content

Nitrogen and mineral data pertaining to differences between lines between leaf and stem, and between sward strata are presented in Table 4. The *D. sandwicense* accessions had lower nitrogen, phosphorus and potassium contents than *D. intortum*

TABLE 4

Mean nitrogen and mineral content of 6 week regrowths of Desmodium species and hybrids together with leaf and stem composition and contents in base, middle and top of the swards.

	N	P	Ca	Na	K	Mg
			(% dm)			
D. intortum						
CPI 18009	3·04	0·31	0·86	0·03	2·18	0·29
CPI 17916	3·04	0·31	0·91	0·04	1·81	0·34
D. intortum × *D. sandwicense*						
208–2	3·14	0·30	0·91	0·03	1·58	0·31
247	2·80	0·28	0·95	0·03	1·69	0·27
D. sandwicense						
CPI 40146	2·87	0·27	0·83	0·04	1·58	0·32
CPI 19677	2·68	0·26	0·82	0·02	1·56	0·34
Significance level†	**	**	*	n.s.	**	n.s.
L.S.D. (P = 0·05)	0·14	0·03	0·08		0·21	
Leaf	3·81	0·32	1·09	0·03	1·56	0·32
Stem	1·91	0·26	0·71	0·04	1·97	0·29
Significance level†	***	***	***	n.s.	***	**
L.S.D. (P = 0·05)	0·17	0·02	0·07		0·19	0·02
Base††	2·68	0·24	0·96	0·03	1·92	0·32
Middle	2·96	0·28	0·94	0·04	1·73	0·31
Top	3·06	0·34	0·87	0·03	1·58	0·30
Significance level†	***	***	n.s.	n.s.	**	n.s.
L.S.D. (P = 0·05)	0·11	0·02			0·23	

† n.s. = non significant * = P < 0·05 ** = P < 0·01 *** P < 0·001
†† Base = 5–15 cm Middle = 15–25 cm Top = over 25 cm

accessions with the hybrids generally intermediate. Potassium content showed a progressive decline throughout the season, while sodium content of all herbage fractions of all lines was low.

DISCUSSION

Protein and mineral content of *D. intortum*, with the possible exception of sodium, were high and the low milk production reported for cows grazing this species (Stobbs 1971) was therefore most likely to be caused by a low feed intake associated with low bulk density, particularly in the top layer of the sward, or the low sodium content. Quality of *D. intortum* herbage was maintained throughout the year but in *D. sandwicense* yield and quality declined following the commencement of flowering in mid-summer. The hybrids were intermediate, being more like *D. intortum* in some characters and more like *D. sandwicense* in others.

Although data are presented for only one season, the yields reported are similar to those obtained by Jones (1973) and Imrie (unpublished data). Yields were low compared with tropical grass swards, probably due to their lower net photosynthesis rate compared with grasses (Wilson and Ludlow 1970). Throughout the growing season of about seven months the highest yielding lines, CPI 17916 and hybrid 247, averaged approximately 35 kg ha^{-1} day^{-1}. The poor performance of CPI 18009, which together with CPI 17916 was a component of cv. Greenleaf, was mainly due to the low yield recorded at the autumn (April) sampling. This accession was probably derived from a population in which there had been some introgression of *D. sandwicense* genes. The two *D. sandwicense* accessions and the hybrid 208-2 commenced flowering in mid-summer which resulted in lower forage production in the latter half of the season.

Grazing animals prefer the leaf component of the sward, mainly from the upper layers with increased quantities of stem only being eaten as the amount of feed on offer diminishes (Stobbs 1975). Leaf bulk densities averaged only 32 kg ha^{-1} cm^{-1}

compared with a range of 47-104 kg ha^{-1} cm^{-1} for white clover (*Trifolium repens*) swards (Stobbs, unpublished data). Therefore only a small quantity of leaf can be harvested with each sweep of the animals tongue when grazing these legume swards. CPI 17916 had the highest leaf bulk density but much of the leaf was in the less accessible lower strata of the sward. Hybrid 247 had the lowest leaf/stem ratio but leaf yield and leaf bulk density in the top of the sward were relatively high.

Care should be exercised when considering the practical significance of predicting digestibility (McLeod and Minson 1976) particularly since animal production from *D. intortum* (cv. Greenleaf) has been higher than that from other tropical legumes of apparently higher digestibility when grown in pure stands (Stobbs 1971) or in grass-legume mixtures (Jones 1974). It is possible that the tannins in desmodium affect the *in vitro* digestion process but no relationship could be established between the tannin content of a range of *D. intortum* and *D. sandwicense* lines and *in vitro* digestibility (Imrie, unpublished data). Differences in digestibility between species and seasons are likely to represent real differences.

The lower nitrogen and phosphorus content of the two *D. sandwicense* accessions and hybrid line 247 could partly be explained by the lower leaf to stem ratio at the last three samplings. Mineral composition suggests that the pastures received adequate nutrition (Andrew and Robins 1969a, 1969b) and levels, even in the base of the sward, are adequate for both liveweight gain and milk production, except for a low sodium content (a mean of 0.03%). This low sodium content is common to a number of tropical legume species (Minson 1976). The large variation in nitrogen and mineral composition between leaf and stem and between layers emphasises the potential for animal selection.

It is concluded that there is variation in desmodium for characters likely to influence intake, and the nutritive value of ingested forage, both of which could affect milk yield. Accession CPI 17916, typical of *D. intortum*, is superior to *D. sandwicense* in yield, leafiness, and forage quality, while the hybrids combined attributes from both species. Line 247, which had been selected for the earliness and large seeded characters of *D. sandwicense* had the yield and digestibility of CPI 17916 by a higher proportion of its leaf in the more accessible upper layer of the pasture than CPI 17916.

ACKNOWLEDGEMENTS

The authors wish to thank Messrs. C. A. Ross, B. R. Smith and J. J. Barrett for field assistance, Mr. M. N. McLeod for *in vitro* digestibility analyses, and Mr. A. D. Johnson for chemical analyses.

REFERENCES

ANDREW, C. S., and ROBINS, M. F. (1969a)—Effect of phosphorus on the growth and chemical composition of some tropical pasture legumes. I. Growth and critical percentages of phosphorus. *Australian Journal of Agricultural Research* **20**: 665-74.

ANDREW, C. S., and ROBINS, M. F. (1969b)—Effect of phosphorus on the growth and chemical composition of some tropical pasture legumes. II. Nitrogen, calcium, magnesium, potassium, and sodium contents. *Australian Journal of Agricultural Research* **20**: 675-85.

IMRIE, B. C. (1973)—Variation in *Desmodium intortum:* A preliminary study. *Tropical Grasslands* **7**: 305-11.

JONES, R. J. (1973)—The effect of frequency and severity of cutting on yield and persistence of *Desmodium intortum* cv. Greenleaf in a subtropical environment. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13**: 171-7.

JONES, R. J. (1974)—The relation of animal and pasture production to stocking rate on legume based and nitrogen fertilized sub-tropical pastures. *Proceedings of the Australian Society of Animal Production* **10**: 340-4.

McLeod, M. N., and Minson, D. J. (1976)—The analytical and biological accuracy of estimating the dry matter digestibility of different legume species. *Animal Feed Science and Technology* **1**: 61-72.

Milford, R., and Minson, D. J. (1966)—Proceedings of Ninth International Grass land Congress, Sao Paulo, 1964, p. 815.

Minson, D. J. (1976)—The chemical composition and nutritive value of tropical legumes. *In* "Handbook of Tropical Forage Legumes", Ed. P. Skerman F.A.O. (in press).

Minson, D. J., and McLeod, M. N. (1972)—The *in vitro* technique. Its modification for estimating digestibility of large numbers of tropical pasture samples. Division of Tropical Pastures Technical Paper No. 8, C.S.I.R.O. Australia.

Stobbs, T. H. (1971)—Production and composition of milk from cows grazing Siratro (*Phaseolus atropurpureus*) and Greenleaf Desmodium (*Desmodium intortum*). *Australian Journal of Experimental Agriculture and Animal Husbandry* **11**: 268-73.

Stobbs, T. H. (1973)—The effect of plant structure on the intake of tropical pastures. I. Variation in the bite size of grazing cattle. *Australian Journal of Agricultural Research* **24**: 809-19.

Stobbs, T. H. (1975)—Factors influencing the nutritional value of grazed tropical pastures for beef and milk production. *Tropical Grasslands* **9**: 141-50.

Thornton, R. F., and Minson, D. J. (1973)—The relationship between apparent retention time in the rumen, voluntary intake, and apparent digestibility of legume and grass diets in sheep. *Australian Journal of Agricultural Research* **24**: 889-98.

Wilson, G. L., and Ludlow, M. M. (1970)—Net photosynthesis rates of tropical grass and legume leaves. Proceedings of Eleventh International Grassland Congress. Surfers Paradise, p. 534.

[accepted for publication July 21, 1976