

Stimulation of wool growth by *Desmanthus* spp. as a supplement to a diet of Mitchell grass hay

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Abstract

Desmanthus spp. have been released for the more favoured environments of southern Queensland and offer the possibility of fulfilling the role of *Stylosanthes* in the semi-arid clay soil Mitchell grass bioregion of western Queensland. An experiment was carried out to evaluate the potential of *Desmanthus* spp. to enhance liveweight gains and wool production of sheep grazing Mitchell grass. Thirty-six Merino wethers in individual metabolism cages were fed a basal diet of 600 g/hd/d of Mitchell grass plus mineral, alone or supplemented with 200 g hay of one of 4 *Desmanthus* spp. accessions, or *Stylosanthes hamata* cv. Verano. The basal diet supplied 7.96 g/d N and the supplemented diets 8.73–12.43 g/d N, and N retention was 5.16 g/d on the basal diet and 4.82–7.29 g/d on the supplemented diets. All sheep lost weight during the study, with greater losses ($P < 0.05$) on the control diet. Wool growth varied from 0.53 mg/cm²/d for the Control to 0.71 mg/cm²/d for the diet containing *D. virgatus* CPI 78382. Verano stylo and the *Desmanthus* accessions had similar beneficial effects on wool growth. These results associated with the agronomic adaptation of *Desmanthus* genotypes to the Mitchell grass bioregion suggest that these legumes have potential to improve wool growth in that area.

Introduction

Major improvements in productivity in tropical areas of Australia have been achieved by the introduction of forage legumes, the most successful belonging to the genus *Stylosanthes*, which was introduced from South America and successfully adapted to a range of soils and climates across much of northern Australia. However, the main cultivars of *Stylosanthes* in use (cvv. Verano and Seca) do not thrive well on heavy clay soils (Burt 1993), and there are currently no introduced pasture legumes for the approximately 28 M ha of the semi-arid Mitchell grass (*Astrebla* spp.) bioregion of western Queensland. Despite the reasonable nutritional value of Mitchell grass (4–5% CP, 48% DMD and 6.1 MJ/kg DM of ME) reported by Silcock and Hall (2007), sheep performance on these pastures is boosted in years when the rainfall pattern promotes additional forbs growth between grass tussocks (Phelps 1999). While native legumes exist in these pastures and contribute to the diets of sheep (Lorimer 1978, 1981; McMeniman *et al.* 1986), Hacker (1990) describes many of them as being unpalatable, toxic or of little grazing significance. Quirk (2000) states that native legumes contribute relatively little N to the soil and Orr (personal communication) found that, where grazing utilisation is >10%, native herbaceous legumes are a minor component of the available pasture.

Members of the *Desmanthus* genus have persisted for decades in the Mitchell grass bioregion, and appear to be well adapted to conditions there (Gardiner 1999; Gardiner *et al.* 2004; Johnson 2008). A production of 5–7 tonnes of *Desmanthus* seeds has been targeted by Progressive Seed Pty Ltd for 2008, based on definite interest in this legume from graziers in Queensland (M. Aitchinson, personal communication). The agronomic potential of *Desmanthus*, in terms of soil and climatic adaptation, biomass

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yield and forage quality, has been studied in Australia and elsewhere (Gardiner and Rangel 1996; Pengelly and Conway 2000; Gardiner *et al.* 2004; Ocumpaugh *et al.* 2004; Cook *et al.* 2005; Silva 2008). However, there is a lack of information relating to the nutritional value of *Desmanthus* and its influence on animal performance. Furthermore, some *Desmanthus* genotypes have been shown to contain high concentrations of sulphur (Schlink and Burt 1995), which, when present in amino acids, plays an important role in wool growth (Weston and Hogan 1986).

The present work reports the potential of 4 *Desmanthus* accessions as supplements to a diet of Mitchell grass (*Astrelba* spp.) hay, in comparison with Verano stylo, for stimulating wool growth of Merino wethers.

Materials and methods

Site

The experiment was carried out at the CSIRO Lansdown Research Station, 50 km south of Townsville, Queensland, Australia.

Treatments

Thirty-six Merino wethers (average liveweight 34.0 kg, SD 1.82 kg) were individually housed in metabolism cages and offered daily 800 g (3% of average metabolic body weight) of Verano (*Stylosanthes hamata* cv. Verano) chaff as an exclusive diet, for a 3-week pre-treatment period (July 24–August 14, 1991). On August 15, the animals were allocated to 6 groups according to live weight, following the protocol of Weston and Hogan (1986) and offered 1 of 6 diets:

- 600 g/hd/d of Mitchell grass (MG) chaff — Control;
- 600 g MG + 200 g/hd/d of Verano chaff;
- 600 g MG + 200 g/hd/d of *Desmanthus leptophyllus* CPI 38351 chaff;
- 600 g MG + 200 g/hd/d of *D. pubescens* CPI 92803 cv. Uman chaff;
- 600 g MG + 200 g/hd/d of *D. virgatus* CPI 78382 chaff;
- 600 g MG + 200 g/hd/d of *D. virgatus* CPI 79653 chaff.

Hays of Mitchell grass and Verano had been stored for 5 years and those of the *Desmanthus* spp. for 2 years.

Experimental management

The hays were passed through a chaff-cutter (particles 10 mm long) and thoroughly mixed before being offered to the animals. Excluding the pre-experimental period, the experiment was carried out over a 6-week period (August 15–September 25, 1991). All sheep were provided with 26 g/d of a mineral supplement to provide essential minerals: phosphorus, calcium, sodium, magnesium, iron, zinc, copper, manganese, cobalt, molybdenum, sulphur and iodate (Weston and Hogan 1968). Water was available *ad libitum*. Individual food residues were collected daily and bulked per sheep for the whole period to be used in the calculation of daily dry matter intake. Faeces were collected daily during a 10-day period (September 16–25, 1991) and subsamples stored in a freezer for subsequent analyses. Sheep were weighed at the beginning (August 15, 1991) and end of the experiment (September 25, 1991).

Measurements

Analyses for neutral detergent fibre, acid detergent fibre (van Soest and Moore 1966) and Kjeldahl nitrogen (AOAC 1970) were performed on the dietary components, bulked food residues and bulked faeces. Food residues and faeces were dried for 48 h at 105°C to determine dry matter concentration. Metabolisable energy intake was calculated as dry matter intake \times $(0.147 \times \textit{in vivo}$ dry matter digestibility % $- 0.72)$ (MAFF 1975). The sulphur concentration (S) in the hays was determined by a semi-quantitative x-ray diffraction in the Geology Department of James Cook University. *In vivo* digestion of dry matter, organic matter and nitrogen (MAFF 1975) was determined in the last 10 days of the experimental period.

On August 15, 1991, sheep were completely shorn and wool discarded. Wool growth during the feeding period was determined by clipping delineated mid-side patches of 15 cm \times 10 cm (150 cm²) on August 29 and September 25, 1991. Clean wool yield (mg/100 cm²/d), wool yield %

(percentage of clean wool in relation to greasy wool) and fibre diameter (microns) were determined by CSIRO Division of Animal Production, Wembley, Western Australia.

Statistical analysis

Data were analysed using the General ANOVA System of the STATISTIX (1994) Analytical Software, Version 4.1. Means were compared by the Tukey test at the 5% level. Correlation analyses were calculated between wool growth and various dietary parameters.

Results

Composition of dietary components

Analyses of the dietary components used in the experiment are presented in Table 1. Dry matter concentrations were similar for all components, except *D. virgatus* CPI 78382, which contained higher moisture levels than other hays. *S. hamata* cv. Verano and *D. virgatus* CPI 79653 had the

lowest values for neutral detergent fibre and acid detergent fibre, and the highest nitrogen concentrations, while the hay of *D. virgatus* CPI 79653 had the highest S concentration. The N:S ratios varied from 6:1 in Mitchell grass to 12:1 in Verano (Table 1).

Liveweight change, intake and digestion

Sheep on all treatments lost weight during the study, with significantly higher losses ($P<0.05$) on the Control diet (Mitchell grass alone) than on the mixed diets (Table 2). Dry matter intake on the mixed diets exceeded that on the Control diet, but differences reached significance ($P<0.05$) only for the diet containing *D. virgatus* CPI 79653. Residues were always less than 10% of the feed offered and were as low as 4% for the diet containing *D. virgatus* CPI 79653. Differences in digestibility of the various diets were small, but the diet containing *D. pubescens* CPI 92803 showed the lowest values. Metabolisable energy intakes of the mixed diets were higher than that of the Control diet but differences were significant only for the diets containing Verano and

Table 1. Dry matter and chemical composition of the dietary components used in the wool growth study.

Parameter	Diet component					
	Mitchell grass	Verano	CPI 38351	CPI 92803	CPI 78382	CPI 79653
Dry matter (%)	94.3	92.9	93.6	92.4	82.3	92.5
Organic matter (% DM)	90.7	93.9	95.4	96.7	94.7	92.8
Neutral detergent fibre (%)	79.3	66.2	69.1	76.5	71.3	58.5
Acid detergent fibre (%)	47.6	44.5	50.2	55.9	53.9	43.8
Nitrogen (%)	0.50	1.60	1.58	0.92	1.42	2.64
Sulphur (%)	0.08	0.13	0.22	0.11	0.18	0.36
N:S ratio	6:1	12:1	7:1	8:1	8:1	7:1

Table 2. Digestibility and intakes of Control (Mitchell grass hay) and supplemented (Mitchell grass + individual legumes) diets and liveweight change of Merino wethers in the feeding trial.

Parameter	Diet component					
	Control	Verano	CPI 38351	CPI 92803	CPI 78382	CPI 79653
Liveweight change (kg/hd)	-5.83 b ²	-1.15 a	-1.53 a	-2.33 a	-1.33 a	-2.28 a
Total dry matter intake (g/kg BW ¹ /d)	19.91 b	22.82 ab	23.00 ab	22.82 ab	23.01 ab	24.66 a
Dry matter digestibility (%)	42.5 bc	46.5 a	43.8 abc	39.8 c	42.2 bc	44.9 ab
Organic matter digestibility (%)	49.1 a	51.4 a	48.4 ab	45.3 b	48.6 ab	48.3 ab
Neutral detergent fibre (%)	55.3 a	55.0 a	51.2 ab	48.7 b	52.8 ab	51.6 ab
Acid detergent fibre (%)	52.7 a	50.3 a	45.0 b	43.4 b	48.2 ab	43.8 b
Metabolisable energy intake (kJ/kg BW/d)	109.8 c	139.5 ab	131.3 abc	117.2 bc	126.7 abc	144.9 a
Total nitrogen intake (g/d)	7.58 d	9.39 bc	10.17 b	8.73 c	10.19 b	12.43 a
N digestibility (%)	68.1 a	61.9 ab	62.2 ab	55.2 bc	53.9 c	58.7 bc

¹ Body weight.

² Means within rows followed by the same letter are not significantly different according to the Tukey test ($P>0.05$).

CPI 79653. Nitrogen intake on the mixed diets exceeded ($P < 0.05$) that on the Control. However, digestibility of N tended to be higher on the Control than on the mixed diets.

Wool growth

In both periods of wool growth, clean wool production on the mixed diets exceeded that of the Control but differences were not always significant (Table 3). A similar situation existed for wool yield percentage in Period 1, but the Control produced a higher wool yield than the mixed diets in Period 2. The mixed diets produced higher fibre diameters than the Control throughout but differences were not always significant.

While a number of dietary factors were significantly correlated with wool growth in Period 2, the strongest correlation between wool growth and any dietary factor was with organic matter intake ($r^2 = 0.92$).

Table 4. Correlation coefficients between clean wool production and nutritional parameters in the second period of wool growth.

Nutritional parameter	Correlation with clean wool production (r^2)
Organic matter intake	0.95
Dry matter intake	0.88
Nitrogen intake	0.72
Digested dry matter	0.67
Metabolisable energy intake	0.66
Sulphur intake	0.61

Discussion

This study has demonstrated the potential benefit of providing a legume supplement to sheep fed a diet of Mitchell grass hay, as manifested in higher feed intake, reduced weight loss and higher wool growth. Hay intakes were always above 90% of that on offer, rising to 96% for the *D. virgatus* CPI 79653-supplemented diet. Since poorly chopped, thick stems were present in the residues of all but the *D. virgatus* CPI 79653 and CPI 78382-supplemented groups, intakes obtained may not have reflected appetite on the various diets, *i.e.*, the true voluntary intakes under a regime where food was more readily available. Since the supplemented groups were offered 800 g/d and the Controls only 600 g/d, intake of the Control group might have also increased with higher feed on offer.

The lower DM concentration in *D. virgatus* CPI 78382 hay might have resulted from a shorter period between cutting and baling during the hay-making process. Lower levels of neutral detergent fibre and acid detergent fibre found in *D. virgatus* CPI 79653 and Verano hays in relation to that of the other legumes probably reflects their fine stems and a higher leaf:stem ratio compared with the woody characteristics of the *D. leptophyllus* CPI 38351 and *D. pubescens* CPI 92803 hays. We have no explanation for the high levels of neutral detergent fibre and acid detergent fibre in *D. virgatus* CPI 78382 that also has fine stems.

A dietary nitrogen concentration of approximately 10 g/kg DM was indicated by McMeniman *et al.* (1986) as necessary for maintaining rumen microbial activity. Nitrogen concentration in the Mitchell grass control diet fell far below this

Table 3. Wool growth and quality from sheep fed Control (Mitchell grass hay) and supplemented (Mitchell grass + individual legumes) diets.

Parameter	Diet component						LSD ($P < 0.05$)
	Control	Verano	CPI 38351	CPI 92803	CPI 78382	CPI 79653	
<i>First growth period</i>							
Clean wool (mg/100 cm ² /d)	42.02 d ¹	56.51 ab	55.25 abc	62.56 a	51.20 bcd	45.91 cd	10.24
Wool yield (%)	59.2 c	67.9 b	67.9 b	77.4 a	67.5 b	64.6 bc	8.02
Fibre diameter (microns)	18.9 a	20.4 a	19.8 a	19.1 a	19.8 a	20.5 a	2.53
<i>Second growth period</i>							
Clean wool (mg/100 cm ² /d)	53.57 b	66.67 a	63.24 ab	66.76 a	71.37 a	70.01 a	12.82
Wool yield (%)	79.1 a	69.8 b	72.2 b	72.1 b	72.6 b	70.0 b	6.51
Fibre diameter (microns)	18.1 c	20.1 ab	18.9 bc	18.2c	19.2 abc	20.7 a	1.67
<i>Clean wool over the total period (mg/100 cm²/d)</i>	47.92 b	61.50 a	59.50 a	64.83 a	57.00 b	57.75 ab	1.67

¹ Means within rows followed by the same letter are not significantly different by the Tukey test ($P > 0.05$).

level. Since there was a wide range in N concentration in the legumes (0.92–2.64%), some could be much more suitable than others for supplying supplementary N to low quality Mitchell grass diets. These N levels are similar to those reported by Little *et al.* (1984) for mature Verano herbage and by Gardiner and Rangel (1996) for the same *Desmanthus* genotypes. Gardiner and Rangel (1996) also found similar high N concentrations in leaves and stems of *D. virgatus* CPI 79653.

The lack of a significant correlation between wool growth and the various dietary parameters in Period 1 may reflect residual effects from the pre-experimental period, where all animals were fed 800 g/d of Verano hay. The positive relationships between wool growth and nutritional parameters in Period 2 were expected as positive relationships between dry matter and nitrogen intakes and wool production are frequently reported in the literature (Cronje and Weites 1990; Coombe 1992; Lee and Williams 1993).

The higher sulphur concentrations in the *Desmanthus* hays than in Verano support the findings of Schlink and Burt (1995), who found higher sulphur concentrations in seeds of 6 *Desmanthus* genotypes than in 5 other forage legumes. Adequate concentrations of sulphur-containing amino acids in the diet are essential for high levels of wool production (Reis 1967; Weston and Hogan 1986; Weston *et al.* 1988; Hume and Bird 1997). Wool growth of sheep receiving a maintenance diet of wheaten straw was increased by 86% through the addition of 10 g of a mixture of essential amino acids containing 3 g methionine or 1 g methionine and 2 g cysteine (Reis *et al.* 1990). Fenn and Leng (1989) increased wool growth by 16% by supplementing a roughage-based diet with methionine via drinking water. A N:S ratio of 10:1 in the diet was suggested by Morrison *et al.* (1986) as being adequate to maintain a vigorous microbial population in the rumen. Nitrogen:sulphur ratios observed in the present study for individual components of the diets revealed a sulphur deficiency in Verano hay, while sulphur concentrations in *Desmanthus* genotypes were adequate to support an ideal microbial population. The mixtures of legumes and Mitchell grass hay in the supplemented diets produced N:S ratios that were all very close to the recommended ratio of 10:1. Since animals on all diets received a mineral mixture containing sulphur, responses to sulphur provided by the legumes would not have been expected.

The use of engineered plants to produce proteins high in sulphur and resistant to rumen degradation has been proposed by Higgins *et al.* (1989) as a means of improving wool growth in sheep. Adapted sown pasture legumes with naturally high levels of protein and rich in sulphur-containing amino acids should be a more economical approach. The levels of nitrogen and sulphur present in some *Desmanthus* spp. used in the present study (especially *D. virgatus* CPI 79653 with 2.64% N and 0.36% S) suggest that they might fill this role. More detailed studies where legumes are fed in the absence of mineral supplementation, especially in relation to specific amino acids present, and the proportion of proteins and protein degradability in such fodder, seem warranted.

The wool growth response to legume supplementation in this study always exceeded 19% over the total experimental period with the largest response being 35%. These results associated with the agronomic adaptation of *Desmanthus* genotypes to semi-arid clay soils (Clem and Hall 1994; Johnson 2008) and specifically those in the Mitchell grass bioregion of north and western Queensland (Gardiner 1999, 2003; Gardiner *et al.* 2004) represent an option for improving wool production in those regions. In addition, these legumes have the potential to enhance other forms of livestock production in these areas where currently no adapted sown pasture legumes are available. Their contribution to sustainability of these grasslands would emerge over time.

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