Low-input, high-quality legume hays for north Queensland.

Kendrick Cox[1], Mark Keating[1], Steven Dayes[1] and Chris Gardiner[2]

[1] DEEDI, PO Box 1054, Mareeba, Q4880. www.deedi.qld.gov.au Email kendrick.cox@deedi.qld.gov.au
[2] James Cook University, JCU, School of Veterinary and Biomedical Sciences, Townsville Qld 4811 Email christopher.gardiner@jcu.edu.au

Abstract

Perennial herbaceous legumes grown for hay can improve beef and dairy production in north Queensland through providing affordable high-quality (digestible protein) dry-season feed. Eleven *Arachis* ecotypes [*A. pintoi* (5), *A. glabrata* (3), *A. paraguariensis* (2) and *A. kretschmeri* (1)], two *Stylosanthes guianensis* varieties and two commercial *Medicago sativa* varieties were grown for hay under irrigation using standardised populations in replicated small-plots over two wet seasons (summer) and compared for dry-matter production and fodder quality using 8-week cutting cycles. *Medicago sativa* plants were damaged by leaf and stem diseases during wet summer periods reducing leaf and stem growth and resulting in open, weedy stands; the *Arachis* and *Stylosanthes* were relatively unaffected and exhibited strong summer-dominant growth throughout the study. There were significant species and varietal differences in biomass production and some *A. pintoi*, *M. sativa* and *S. guianensis* produced over 30 t DM/ha (above ground biomass) over a 19 month period. *Arachis glabrata* also yielded well (16-18 t DM/ha) following a prolonged establishment phase. Feed quality was high for all legumes, and overall best in the *Arachis* spp., with crude protein percentages mostly above 16% and high levels of protein and carbohydrate rumen degradability.

Key words

Hay, lucerne, stylo, peanut, north Queensland

Introduction

Dairy and beef-finishing industries on the Atherton Tablelands, north Queensland, require year-round supply of affordable high-quality (digestible protein and carbohydrates) feed to achieve meat and milk production at levels suitable for maintaining profitable enterprises. Most enterprises rely on pastures based on tropical grasses (*Brachiaria*, *Panicum*, *Setaria*) and legumes (*Arachis, Centrosema*, *Neonotonia*, *Desmodium* and *Vigna*). However, poor winter growth of these pastures results in a seasonal feed shortage, which is variously overcome through the use of expensive supplements or short-term irrigated temperate grass pastures. Perennial herbaceous legumes grown for hay could provide an affordable alternative.

Lucerne (*Medicago sativa*) has long been a highly productive legume hay in the sub-tropics (Cook et al. 2005; Lowe et al. 1988), but (anecdotal) producer experience suggested lucerne poorly tolerates the wet summer climate and acidic clay soils of the Atherton Tablelands. Some promising alternative legumes, including recently released legumes, had not been evaluated for hay production in the local area. These included two *Colletotrichum*-resistant *Stylosanthes guianensis* varieties and a range of *Arachis* spp., particularly within *A. pintoi* and *A. glabrata*. The *S. guianensis* have an erect and open growth habit similar to lucerne, whereas *A. pintoi* and *A. glabrata* form a dense canopy and spread through stolons or rhizomes. Other *Arachis* species with erect growth habits were also considered to have potential for hay production. All have excellent feed quality for ruminants; 12-25% crude protein content and dry matter digestibility of 50-73% (Cook et al. 2005).

Here, we report the results of a pilot experiment in which we sought to compare hay production of the promising legumes with lucerne varieties sold in north Queensland.

Methods

The experiment was conducted at the Queensland Government research station at Walkamin (17.14°S, 145.43°E; 630 m asl) on the Atherton Tablelands in north Queensland. The area had an upland tropical environment with annual summer-dominant rainfall of 1019 mm. The soil was a deep, free-draining krasnozem with a site slope <5°. The previous crop was grass seed (*Setaria surgens*). Soil tests conducted immediately before cultivation revealed a near-neutral reaction (pH_{water}=6.7) and P, S, K, Mg levels optimum for legume production. The site was prepared using cycles of cultivation, rolling and controlling emerging weeds with glyphosate. Single superphosphate (200 kg/ha) and muriate of potash (100 kg/ha) were incorporated into soil during the final cultivation on 22 September 2009.

Plants of all but the *A. glabrata* types (Table 1) were established from seeds or cuttings and raised in a shade house. Appropriate *Rhizobium* inoculant was watered onto the seedlings. The *A. glabrata* lines were sourced from nearby plots. The plants were planted in 1.2 x 4.5 m plots in two replicates on 25 September 2009, either as seedlings or 25 cm lengths of rhizome (*A. glabrata*). There were 60 plants/plot arranged in four rows using 30 x 30 cm spacings. Weeds were controlled using herbicides at label rates (bentazone, sethoxydim and fluazifop-P) and hand-weeding. Irrigation was applied using overhead sprinklers to supplement rainfall (~25 mm/wk if no rainfall), particularly during May-November.

Two regrowth experiments were completed sequentially on the same plots: *Experiment 1* – plots were cut immediately after every herbage sampling, at 8-9 week intervals, between 25 March 2010 and 14 September 2011; *Experiment 2* – plots were sampled three times between 9 November 2011 and 31 January 2012 without cutting the plots. Cutting was completed with a side-arm mower set to 5 cm above ground level and the cut material was removed.

Plant ground cover and biomass were measured immediately before sampling herbage. Two randomly placed 0.5 m^2 quadrats per plot were used for all measurements. Visual estimates of percentage ground cover were completed before cutting to 5 cm height, weighing wet samples and drying at 70°C for 48 hours (until constant weight) before reweighing. The samples were ground (1 mm screen) and submitted to Dairy One™, United States, for plant nutrient analysis suitable for ruminants. Dairy One™ NIR calibration curves for lucerne, ‘legume’ (*Stylosanthes*) and peanut hay (*Arachis*) were used. Selected duplicate samples were analysed using wet chemistry to check NIR results. Daily temperature, rainfall, sunshine hours and pan evaporation data were collected at the Bureau of Meteorology weather station located 200 m from the experimental site.

Simple one-way analysis of variance was used to compare means. Those with a significant F-value were compared with Fischer’s least significant difference (P=0.05) procedure.

Results and discussion

Seasonal conditions and plant growth

Mean monthly temperatures ranged from 13.0-23.4 °C (July 2010) to 21.4-31.9 °C (November 2010) and were broadly representative of the area. Total rainfall of 713 mm during January-February 2010 was similar to the long term mean. However, November to March rainfall (1570 mm) in the second year was almost double the long-term average. A cyclone during early February 2011 caused some wind damage to plants.

The *Stylosanthes* and *Arachis* spp. grew vigorously in warmer months and growth appeared unaffected by insects or diseases. The *M. sativa* varieties, however, were damaged by foliar diseases (*Cercospora*, *Leptospherulina* and *Heterosporium*) and chewing insects during the wet summer months and weevils were found in the roots of sampled plants. Some individual plants had died by the end of the second year.

Colonisation of plots by plants varied between species (P<0.001, data not presented). The *A. pintoi* (stoloniferous) and *A. glabrata* (rhizomatous) plants colonised plots through lateral growth, whereas the other species had erect growth habits. The fastest to colonise plots were the *S. guianensis* and *A. pintoi* types with over 85% ground cover by 25 March 2010 and full cover thereafter. The *A. glabrata* and *A. kretschmeri* types, plus *A. paraguariensis* CQ1780, did not achieve similar cover until November 2010. Ground cover of the *M. sativa* varieties was poor (40-60%) resulting in the establishment of weeds which frequently needed to be removed by hand (unlike for the other species).

Hay biomass

Biomass production was seasonal for all species. *Medicago sativa* produced the most biomass during the winter months and the *Arachis* and *Stylosanthes* during summer (Table 1). The two *M. sativa* varieties produced high biomass yields (22.5 and 30.7 t DM/ha) over the 19 month assessment period despite damage by insects and diseases. However, biomass yields after this time were poor (1.5-2.2 t DM/ha) compared to some of the other legumes (5-10 t DM/ha) when grown for 139 days without cutting. Many individual plants had died by this time, presumably due to the accumulated damage caused by disease and insect pressure, indicating a limited productive life under regular cutting on acid clay soils in the upland environment of north Queensland.

Table 1. Above ground dry matter production (kg DM/ha) of 15 legume varieties grown in northern Queensland

	Biomass of regrowth (kg DM/ha)											
	Experiment 1: cutting immediately after sampling									Experiment 2: no cutting		
Sampling date	2010				2011							2012
	25 Mar	7 Jul	30 Aug	1 Nov	11 Jan	15 Mar	10 May	20 Jul	14 Sep	9 Nov	13 Dec	31 Jan
Days from last cut	-	104	54	62	71	63	56	57	56	56	90	139
Arachis paraguariensis												
CPI91419	440	492	268	964	1028	1796	364	60	88	2880	755	496
CQ1780	92	268	296	3048	4460	3824	1868	1032	1112	2420	3590	6231
Arachis glabrata												
cv. Prine	236	164	0	924	4516	4424	2136	1144	692	2812	5240	5988
CPI93469	124	60	0	1776	4332	4596	2216	1612	0	3508	5310	5146
AGC93481	328	216	164	1452	4000	3660	1544	1308	924	3056	5740	6210
Arachis kretschmeri												
CPI85804	568	372	520	1652	2584	1616	1040	292	40	540	627	2364
Arachis pintoi												
cv. Amarillo	464	248	440	936	2168	2532	1160	564	556	2168	3530	4427
ATF2320	2136	1164	1252	5344	5512	4852	1812	1168	924	2420	6640	9295
ATF494	468	156	436	1680	4268	3120	1520	1540	1468	2752	4980	7126
ATF495	144	128	436	1640	3096	4248	1432	1268	1032	2448	4910	7884
CPI1006	6380	3516	1364	4388	4548	2640	828	1848	600	1752	4135	5732
Medicago sativa												
cv. Q11	1924	2704	3228	3600	2860	2052	2964	1972	4320	5148	3360	2249
cv. Silverado	1384	1852	3068	2564	2668	1564	1944	1864	2420	3612	2240	1466
Stylosanthes guianensis												
ATF3308	6036	2900	1760	4400	3472	4568	1180	1148	828	4712	6290	10725
ATF3309	6132	1508	684	4504	4524	5004	1112	452	1624	2988	5660	8248
LSD(P=0.05)	2004	488	696	1436	1536	1156	596	904	660	1108	1700	1820
F probability	<0.001 for all harvests											

Table 2. Mean[1] of dry matter production (kg DM/ha) and forage quality of samples collected on 1 November 2010 and 11 January 2011 and analysed separately by replicate and harvest date

	Dry matter	Dry matter content	Crude protein	Rumen degrade -able protein	Lignin	Acid detergent fibre	Neutral detergent fibre	Metabolis-able energy	Relative feed value[2]
	(kg/ha)	(%)	(% dry)	(% dry)	(% dry)	(% dry)	(% dry)	(MJ/kg)	
Arachis paraguariensis[3]									
CQ1780	3755	28.37	13.68	64.50	5.80	30.10	39.65	10.42	154.5
Arachis glabrata									
Prine	3621	26.70	16.24	61.92	7.32	32.58	38.92	9.81	159.9
CPI93469	3040	27.05	16.70	64.75	6.85	31.95	37.65	9.95	161.8
CPI93481	2726	25.63	16.73	64.00	6.90	32.62	37.07	9.96	161.5
Arachis kretschmeri									
CPI85804	2094	26.24	16.83	69.50	5.73	27.05	33.15	10.92	191.2
Arachis pintoi									
Amarillo	1711	23.42	17.68	67.92	6.25	28.15	34.02	10.80	183.9
ATF2320	5428	20.03	17.43	69.00	6.98	32.55	40.05	10.08	148.5
ATF494	2975	20.05	19.45	69.75	6.15	28.18	35.90	10.69	175.8
ATF495	2368	22.59	18.13	68.75	6.48	29.38	35.52	10.54	174.5
CPI1006	4776	22.66	19.10	71.22	5.71	28.20	32.82	10.91	192.5
Medicago sativa									
Q11	3232	24.00	20.45	64.25	8.58	36.33	47.95	9.32	119.0
Silverado	2617	25.84	19.30	64.50	8.90	38.15	49.72	9.15	111.2
Stylosanthes guianensis									
ATF3308	3941	19.46	16.88	60.25	9.65 (6.1 wet)	39.55	49.35	8.58	110.0
ATF3309	4514	21.06	15.28	57.25	8.63 (5.8 wet)	39.43	50.55	8.69	107.2
LSD(P=0.05)	1457	2.55	2.10	3.07	0.91	2.75	3.92	0.54	20.6
F probability	<0.001 for all indices								

[1] samples represent one quadrat (of two) from each of two replicates analysed separately

[2] a calculated feed value: 100 represents *M. sativa* hay with 41% ADF and 53% NDF (Dairy One, 2012)

[3] there was insufficient biomass of CPI91419 to complete nutrient analysis

The two *S. guianensis* types performed well in all but the winter months. Total biomass ranged from 28.3 to 31.0 t DM/ha over the cutting experiment, and summer 8-week cycles often yielded over 4.5 t DM/ha. Yields remained high until the end of the cutting experiment and 8.2 and 10.7 t DM/ha were produced over the following 139 days without cutting (Experiment 2). Plant crowns were woody by the end of the experiments but continued to produce green shoots indicating only minimal decline in feed quality.

There were considerable differences in biomass production between and within the *Arachis* spp. *Arachis pintoi* was the best performing species, while types CPI1006 and ATF2320 had high production, similar to the best *Medicago* and *Stylosanthes* lines during summer months. These, ATF494 and ATF495 produced 5.7-

9.3 t DM/ha during the 139 day un-cut period. The three *A. glabrata* types and *A. paraguariensis* CQ1780 also showed promise as each produced 16.7-18.2 t DM/ha over the 19 months after slow establishment and, when grown uncut for 139 days, yielded 5.1-6.2 t DM/ha. All *Arachis* were growing vigorously at the completion of the experiments in February 2012.

Hay quality

All varieties produced high-quality feed for ruminants but there was substantial variation between types/varieties and some clear species trends (Table 2). Protein content and digestibility were high overall; *M. sativa* (19.3-20.5%) and some *A. pintoi* types (18.1-19.5%) had the highest crude protein contents and *A. pintoi* and *A. kretschmeri* the highest values for protein degradability (67.9-71.2%). The two *S. guianensis* and *A. paraguariensis* had lower values.

Lignin content (5.7-9.7% or 5.7-8.9% if wet chemistry values used for *S. guianensis*) and acid detergent fibre (28.2-39.6%) values were low overall, indicating high levels of microbial degradability and therefore value as a feed. Values for *Arachis* spp. were lower than for *M. sativa* indicating more rapid and complete digestion of the *Arachis* spp. by ruminants. Neutral detergent fibre values, a measure of the cell wall fraction and an indicator of feed intake, were also lower in the *Arachis* spp. (32.8-40.1%) than for *M. sativa* and *S. guianensis* (48.0-50.6%).

Metabolisable energy, a calculated estimation of the energy value of a feed based on protein, carbohydrate and fat content ranged from 8.6-10.9 MJ/kg, and was higher in the *Arachis* spp. than *M. sativa* and *S. guianensis*. Relative feed values, an estimation of overall feed value based on acid and neutral detergent fibre values, also indicated that the *Arachis* spp. were of particularly high feed value.

The NIR values presented here provided a satisfactory estimate of wet chemistry values in most instances. Paired samples were mostly within 5% of the wet chemistry values for the nutrient quality parameters discussed (data not presented). The notable exception was lignin content, which was 27-48% higher for *S. guianensis* (but not the other species) when estimated using NIR (both values presented).

Conclusions

- Q11 and Silverado lucerne can produce satisfactory hay crops when grown under irrigation during the dry season (April-November), but long-term production is compromised by disease and insect damage during wet summer conditions. Vigorous summer-dominant growth and tolerance to cutting, pests and diseases indicate the assessed *Arachis* and *Stylosanthes* types are suitable for perennial hay production in north Queensland. Large yields of high-quality biomass indicate four *A. pintoi* types have excellent potential and three *A. glabrata* and one *A. paraguariensis* type also show promise. Two commercially available *S. guianensis* varieties were shown to produce excellent hay yields, although feed value was lower than for *Arachis*.

References

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M and Schultze-Kraft R (2005). Tropical Forages: an interactive selection tool. www.tropicalforages.info

Dairy One (2012). Understanding and significance of forage analysis results. www.dairyone.com/Forage/Factsheet/ForageAnalysis.htm.

Lowe KF, Bartholemew BL and Bowdler TM (1988). Hay production of lucerne cultivars in the Lockyer Valley, south-east Queensland. Tropical Grasslands 22, 184-189.