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

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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
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**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 \( \text{pH}_{\text{water}} = 6.7 \) 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 (bentazon, 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 m² 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 \( (P<0.001, \text{ data not presented}) \). The *A. pintoi*
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(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**

<table>
<thead>
<tr>
<th></th>
<th>Biomass of regrowth (kg DM/ha)</th>
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<tbody>
<tr>
<td></td>
<td>Experiment 1: cutting immediately after sampling</td>
<td>Experiment 2: no cutting</td>
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<td></td>
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<tr>
<td>Sampling date</td>
<td>25 Mar</td>
<td>7 Jul</td>
<td>30 Aug</td>
<td>1 Nov</td>
<td>11 Jan</td>
<td>15 Mar</td>
<td>10 May</td>
<td>20 Jul</td>
<td>14 Sep</td>
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<tr>
<td>Days from last cut</td>
<td>-</td>
<td>104</td>
<td>54</td>
<td>62</td>
<td>71</td>
<td>63</td>
<td>56</td>
<td>57</td>
<td>56</td>
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</tbody>
</table>

**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

<table>
<thead>
<tr>
<th></th>
<th>Dry matter</th>
<th>Dry matter content</th>
<th>Crude protein</th>
<th>Rumen degrade - able protein</th>
<th>Lignin</th>
<th>Acid detergent fibre</th>
<th>Neutral detergent fibre</th>
<th>Metabolisable energy</th>
<th>Relative feed value(^2)</th>
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<tr>
<td></td>
<td>(kg/ha)</td>
<td>(%)</td>
<td>(%) dry</td>
<td>(%) dry</td>
<td>(%)</td>
<td>(%) dry</td>
<td>(%) dry</td>
<td>(MJ/kg)</td>
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<td><em>Arachis paraguariensis</em>(^3)</td>
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<tr>
<td>CQ1780</td>
<td>3755</td>
<td>28.37</td>
<td>13.68</td>
<td>64.50</td>
<td>5.80</td>
<td>30.10</td>
<td>39.65</td>
<td>10.42</td>
<td>154.5</td>
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<tr>
<td>Prine</td>
<td>3621</td>
<td>26.70</td>
<td>16.24</td>
<td>61.92</td>
<td>7.32</td>
<td>32.58</td>
<td>38.92</td>
<td>9.81</td>
<td>159.9</td>
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<td>CPI93469</td>
<td>3040</td>
<td>27.05</td>
<td>16.70</td>
<td>64.75</td>
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<td>37.65</td>
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<td>2726</td>
<td>25.63</td>
<td>16.73</td>
<td>64.00</td>
<td>6.90</td>
<td>32.62</td>
<td>37.07</td>
<td>9.96</td>
<td>161.5</td>
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<td><em>Arachis kretschmeri</em></td>
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<td>2094</td>
<td>26.24</td>
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<td>33.15</td>
<td>10.92</td>
<td>191.2</td>
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<td><em>Arachis pintoi</em></td>
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<td>Amarillo</td>
<td>1711</td>
<td>23.42</td>
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<td>67.92</td>
<td>6.25</td>
<td>28.15</td>
<td>34.02</td>
<td>10.80</td>
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<td>ATF2320</td>
<td>5428</td>
<td>20.03</td>
<td>17.43</td>
<td>69.00</td>
<td>6.98</td>
<td>32.55</td>
<td>40.05</td>
<td>10.08</td>
<td>148.5</td>
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<td>ATF494</td>
<td>2975</td>
<td>20.05</td>
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<td>69.75</td>
<td>6.15</td>
<td>28.18</td>
<td>35.90</td>
<td>10.69</td>
<td>175.8</td>
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<td>ATF495</td>
<td>2368</td>
<td>22.59</td>
<td>18.13</td>
<td>68.75</td>
<td>6.48</td>
<td>29.38</td>
<td>35.52</td>
<td>10.54</td>
<td>174.5</td>
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<td>CPI1006</td>
<td>4776</td>
<td>22.66</td>
<td>19.10</td>
<td>71.22</td>
<td>5.71</td>
<td>28.20</td>
<td>32.82</td>
<td>10.91</td>
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<tr>
<td><em>Medicago sativa</em></td>
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<td>Q11</td>
<td>3232</td>
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<td>64.25</td>
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<td>36.33</td>
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<td>Silverado</td>
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<td>25.84</td>
<td>19.30</td>
<td>64.50</td>
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<td>38.15</td>
<td>49.72</td>
<td>9.15</td>
<td>111.2</td>
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<tr>
<td><em>Stylosanthes guianensis</em></td>
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<tr>
<td>ATF3308</td>
<td>3941</td>
<td>19.46</td>
<td>16.88</td>
<td>60.25</td>
<td>9.65(^{6.1}) wet)</td>
<td>39.55</td>
<td>49.35</td>
<td>8.58</td>
<td>110.0</td>
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<td>ATF3309</td>
<td>4514</td>
<td>21.06</td>
<td>15.28</td>
<td>57.25</td>
<td>8.63(^{5.8}) wet)</td>
<td>39.43</td>
<td>50.55</td>
<td>8.69</td>
<td>107.2</td>
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<tr>
<td>LSD(P=0.05)</td>
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<td>2.55</td>
<td>2.10</td>
<td>3.07</td>
<td>0.91</td>
<td>2.75</td>
<td>3.92</td>
<td>0.54</td>
<td>20.6</td>
</tr>
</tbody>
</table>

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-
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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**


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