Perennial Forage Peanut (*Arachis pintoi*) in Pastures for Raising Replacement Heifers/Stocker Steers in Hawai‘i

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**ABSTRACT**

During 1998 and 1999 pastures of perennial forage peanut (*Arachis pintoi* cv. Amarillo) mixed with common guinea grass (*Panicum maximum* (Jacq.) L.) were used to determine the effects of stocking rate (SR) on the performance of 280-kg Brangus heifers and steers (Bos spp.) and forage production and nutritive value under Hawaiian lowland conditions. Average daily gain was outstanding, ranging from 0.72 to 0.95 kg at SR of 2 to 5 head ha⁻¹ in 1998, and 0.88 to 1.07 kg at SR of 3 to 6 head ha⁻¹ in 1999. Forage peanut consistently comprised about 25 to 30 percent of the total palatable herbage mass in all pastures. Total digestible nutrient concentration averaged 608 g kg⁻¹ dry matter (DM) for forage peanut and 658 g kg⁻¹ DM for guinea grass, but as expected, the total cell wall or neutral detergent fiber concentration was substantially lower for forage peanut (423 g kg⁻¹ DM) than guinea grass (585 g kg⁻¹ DM). Nitrogen concentration averaged 33.1 and 16.9 g kg⁻¹ for forage peanut and guinea grass, respectively. Under the conditions of our two-year study, it was demonstrated that forage peanut holds potential as an N₂-fixing pasture legume in commercial cattle operations in Hawaii due to its nutritional value, persistence under high SR, and N contribution to the pasture sward.

**INTRODUCTION**

The cattle industry is an integral part of Big Island agriculture and its economy; however, low concentrations of digestible energy and (or) protein, and high fiber content in our low to medium quality tropical forage grasses seriously limits the productivity of our cattle industry. Poor average daily gains (ADG) of less than 0.55 kg d⁻¹ for dairy and beef replacement heifers/stocker steers are common on tropical pastures (Plucknett, 1970; Smith et al., 1983; Rotar, 1989). The development cost on our low-input pastures is minimal, but the loss of return due to slow animal growth is very expensive (Buckley, 1988; Rice, 1991; Parsons and Allison, 1991), as is importing sources of high quality supplemental feed or using fertilizer nitrogen to increase the crude protein concentration of tropical grasses (Rotar, 1989).

During the past 10 years, rapid advances in pasture-based cattle production have been made in Australia, South America, and Florida because of the introduction and development of high quality, non-bloating, perennial forage peanuts (*Arachis pintoi* and *Arachis glabrata*) that are relatives of the commonly cultivated annual groundnut or peanut (*Arachis hypogaea*). Studies conducted in these regions indicate that this perennial, highly persistent, broad-leaf weed-suppressing, drought tolerant, prostrate (non-climbing), stoloniferous, legume with oval-shaped leaflets (in pairs of four) and yellow pea-like flowers, generally supports ADG in the desired range of 0.7 to 0.9 kg d⁻¹ or better on well-managed pasture (French, 1988; Kerridge and Hardy, 1994; Boddey et al., 1997; Lowe et al., 1998). Their results also indicate that forage peanut forms desirable mixtures with urochloa (*Urochloa* spp.), digit (*Digitaria* spp.), and guinea

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*a* Presented at Forage Field Day; June 16, 2000, Mealani Research Station, Kamuela, HI 96743.
**Panicum maximum** (Jacq.) L.] grasses and is tolerant of high stocking rates (SR), unlike most tropical forage legumes (O’Reilly and Cameron, 1992; Lowe et al., 1993; Kerridge and Hardy, 1994). Long-term groundcover and small plot studies conducted near Hilo at the Tropical Rural and Island/Atoll Development Experiment Station (TRIADES) of Hawai‘i Island suggest that *Arachis pintoi* is well-adapted to the low- to medium fertility, acid soils of the region, and has no serious pest or disease problems (Glover, 1994). The value of forage peanuts as aesthetically pleasing groundcovers to control weeds and soil erosion under tree and annual crops has been well-documented in Hawai‘i and throughout the tropics (Glover, 1994; Kerridge and Hardy 1994).

The objective of our study was to evaluate the effect of SR on a forage peanut-guinea grass mixture in terms of pasture yield and composition and growth rate of growing beef cattle. Specific objectives were to quantify forage production and nutritive value, cattle average daily gain, and beef production per unit land area.

**MATERIALS AND METHODS**

**Pasture Preparation**

The experiment was conducted on 4 hectares of abandoned sugarcane land (elevation = 240 m) that was leased by Pu‘u‘alā Farm and Ranch near Pauuilo (20°03 N lat) on the Island of Hawai‘i. The site was planted with 'Amarillo' perennial forage peanut seed (*Arachis pintoi*, pre-coated with a cowpea type *Rhizobium* inoculant [QA 1090]) on 18 June 1997 at a rate of 28 kg seed ha⁻¹ using the row planter drill method (O’Reilly and Cameron, 1992; Glover, 1994). Planting depth was 2.5 cm while spacing between rows was 75 cm. The volunteer grass species mixed with the forage peanut was common guinea grass, one of the three most common tropical forage grasses in the region. Dolomitic limestone was applied 1 wk prior to planting at the rate of 280 kg ha⁻¹ and an 8% N - 20% P₂O₅ - 15% K₂O fertilizer blended from urea, sulfur coated urea, monoammonium phosphate, sulfate of potash, and sulfate of potash magnesia was applied during pasture planting at a rate of 715 kg ha⁻¹. The site received no subsequent fertilization. In the months following planting, the site was mowed occasionally to a height of 8 cm to encourage the spread of forage peanut stolons from the planting rows and to control guinea grass growth (Glover, 1994). Soils were of the Kukaiu silty clay loam series (hydrors, isothermic Typic Hapludands). At initiation of grazing in April 1998, mean soil pH (1:2, soil:deionized H₂O ratio) was 5.8; organic C was 87.6 g kg⁻¹; and K, Ca, Mg, and Na extractable by neutral M NH₄OAc were 87, 1050, 205, and 61 mg kg⁻¹, respectively.

**Animal Assignments**

In April 1998 the site was equally divided into four 1 ha pastures with permanent fencing (Fig. 1). Each pasture was further subdivided into three 0.33 ha paddocks using portable electric tape fencing, and waterers (189.25 l with automatic floats) that were rotated among the three paddocks. TM salt formulated for cattle was available *ad libitum*. Brangus heifers and steers (6- to 8-mo-old; 280-kg mean body weight) were randomly assigned to one of four SR treatments (2, 3, 4 or 5 animals ha⁻¹) in each of the paddocks on 17 Apr. 1998. The rotational grazing schedule consisted of a 2 wk grazing period per sub-paddock followed by a 4 wk rest period. The 1998 grazing season ended on 28 Aug. (133 d). During the non-ttrial winter months, the pastures were occasionally mob-grazed with non-experimental cattle and horses for a few days each month to control pasture growth. The second experimental grazing season commenced on 5 Mar. 1999 with new heifers and steers. The SR treatments on each pasture were increased to 3, 4, 5 or 6 cattle ha⁻¹. The 1999 grazing season ended on 16 July (133 d). All cattle were weighed at the beginning, middle, and end of each grazing season in order to calculate ADG and beef production per acre. Hip heights and body condition scores were also taken at the beginning and end of each trial and were the average of two assessments.

**Forage Sampling and Analysis**

Throughout each grazing season, forage samples were collected every 6 wk immediately prior to movement of the cattle into new paddocks in each pasture. This resulted in four sampling dates per grazing
season. Six sample sites (0.2m$^2$), representing mean herbage mass and pasture condition were selected from the next paddock to be grazed in each pasture. The guinea grass was clipped to a 15-cm stubble while the forage peanut was clipped to a 1.5 cm stubble in order to reflect the expected heights to which the animals might defoliate these species (Rotar et al., 1966; Santana and McDowell, 1993; Lowe et al., 1993). The collected forage was hand-separated by forage species, dried at 60°C for 48 h, and weighed.

At the time of herbage mass sampling, 20 or more hand-plucked samples (grab samples clipped by hand) were taken at randomly selected locations in each pasture to estimate the nutritive value and in vitro digestibility (Ankom 200 Fiber Analyzer, Fairport, NY) of the diet. These samples were composited by forage species for each pasture, dried as described above, and ground to pass a 1-mm stainless steel screen using a Wiley mill. Sixteen samples of each forage type for both years were analyzed on a dry matter (DM) basis for crude protein (CP = N * 6.25), neutral detergent fiber (NDF), and acid detergent fiber (ADF) using NIR spectroscopy (Precision Scientific Model 4250), and minerals (nitric acid digestion and ICPE spectroscopy; Jones and Case, 1990). Estimates for energy were calculated (Gardner Neotec Division, Pacific Scientific):

Net Energy for maintenance = [-.508 + (1.37 * ME) - (.3042 * ME$^2$) + (.051 * ME$^3$)]/2.205  
(Mcal per kg DM)

Net Energy for lactation = [1.085 - (.0124 * ADF)]/2.205 for guinea grass  
(Mcal per kg DM)  
[1.044 - (.019 * ADF)]/2.205 for forage peanut

Net Energy for gain = [-.7484 + (1.42 * ME) - (.3836 * ME$^2$) + (.0593 * ME$^3$)]/2.205  
(Mcal per kg DM)

Total Digestible Nutrients (TDN), % = 4.898 + (89.796 * NEI)

where: ADF = % Acid Detergent Fiber, and ME = Metabolizable Energy = .01642 * TDN

**Statistical Analysis**

Forage data were statistically analyzed as a function of SR and sampling date using PROC GLM of SAS (1985).

**RESULTS AND DISCUSSION**

**Nutritive Value of Hand-Plucked Forage**

Average nutrient and mineral composition, and predicted TDN, Nem, NEg and NEI energy values of guinea grass and perennial peanut pastures are shown in tables 1 and 2, representing the averages of sixteen samples of each forage type per trial.

There was no effect (P>0.10) of SR or sampling date on the TDN and NDF concentrations in guinea grass (642 g kg$^{-1}$; 594 g kg$^{-1}$) or forage peanut (585 g kg$^{-1}$; 406 g kg$^{-1}$). These concentrations are similar to those reported elsewhere with these species (Wan Hassan et al., 1990; Lowe et al., 1993; Santana and McDowell, 1993; Kerridge and Hardy, 1994; Singh et al., 1995). The lower NDF concentrations for forage peanut may have been beneficial in increasing total forage intake and digestion rate (Lowe et al., 1993).

The level of N in guinea grass was greater during the summer than the spring. In general, forage peanut N content (Fig. 2) tended to increase with SR, and like guinea grass, was higher during the summer than the spring (data not shown). The high levels of N in forage peanut undoubtedly contributed to the protein nutrition of the cattle (Kerridge and Hardy, 1994).

Guinea grass P concentrations tended to be higher in late spring and late summer than in early spring, while forage peanut P content was higher in late summer than at other sampling dates (data not shown). Guinea grass Mg level was lower during early spring than other sampling dates, while forage peanut Mg content was higher during the summer than the spring (data not shown).
All N and mineral concentrations were within normally expected ranges for guinea grass and forage peanut (Santana and McDowell, 1993; Kerridge and Hardy, 1994), and there were little differences between the two years except for decreases in peanut P, K, and S during the drought year (year 2). In fact, guinea grass crude protein concentrations (Table 1) were similar to those typically obtained with N fertilized guinea grass (Wan Hassan et al., 1990; Santana and McDowell, 1993), indicating N recycling in the system from the forage peanut (Kerridge and Hardy, 1994). Unfertilized guinea grass pastures at Pu‘u‘ala Farm and Ranch typically have crude protein concentrations of no more than 75 g kg⁻¹ (data collected by B.W. Mathews). From a ruminant nutrition standpoint, however, P in both species was less than the 2.5 g kg⁻¹ recommended by McDowell (1997). Additionally Na was less than the recommended 600 mg kg⁻¹ in forage peanut and guinea grass Cu and Zn concentrations were less than the 10 and 30 mg kg⁻¹ recommended (McDowell, 1997). These nutrients were easily supplied by the TM salt supplement.

**Forage Production**

There was no effect of SR (P > 0.10) in either grazing season on guinea grass herbage mass above the 6 in height to which cattle are normally expected to defoliate this species at a maximum. In addition to inherent pasture variability, this appeared (not quantified) to be due in part to increased tillering of the guinea grass with increased SR as observed in several studies reviewed by Humphreys (1991). There were, however, considerable differences (P < 0.003) between sampling dates (Fig. 3). In 1998, the increase in guinea grass herbage mass during July and especially August was attributed to favorable rainfall conditions during the summer period (Fig. 4). In contrast, there was extreme drought during June 1999 (rainfall May through October averaged less than 7.5 cm mo⁻³) that greatly decreased herbage mass in July, and postponed subsequent non-experimental grazing of the paddocks until September. During the drought, the forage peanut lost most of its leaves and was dry in appearance; however, it rapidly recovered with the onset of late summer rainfall as has been observed elsewhere (Kerridge and Hardy, 1994). Levels of guinea grass herbage mass during the study periods were within the expected ranges when defoliation occurs every 4 wk (Wan Hassan et al., 1990; Singh et al., 1995).

In both grazing seasons forage peanut herbage mass (Fig. 5) above the 1.5 cm height to which cattle are normally expected to defoliate this species at a maximum was affected by SR (P < 0.03) and sampling date (P < 0.10). In 1998 there was less than forage peanut at the lowest SR and forage peanut herbage mass decreased for all SR in May relative to April. By Mar. 1999 forage peanut had become well established in the paddock with the lowest SR but for some unexplained reason forage peanut tended to be lower in the SR = 5 treatment relative to the others during April and May 1999.

The levels of forage peanut herbage mass observed in this study were similar to those observed in other grass (Urochloa and Digitaria spp.)-forage peanut mixtures by Grof (1985) in Colombia and Lowe et al. (1993) in Australia. In agreement with Grof (1985), the present study also suggests forage peanut can consistently comprise approximately 25 to 30 percent of the total palatable herbage on offer in at least the short-term when grown in a mixture with guinea grass and grazed every 4 wk. There were also few weeds in the pastures and greenleaf desmodium [Desmodium intortum (Mill.) Urb.; a volunteer forage legume] that was present in some parts of the pastures at the initiation of the study in 1998 soon disappeared.

**Cattle Performance**

Average daily gain per head on the forage peanut-guinea grass pastures (Fig. 6) ranged from 0.72 to 0.95 kg in 1998 and 0.88 to 1.07 kg in 1999. These ADG were outstanding considering that cattle in Hawaii and elsewhere in the tropics typically only gain about 0.40 to 0.55 kg ani⁻¹ d⁻¹ on pure guinea grass pastures under conventional management with 4 to 6 wk regrowth periods between paddock grazing periods (Chen et al., 1981; Humphreys, 1991). This was the case at Pu‘u‘ala Farm and Ranch with similar Brangus cattle stocked at 3.2 animal⁻¹ ha⁻¹ during the study period (personal communication with Lawrence Martinez; Ranch Manager). In 1998 the ADG data followed an expected response (Humphreys, 1991) with a more or less linear decrease in gain per animal as SR was increased beyond that which gave the greatest gain, but trends with SR were less clear in 1999.
As expected beef production per unit land area (Fig. 6) increased with SR in 1998 until a plateau was achieved. Although SR was increased in 1999, a clear plateau was not achieved since the greatest SR produced the most gain per unit land area. In the future, replicated trials are needed to better assess the relationship between SR and animal performance (Bransby, 1989) on forage peanut-guinea grass pastures, however, the high levels of individual animal performance achieved in this preliminary study are very promising.

CONCLUSIONS AND IMPLICATIONS

To date, there has been little adoption of forage peanut by the cattle industry in Hawai‘i. This may be due to high seed costs and lack of local information on management and animal production levels. This experiment has addressed some of the latter concerns by providing information that demonstrates the value of forage peanut. Its outstanding performance even under the higher SR may alleviate the worries of many farmers who have been disillusioned by the poor performance of other tropical forage legumes in Hawai‘i (Rotar, 1989).

The impact of forage peanut on the local livestock industry may be minimal in the immediate future, however, because of the high cost of seed which is imported from Australia and Latin America. At seeding rates of 15 to 30 kg ha\(^{-1}\) (O’Reilly and Cameron, 1992; Glover, 1994), seed costs alone will amount to $300 to 600 per ha or more depending on supply. This will result in only small areas being sown initially. If producers consider, however, the elimination of chemical N fertilizer inputs 112 to 336 kg ha\(^{-1}\) yr\(^{-1}\), this results in a $115 to 345 per ha savings per year without even considering the benefit of improved animal performance (ADG). While slower, the potential for vegetative propagation of forage peanut pastures using sprigs should be investigated under Hawaiian conditions (Glover, 1994; Kerridge and Hardy, 1994).

Results from this study suggest that forage peanut holds potential as a persistent herbaceous legume for a sustainable pasture mixture for lowland Hawaiian conditions. Forage peanut mixed with guinea grass and grazed every 4 wk was very tolerant of stocking and definitely capable of high animal production in this short-term study. Perennial forage peanut pasture mixtures should be further evaluated in Hawai‘i with both on farm demonstrations and replicated research studies.

ACKNOWLEDGEMENT

Funding for this research was provided in part by USDA-SARE and the County of Hawai‘i, Department of Research and Development.

LITERATURE CITED


Humphreys, L.R. 1991. Tropical pasture utilisation. Cambridge Univ. Press, UK.


Table 1. Nutrient composition and estimated energy values of guinea grass and perennial peanut pastures.

<table>
<thead>
<tr>
<th>Forage</th>
<th>Crude Protein</th>
<th>Neutral Det. Fiber</th>
<th>Acid Det. Fiber</th>
<th>Total Digestible Nutrients</th>
<th>NE, Maint.</th>
<th>NE, Gain</th>
<th>NE, Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinea Grass</td>
<td>---------------</td>
<td>--------------------</td>
<td>-----------------</td>
<td>---------------------------</td>
<td>------------</td>
<td>----------</td>
<td>---------------</td>
</tr>
<tr>
<td>Trial 1</td>
<td>94</td>
<td>586</td>
<td>328</td>
<td>658</td>
<td>1.50</td>
<td>.91</td>
<td>1.50</td>
</tr>
<tr>
<td>Trial 2</td>
<td>85</td>
<td>603</td>
<td>368</td>
<td>625</td>
<td>1.39</td>
<td>.81</td>
<td>1.42</td>
</tr>
<tr>
<td>Average</td>
<td>90</td>
<td>594</td>
<td>343</td>
<td>642</td>
<td>1.45</td>
<td>.86</td>
<td>1.46</td>
</tr>
</tbody>
</table>

| Forage Peanut | | | | | | | |
|---------------| | | | | | | |
| Trial 1       | 193            | 423                | 373             | 608                       | 1.34       | .76      | 1.37          |
| Trial 2       | 206            | 389                | 398             | 561                       | 1.18       | .62      | 1.29          |
| Average       | 200            | 406                | 385             | 585                       | 1.26       | .69      | 1.33          |

Table 2. Mineral composition of guinea grass and perennial peanut pastures.

<table>
<thead>
<tr>
<th>Forage</th>
<th>Ca</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>S</th>
<th>Cu</th>
<th>Fe</th>
<th>Mn</th>
<th>Na</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinea Grass</td>
<td>-----</td>
<td>g kg⁻¹, dry matter basis</td>
<td>-----</td>
<td>mg kg⁻¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>4.4</td>
<td>2.0</td>
<td>16.7</td>
<td>2.6</td>
<td>1.4</td>
<td>6</td>
<td>93</td>
<td>46</td>
<td>1026</td>
<td>15</td>
</tr>
<tr>
<td>Trial 2</td>
<td>5.1</td>
<td>1.9</td>
<td>13.5</td>
<td>2.4</td>
<td>1.2</td>
<td>5</td>
<td>134</td>
<td>55</td>
<td>1268</td>
<td>17</td>
</tr>
<tr>
<td>Average</td>
<td>4.7</td>
<td>2.0</td>
<td>15.1</td>
<td>2.5</td>
<td>1.3</td>
<td>5</td>
<td>113</td>
<td>50</td>
<td>1147</td>
<td>16</td>
</tr>
</tbody>
</table>

| Forage Peanut | | | | | | | | |
|---------------| | | | | | | | |
| Trial 1       | 19.4 | 2.1 | 15.9 | 4.6 | 2.6 | 11 | 229| 70 | 149 | 24 |
| Trial 2       | 21.2 | 1.6 | 10.7 | 4.8 | 1.9 | 9  | 233| 80 | 205 | 24 |
| Average       | 20.4 | 1.9 | 13.3 | 4.7 | 2.3 | 10 | 234| 76 | 176 | 24 |
Figure 1. Pasture configuration for guinea grass and perennial peanut trials.

Figure 2. Influence of stocking rate (SR) and sampling date on perennial forage peanut nitrogen concentration.

Figure 3. Average guinea grass production during 1998 and 1999.
Figure 4. Average temperature and rainfall during 1998 and 1999.

Figure 5. Forage peanut production at different stocking rates during trials in 1998 and 1999.

Figure 6. Influence of stocking rate on average daily gain and beef production per hectare on guinea grass and perennial peanut pastures during 1998 and 1999.