Summary
This study determined the herbage mass, leaf-to-stem ratio, and nutritive value of soybean [Glycine max (L.) Merr.], cowpea [Vigna unguiculata (L.) Walp.], and pigeonpea [Cajanus cajan (L.) Millsp.] grown in North Florida. Forages were grown in each of four blocks in three yr and harvested biweekly until the recommended maturity stage. Herbage mass of the forages increased through the growing season, and at the respective maturity stages soybean (3.8 tons dry matter (DM)/ac) and pigeonpea (3.9 tons DM/ac) had greater herbage mass than cowpea (2.3 tons DM/ac). Leaf-to-stem ratio decreased with maturity after a slight initial increase in all forages. At harvest, pigeonpea contained 12% crude protein (CP; DM basis) and 35% in vitro true DM digestibility (IVTD), soybean contained 18% CP and 73% IVTD, and cowpea contained 19% CP and 69% IVTD. Soybean and cowpea have potential to provide high quality forage to livestock in North Florida.

Introduction
In Florida and much of the Southern USA, bahiagrass [Paspalum notatum Flügge] and bermudagrass [Cynodon dactylon (L.) Pers.] are the main pasture forages. However, their availability for winter grazing is limited and their digestibility and CP concentration are often insufficient for growing and lactating cattle in mid-to-late fall. Warm-season legumes can provide the needed supplementary nutrients, and when stored as hay or haylage, they can be fed in the winter to supplement stored and stockpiled grasses. The increasing costs of fuel and fertilizer have made such legumes more attractive to producers and necessitated evaluation of their yield and nutritive value. The objective of this study was to compare the herbage mass, chemical composition, IVTD, and leaf-to-stem ratio of cowpea (cv. ‘Iron clay’), soybean (cv. ‘Pioneer 97B52’) and pigeonpea (cv. ‘GA-2’).

Materials and Methods
In each of three yr, cowpea, soybean, and pigeonpea were grown at the North Florida Research and Education Center in Marianna, FL. Each legume was grown on a replicated plot within each of four blocks. The field was prepared by plowing and fertilizing with P and K to soil test recommendation. Immediately prior to planting, seeds were inoculated with the appropriate rhizobia and drilled at 50 lb/ac and 6-in row spacing. Planting dates for yr one (2005) and two (2007) were 9 and 10 May, respectively.

Duplicate forage samples were taken from each plot with mechanical clippers from a 0.2-m² area and harvested to a 2-in stubble height after
plants reached approximately 11 in height. Sampling continued every 2 weeks until harvest at the following recommended maturity stages: pods began to turn yellow for cowpea (Twidwell et al., 2002), pod setting for pigeonpea (Le Houërou, 2006), and stage R6 (full size seed in pods at one of the four uppermost nodes and completely unrolled leaves) for soybean (Sheaffer et al., 2001). Leaf-to-stem ratio was measured on duplicate samples from each plot after removal of leaves at the node. Samples were ground and analyzed for CP, neutral detergent fiber (NDF), and IVTD. Economics of producing these forages was compared to that for perennial and annual peanut forage using models of Hewitt (2006) and Prevatt (2008).

Statistical Analyses
The experimental design was a randomized complete block. Data were analyzed as repeated measures with PROC MIXED (SAS Inst. Inc., Cary, NC). The model included yr, forage species, week after planting (WAP), block and the interactions. Significance was declared at $P < 0.05$.

Results and Discussion
Herbage Mass and Leaf-to-stem Ratio
There were no yr or yr × forage species interactions therefore results shown are means across yr. Figure 1 shows the herbage mass for each legume through the growing season. Pigeonpea reached the recommended harvest stage at 14 WAP, whereas soybean and cowpea reached their recommended harvest stages at 16 and 20 weeks per planting, respectively. At the recommended maturity stage, soybean and pigeonpea had greater herbage mass than cowpea. Figure 2 shows that leaf-to-stem ratio decreased with maturity after a slight initial increase in all forages. From 10 to 14 WAP, the leaf-to-stem ratio of cowpea was greater than those of pigeonpea and soybean, which were similar. Herbage mass and leaf-to-stem ratio differences among the species are due to morphological and physiological differences. ‘Iron clay’ cowpea is a viney, low growing plant with large leaves and an indeterminate growth habit; therefore, it continued to produce new foliage after flowering and leaves did not senesce as soon as the other species. The soybean cultivar used in this experiment was late maturing (VII), with upright, tall (1.5 to 2.0 m) growth and the proportion of leaf declined through maturity at R7 stage. Pigeonpea is a tree-like legume that grows tall and has a woody main stem, and its small leaves begin to senesce at 9 WAP. Pigeonpea and soybean had greater herbage mass than cowpea because of their upright growth habit and thicker stems which supported greater herbage mass.

Nutritive Value
The CP concentration of each forage decreased through the growing season (Figure 3). Between 8 WAP and the respective recommended harvest stages, cowpea had the greatest CP concentration, whereas soybean had a greater CP concentration than pigeonpea from 10 WAP to the recommended harvest stage for pigeonpea. Pigeonpea had a greater NDF concentration than the other legumes between 10 and 14 WAP, and soybean had a greater NDF concentration than cowpea between 8 and 14 WAP. The IVTD of annual legumes decreased with maturity in pigeonpea and cowpea, but the rate and extent of the decrease was greater in pigeonpea. From 8 to 14 WAP, cowpea had the greatest IVTD, followed by soybean. Soybean and cowpea have more potential as forages for ruminants than pigeonpea. Cowpea is a promising energy and protein supplement but the herbage mass is relatively low. The greater herbage mass and high energy and protein concentration of soybean makes it ideal for producing large quantities of quality hay or haylage. Pigeonpea is only recommended for grazing cattle or storage as hay or haylage if it is less than 8 WAP.

Economics
Establishment of perennial peanut is more expensive than establishment of the other legumes; however, the annual maintenance cost of the seeded legumes is greater because they are planted each yr (Table 1). Cowpea produced the least herbage mass (Table 1) and therefore had the least net present value after 20 yr (Table 2). Perennial peanut is the best long term investment, but the other legumes will produce earlier returns on the investment.
**Literature Cited**


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1Jamie Foster, Former Graduate Student; Adebola Adesogan, Associate Professor, UF/IFAS, Department of Animal Sciences, Gainesville, Florida; and Jeffery Carter, Former Assistant Professor; Bob Myer, Professor; Ann Blount, Professor, UF/IFAS, North Florida Research and Education Center, Marianna; Florida Lynn Sollenberger, Professor, UF/IFAS, Agronomy Department.
Table 1. Costs of producing perennial peanut (cv. ‘Florigraze’), annual peanut (cv. ‘Florida MDR 98’), cowpea (cv. ‘Iron clay’), pigeonpea (cv. ‘GA-2’), and soybean (cv. ‘Pioneer 97B52’) forage, hay, or haylage production in 2006

<table>
<thead>
<tr>
<th>Forage</th>
<th>Seed or sprig cost, $/bu</th>
<th>Seed or sprig rate/ ac</th>
<th>Initial establishment cost, $/ac</th>
<th>Annual maintenance cost, $/ac</th>
<th>Herbage mass, tons DM/ ac/yr</th>
<th>No. of bales/ ac/yr</th>
<th>Cost of hay baling, $/ac/yr</th>
<th>Cost of Haylage baling, $/ac/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perennial peanut</td>
<td>3.00/bu</td>
<td>80 bu</td>
<td>688</td>
<td>212</td>
<td>4.5</td>
<td>30</td>
<td>420</td>
<td>330</td>
</tr>
<tr>
<td>Annual peanut</td>
<td>0.55/lb</td>
<td>18 lb</td>
<td>256</td>
<td>212</td>
<td>3.6</td>
<td>24</td>
<td>336</td>
<td>264</td>
</tr>
<tr>
<td>Cowpea</td>
<td>0.88/lb</td>
<td>50 kg</td>
<td>296</td>
<td>264</td>
<td>2.3</td>
<td>15</td>
<td>210</td>
<td>165</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>2.00/lb</td>
<td>50 kg</td>
<td>360</td>
<td>328</td>
<td>3.9</td>
<td>26</td>
<td>364</td>
<td>286</td>
</tr>
<tr>
<td>Soybean</td>
<td>0.88/kg</td>
<td>50 kg</td>
<td>296</td>
<td>264</td>
<td>3.8</td>
<td>25</td>
<td>350</td>
<td>275</td>
</tr>
</tbody>
</table>

1Includes seed, fertilizer (290 lb/ac 0-20-40 ratio of N:P2O5:K2O), 1,600 lb/ac lime, herbicide, machinery, labor, and estimated interest on monetary investment

2Includes seed for cowpea, pigeonpea and soybean, fertilizer (290 kg/ha 0-20-40 ratio of N:P2O5:K2O), herbicide, machinery, labor, and estimated interest on monetary investment, but not lime because it should be required every 2 to 3 yr

3Dry matter (DM)

4Estimated from small (300 lb) round bales utilized

5Estimated from $14.00 charge per bale for twine, machinery, and labor

6Estimated from $11.00 charge per bale for twine, plastic wrap, machinery, and labor

Equations from Hewitt, 2006 and Prevatt, 2008

Table 2. Net present value summary for perennial peanut (cv. ‘Florigraze’), annual peanut (cv. ‘Florida MDR 98’), cowpea (cv. ‘Iron clay’), pigeonpea (cv. ‘GA-2’), and soybean (cv. ‘Pioneer 97B52’) forage, hay, or haylage production over a 20-yr horizon

<table>
<thead>
<tr>
<th>Forage</th>
<th>Hay production net present value1, $/ac</th>
<th>Haylage production net present value1, $/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perennial peanut</td>
<td>3,728</td>
<td>4,596</td>
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<tr>
<td>Annual peanut</td>
<td>3,292</td>
<td>4,068</td>
</tr>
<tr>
<td>Cowpea</td>
<td>576</td>
<td>1,064</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>2,664</td>
<td>3,520</td>
</tr>
<tr>
<td>Soybean</td>
<td>3,076</td>
<td>3,892</td>
</tr>
</tbody>
</table>

1Estimated rate of return after 20-yr using the value of income and expense today. The greater the number, the greater the return on investment after 20-yr.

Expenses included 7% interest rate and $80 liming (1,600 kg/ha) in alternate yrs; profit included $37 value of 300 lb round bale.
Figure 1. Changes in herbage mass (tons dry matter (DM)/ac) of cowpea, pigeonpea and soybean. Means at each week after planting without a common superscript letter differ ($P < 0.05$). Standard error of the mean = 0.42 tons DM/ac.

![Graph showing changes in herbage mass of cowpea, pigeonpea, and soybean over weeks after planting.](image)

Figure 2. Leaf-to-stem ratio of cowpea, pigeonpea, and soybean. Means at each week after planting without a common superscript letter differ ($P < 0.05$). Standard error of the mean = 0.05.

![Graph showing leaf-to-stem ratio of cowpea, pigeonpea, and soybean over weeks after planting.](image)
Figure 3. Whole plant crude protein (CP) and neutral detergent fiber (NDF) concentrations (dry matter (DM) basis) and in vitro true DM digestibility (IVTD) of cowpea, pigeonpea, and soybean. Means at each week after planting without a common superscript letter differ ($P < 0.05$). Standard errors of the means for CP, NDF, and IVTD were 14, 18, and 17, respectively.