A Comparison of Pigeonpea and Cowpea Forage Yield and Nutritive Value in the Southern High Plains of the USA

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ABSTRACT

Few options of warm-season annual legumes are available for the higher elevations of semiarid, subtropical regions such as the Southern High Plains of the USA; therefore, candidate species must be explored for these environments. Pigeonpea [*Cajanus cajan* (L.) Millspaugh] has not been evaluated for forage in this environment, and pigeonpea forage yield and nutritive value have not been compared with those of cowpea [*Vigna unguiculata* (L.) Walpers], which is currently the most commonly used warm-season annual legume in the region. Pigeonpea (GA-2) and cowpea (Iron and Clay) were compared in separately analyzed randomized complete block studies conducted in 2006 and 2007 at New Mexico State University's Agricultural Science Center at Tucumcari using different fields and irrigation techniques each year. Cowpea was superior to pigeonpea for forage yield in 2006 and had numerically higher yield in 2007 [6.39 vs. 3.59 Mg ha^{-1} for cowpea and pigeonpea, respectively, in 2006 ($P < 0.01$) and 5.07 vs. 4.06 Mg ha^{-1} in 2007 ($P < 0.30$)]. Forage nutritive value of cowpea was greater than pigeonpea in both years as estimated by crude protein [189 vs. 156 g kg^{-1} in 2006 ($P < 0.05$) and 130 vs. 88 g kg^{-1} in 2007 ($P < 0.01$)] and neutral detergent fiber [323 vs. 467 g kg^{-1} in 2006 ($P < 0.05$) and 440 vs. 505 g kg^{-1} in 2007 ($P < 0.05$)]. Based on these results, cowpea remains the better option than pigeonpea for forage production systems under irrigation in the Southern High Plains of the USA and similar higher elevation, semiarid, subtropical environments.

INTRODUCTION

Forage sorghum [*Sorghum bicolor* (L.) Moench] and sorghum x sudangrass (S. *bicolor* var. *Sudanese*) are important warm-season annual forage grasses in the higher elevations of the semiarid, subtropical Southern High Plains of the USA (eastern New Mexico and Texas Panhandle) because they are relatively drought-tolerant and productive. However, there are limitations regarding crude protein (CP) concentration and other nutritive value components, such as fiber and digestibility, and livestock may require supplementation if these components are too low (Mislevy et al., 2005; Contreras-Govea et al., 2009). Some of these deficiencies in nutritive value can be alleviated by including legumes in the forage system (Muir, 2002; Lauriault and Kirksey, 2004; Contreras-Govea et al., 2009). Few warm-season annual legumes are adapted to humid, subtropical regions (Mislevy et al., 2005). There are even fewer options for semiarid, subtropical regions, and additional potential forage legumes must be explored (Muir, 2002; Lauriault and Kirksey, 2004; Contreras-Govea et al., 2009).

Soybean (*Glycine max* L.) is widely adapted; however, drought limits its forage yields (Ishibashi et al., 2003; Mislevy et al., 2005), and the combination of high temperature and low humidity in the Southern High Plains increases the irrigation requirement for soybean and reduces grain yield (C. Trostle, personal communication, 2009).

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Cowpea [*Vigna unguiculata* (L.) Walpers] is well adapted to low soil moisture situations (Muir, 2002), but not wet soils (Mislevy et al., 2005). Lauriault and Kirksey (2007) found that black-eyed cowpea grown for edible dry beans was well adapted to the Southern High Plains, with no grain yield reduction if planted before mid-June or if furrow irrigation or precipitation were timely, albeit limited. Data published by Contreras-Govea et al. (2009) indicate that forage cowpea has the potential to significantly improve nutritive value of monoculture sorghum forages.

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is also a widely adapted legume, but it prefers climates with an annual average temperature of 19°C and soils with 240 mm available water holding capacity at higher elevations (Mligo and Craufurd, 2005), which are prevalent in the Southern High Plains. Rao et al. (2003) and Mligo and Craufurd (2005) found that pigeonpea was least adapted to wet soil conditions, similar to cowpea (Mislevy et al., 2005). Consequently, pigeonpea has recently been promoted for grain and forage in the southern Great Plains (Rao et al., 2003; Bidlack et al., 2006; Rao and Dao, 2008). But that region has lower elevations than the Southern High Plains [approximately 400 m (Muir, 2002; Rao et al., 2003; Bidlack et al., 2006) vs. approximately 1,300 m (Lauriault and Kirksey, 2004; Contreras-Govea et al., 2009) for the southern Great Plains and the Southern High Plains, respectively] and higher precipitation [May through September, 500 mm in the southern Great Plains (Rao et al., 2003) vs. 280 mm in the Southern High Plains (Kirksey et al., 2003)].

No data are available about pigeonpea performance in the Southern High Plains of the USA. Consequently, the objective of this study was to compare forage yield and nutritive value of pigeonpea and cowpea in the Southern High Plains environment.

MATERIALS AND METHODS

Studies were conducted in 2006 and 2007 at the New Mexico State University Agricultural Science Center at Tucumcari, NM (35.20° N, 103.68° W; elev. 1,247 m), to compare forage production and nutritive value of 'GA-2' pigeonpea (University of Georgia, Athens, GA) to that of 'Iron & Clay' cowpea (Turner Seed, Breckinridge, TX). Different fields with different soil types and irrigation techniques were used each year. The change in fields was warranted to avoid volunteerism by the crops from the previous year and a change in available irrigation techniques. Seeding rates were calculated to establish 150,000 and 111,000 plants ha^{-1} for cowpea (Mislevy et al., 2005) and pigeonpea (Bidlack et al., 2006), respectively. Uninoculated seed was used for both studies because it was speculated that nodulation by either species could be poor locally due to soil factors. The average annual temperature and precipitation for this location are 14.4°C and 404.1 mm, respectively (Kirksey et al., 2003). The precipitation pattern in the area is continental, with approximately 80% (302.1 mm on average) falling from April through September (Kirksey et al., 2003). Weather data were collected from a National Weather Service station located within 1 km of the study areas (Figure 1).

In 2006, the soil was Canez fine sandy loam (fine-loamy, mixed, thermic Ustollic Haplargid), and the previous crop was sorghum x sudangrass that had followed a 7-year-old alfalfa (*Medicago sativa* L.) -grass mixture. Soil testing indicated a pH of 8.4 and N, P, and K levels of 10, 19, and 210 ppm, respectively, in the surface 30 cm. The seedbed was conventionally tilled and formed into beds on 0.91-m centers for furrow irrigation. Fertilizer (116-58-0 kg $N\text{-}P_2O_5\text{-}K_2O$ ha^{-1}) was applied preplant and incorporated, and was based on soil test recommendations for sorghum forage and because the legume seed was not inoculated. There were four randomized complete blocks in which individual plots were 15.24 x 3.66 m, with a single row planted down the center of each of the 4 beds. Planting took place 25 May using a 4-row John Deere flex-planter with a seed-metering cone on each planting unit. Furrow irrigations were applied every other week from planting until mid-August to achieve field capacity with each application for a total estimated application of approximately 457 mm. Micronutrient deficiency was apparent early in the growing season, and was most pronounced on cowpea. Consequently, a commercially available micronutrient solution (HiYield Liquid Iron and Other Micronutrients, Voluntary Purchasing Groups, Bonham, TX) containing Cu, Fe, Mn, S, and Zn

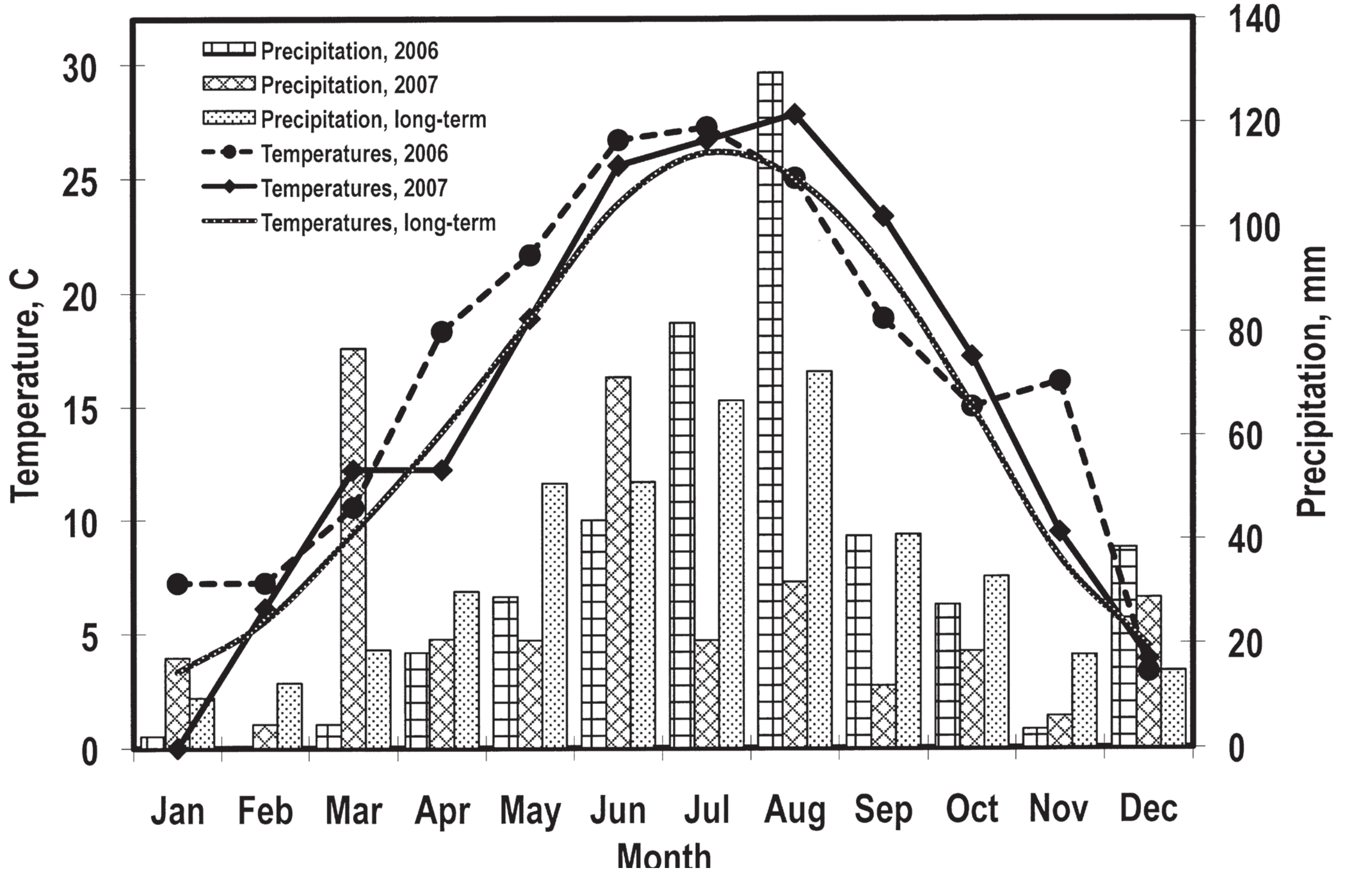

Figure 1. **Mean monthly air temperatures and total monthly precipitation during 2006 and 2007 and the long-term (1905–2005) averages at Tucumcari, NM, in the semiarid, subtropical Southern High Plains of the USA.**

was applied foliarly to all plots at the labeled rate after two of the irrigations.

In 2007, the soil type was Redona fine sandy loam (fine-loamy, mixed, superactive, thermic Ustic Calciargid) in a field that had been in native short prairie grasses for several decades. The pH of this soil was 7.2 and N, P, and K levels were 1, 2, and 19 ppm, respectively. There were three randomized complete blocks. Individual plots were 7.62 x 3.05 m with 4 rows spaced 0.76 m apart. Cowpea and pigeonpea were planted into a conventionally tilled flat seedbed under an overhead irrigation system on 30 May using the same planter that had been used in 2006, adjusted to the 0.76-m row spacing. Fertilizer (201-90-67 kg N-P_2O_5-K_2O ha^{-1}) was applied preplant and incorporated based on soil test recommendations for sorghum forage. Sprinkler irrigations (12.7 mm) were applied approximately every 3 d until harvest, resulting in approximately 470 mm applied for the growing season. Micronutrient deficiency was not observed.

A section (3.05 m in 2006 and 2.0 m in 2007) of a center row of each plot was harvested with hand pruners, leaving a 5-cm stubble on 25 September 2006 and on 14 or 19 September 2007 for pigeonpea and cowpea, respectively, when the pods from the first flush of blooms began turning brown, which was slightly later than the harvest timing described by Mislevy et al. (2005), but within the range of harvest dates used by Rao et al. (2003). In 2006, harvested material from each plot was chopped using a stationary Gehl Model FH188 harvester; a lawn chipper/shredder was used in 2007. Plot weights were measured in the field. A subsample of chopped material (approximately 300 g) from each plot was immediately weighed, dried in a forced-air oven at 65°C for 48 h, and reweighed to determine dry matter (DM) concentration and to convert field

Table 1. Dry Matter Yield and Nutritive Value of Cowpea and Pigeonpea and Results of Statistical Analyses By Year[1]

Variable	Units	Species		P-value
		Cowpea	Pigeonpea	
2006				
DM[2] yield	Mg DM ha^{-1}	6.39	3.59	0.0034
CP	g kg^{-1}	189	130	0.0361
ADF	g kg^{-1}	325	386	0.0675
NDF	g kg^{-1}	329	467	0.0125
TDN	g kg^{-1}	655	586	0.0686
2007				
DM yield	Mg DM ha^{-1}	5.07	4.06	0.2959
CP	g kg^{-1}	156	88	0.0046
ADF	g kg^{-1}	402	402	1.0000
NDF	g kg^{-1}	440	505	0.0122
TDN	g kg^{-1}	567	568	0.9866

[1]The study was conducted in the semiarid, subtropical Southern High Plains at Tucumcari, NM, USA, in different fields in 2006 and 2007.

[2]DM, CP, ADF, NDF, and TDN signify dry matter, crude protein, acid detergent fiber, neutral detergent fiber, and total digestible nutrients, respectively. Data are the means of four randomized complete blocks in 2006 and three randomized complete blocks in 2007.

weights to yield as Mg DM ha^{-1}. Dried samples were ground to pass a 1-mm screen and submitted to Ward Laboratories (Kearney, NE) for estimation of forage nutritive value [CP, acid detergent fiber (ADF), and neutral detergent fiber (NDF)] by near infrared spectroscopy (NIRS) using a universal equation developed from a broad spectrum of annual and perennial forage species. Total digestible nutrients (TDN) was calculated as part of the NIRS analysis.

Forage DM yield and nutritive value data were analyzed by year using SAS PROC MIXED procedures (SAS Institute, 2007) to determine if differences existed ($P <0.05$) between species. Replicate was considered random.

RESULTS AND DISCUSSION

Dry matter yield. Cowpea outyielded pigeonpea in 2006 and had numerically higher yield in 2007 (Table 1). Forage yields in this study compared well with those measured by others. In the southern Great Plains (500 mm average May through September precipitation), Bidlack et al. (2006) reported rainfed pigeonpea yields of 1.9 to 4.6 Mg DM ha^{-1}, with a mean yield over three years of 2.3 Mg DM ha^{-1} at populations and growing season length equivalent to the present study. In the humid subtropical southeastern USA, Mislevy et al. (2005) reported cowpea yields of 6.5 Mg DM ha^{-1}, while at the same location, Rao et al. (2003) measured pigeonpea leaf and stem yield of 6.0 Mg DM ha^{-1}. To the south of Rao et al. (2003) and Bidlack et al. (2006), Muir (2002) measured irrigated hand-plucked forage cowpea yields of 4.3 to 5.6 Mg DM ha^{-1}. While pigeonpea was not included in that study, 290 mm of April to September precipitation was not sufficient for adequate forage production of several annual legumes, including cowpea (Muir, 2002). April through September precipitation in 2006 and 2007 at Tucumcari was 343 and 177 mm, respectively, in addition to the irrigation applications. With the application of irrigation water each year, available soil water should have been sufficient (>240 mm) to optimize pigeonpea yield (Mligo and Craufurd, 2005). Factors associated with lower productivity by pigeonpea compared to studies conducted elsewhere could include climate and soil differences. Annual temperatures at Tucumcari are approximately 5°C lower than the location of Rao et al. (2003) and the higher elevations used by Mligo and Craufurd (2005). Additionally, the soils used by those researchers (Rao et al., 2003; Mligo and Craufurd, 2005) were nearly neutral to heavily acidic (ISRIC, 2001), while the soils in the present study were nearly neutral to alkaline, with pH of 7.2 (2007) and 8.4 (2006).

Forage nutritive value. Cowpea nutritive value was higher in this study as indicated by greater CP and lower NDF than pigeonpea (Table 1). Nutritive value data estimated by NIRS for the present study are also consistent with those reported in the literature. Mislevy et al. (2005) measured cowpea CP of 140 to 220 g kg^{-1} in a one-cut system.

For pigeonpea forage, Karachi and Matata (1996) reported CP concentrations of 205 g kg^{-1}, which is considerably higher than pigeonpea CP in the present study, while Rao et al. (2003) measured 135 g kg^{-1} CP and 580 g kg^{-1} digestibility, which are consistent with the data reported in Table 1 for CP. Still, the direct comparison of cowpea and pigeonpea in the present study demonstrates higher CP and lower NDF for cowpea than for pigeonpea. Lower NDF has been associated with greater intake potential by livestock (Chapko et al., 1991). Chapko et al. (1991) concluded that oat forage was higher in nutritive value than barley forage based on a 17 g kg^{-1} difference in CP and a 67 g kg^{-1} difference in NDF, both of which are considerably lower than the differences measured between cowpea and pigeonpea for those same variables in the present study (Table 1).

CONCLUSION

These data indicate that cowpea forage yield and nutritive value are superior to pigeonpea under irrigation in the Southern High Plains of the USA and similar higher elevation, semiarid, subtropical environments. Lower productivity of pigeonpea in this environment compared to other locations described in the literature may have been related to differences in climatic and soil effects.

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