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Establishment of Tropical Annual Legumes Sod-Seeded into Bermudagrass or Prepared Seedbed

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ABSTRACT

Warm-season annual legumes such as cowpea (*Vigna unguiculata* [L.] Walp) and lablab (*Lablab purpureus* [L.] Sweet) have the potential to be used for grazing and/or hay crop throughout the Southeastern United States. Two studies were conducted at Texas A&M AgriLife Research, Overton, Texas to evaluate cowpea and lablab dry matter (DM) production and nutritive value when sod seeded into bermudagrass (*Cynodon dactylon* (L.) pers) or on prepared seedbed. In Experiment I, 'Iron-and-Clay' cowpea were direct-drilled on June 19 at 0, 56, 112, and 168 kg/ha seeding rates into chemically (Gramoxone®) suppressed or untreated 'Coastal' bermudagrass. A single harvest of cowpea to assess total dry matter was made in August. The dry matter was influenced by chemical treatment and seeding rate. Crude protein concentration in bermudagrass increased with increased seeding rate of cowpea, which indicated some direct nitrogen transfer from the cowpea to bermudagrass. In Experiment II, three seeding rates (28, 56, and 112 kg/ha) were evaluated for Iron-and-Clay cowpea and three selections of lablab for DM and nutritive value. At two harvest dates, DM production and percent stand were greatest at 112 kg/ha seeding rate. Crude protein concentrations in leaves of cowpea and lablab at both harvest dates remained relatively constant at 26.5%.

KEY WORDS: cowpea, lablab, bermudagrass, seeding rate, legumes

INTRODUCTION

Incorporating legumes into warm-season grass grazing systems may be an increasingly desirable option for livestock producers. Warm-season legumes have greater nutritive value than warm-season grasses as well as the ability to fix atmospheric N_2; thus decreasing the need for commercial N fertilizers. With increasing fertilizer costs, landowners often look for a more economical alternative for pasture production. The rise in fertilizer costs as fossil-fuel costs increase may increasingly favor legumes over N fertilizers (Muir et al. 2011). Hybrid bermudagrasses are grown on 10 to 12 million ha in the US (Taliaferro et al. 2004). The use of warm-season annual legumes as companion crops with these perennial grass pastures has been limited. The use of warm-season annual legumes has been limited to cropping system areas as a green manure crop and for

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wildlife supplemental forage plots. To date, there is not a substantial amount of grazing research to promote the utilization of cowpea and lablab in grazing systems.

Cowpea, a warm-season annual legume, are well adapted to the typically infertile, acidic soils and hot, dry summers of the southeastern U.S (Pitman et al. 1992). Cowpea are traditionally used as a green manure crop in cropping system for grain or fiber. In tropical areas, cowpea has produced 3.5 to 8.5 Mg DM/ha/year during the 6-month growing season (Hussein et al. 1994). In Texas, cowpea was persistent from June to November during a two-year clipping study and produced on average 4.4 Mg DM/ha/year (Muir et al. 2008). Vendramini et al. (2011) showed a decrease in forage dry matter when cowpea was intercropped with bahiagrass pastures in Florida. When warm-season annual legumes were intercropped with forage sorghum in the southern High Plains, DM yield was not affected. Lablab had a greater impact on forage crude protein concentration when intercropped with forage sorghum than a monoculture of forage sorghum (Contreras-Govea et al. 2011).

The cowpea cultivar, Iron and Clay, is a varietal mixture with an indeterminate growth habit and regrowth potential, making it suitable for a summer forage crop (Muir et al. 2008; Foster et al. 2009). Lablab is a vining, herbaceous tropical legume with high nutritive value as a forage or browse for ruminants. Useful attributes of lablab include drought tolerance, palatability, and nutritive value, excellent forage yields, and adaptation to diverse environmental conditions. The lablab cultivar, 'Rongai,' was released by the New South Wales Department of Agriculture in 1962 (Wilson et al. 1962). Rongai is very late maturing and generally does not flower in northeast Texas before frost in mid-November. The lablab cultivar, 'Rio Verde,' was released by the Texas Agricultural Experiment Station in 2008 (Smith et al. 2008). Rio Verde was developed through selection for tolerance to defoliation, forage production potential, and seed production in Texas. Rate of seeding often affects seasonal and total dry matter (DM) production of annual forages (Smith et al. 2008). Nutritive value and drought tolerance of both cowpea and lablab makes them a potentially high demand crop to offset fertilizer expenses. The costs and establishment success and lower productivity of forage legume pastures, have limited interest of landowners in the introduced warm-season legumes during recent decades. However, the rise in fertilizer costs may increasingly favor legumes over N fertilizers.

Soil and climatic conditions of east Texas are ideal for growth of cowpea and bermudagrass; however, there is no known scientific information on growing these crops together for grazing. The objectives of this study were to ascertain the influence of a chemical desiccant on bermudagrass, and multiple seeding rates of cowpea on the establishment, dry matter production, and crude protein concentration of bermudagrass-cowpea forage. The objectives of the second study were to assess the effects of three seeding rates on dry matter production of cowpea and lablab, and on nutritive value for leaf and stem components at each harvest.

MATERIALS AND METHODS

Experiment 1. Iron and Clay cowpea was direct-drilled into a well-established Coastal bermudagrass sod at the Texas A&M AgriLife Research & Extension Center, Overton, TX (32°18'12.59 N; 94°58'43.41 W). The bermudagrass sod had either been sprayed with Gramoxone® (paraquat dichloride) at 0.6 kg ai/ha or not been sprayed. The experimental design was a split block with the herbicide treatment serving as main blocks and the cowpea-seeding rates served as subplots. Cowpea were sod-seeded at 0 (control), 56, 112, and 168 kg/ha into each of four replications, and the seeding rate subplot size was 1.5 x 6 m. A 3 m fallow buffer area existed on all sides of the plots. Cowpea was planted on June 19, 1989 and a single harvest was made on August 16. The bermudagrass sod was mowed to 5-cm stubble before planting. The plot area was fertilized with 336 kg/ha of 6-24-24 (20 kg of N; 81 kg of P_2O_5; 81 kg of K_2O) at planting. Nitrogen was applied to support the bermudagrass stand and not the cowpea.

Plots were harvested with a sickle-type power mower and all plant material was removed and separated into cowpea and bermudagrass components before weighing. The harvested forage was weighed, and a subsample taken for cowpea leaf:stem separations and subsequent chemical analyses of both the bermudagrass and cowpea. The separated biomass was then added mathematically to determine total yield. Data were analyzed with PROC GLM, and the Newman-Keuls multiple range tests were used to detect differences between treatments (SAS 2008).

Experiment 2. Iron-and-Clay cowpea, Rongai lablab, Rio Verde lablab, and one experimental lablab cultivar, TX 98-1, were hand broadcast planted, May 7, 2004 on prepared seedbed followed by a roller packer to insure good seed to soil contact. Seeding rates of each legume were made in 3 x 6 m plots with four replicates. The experimental design was a randomized complete block. A 3 m fallow buffer area existed on all sides of the plots. The plots were mechanically harvested to an 8-10 cm height initially on July 7 and regrowth was harvested on November 11.

The harvested cowpea and lablab were weighed, and a subsample taken for leafs: stem separations and subsequent chemical analyses of the leaf and stem portions of the legumes. Samples were oven-dried at 60°C for 72 hours. Plot DM yields were determined for each seeding rate of the four tropical legumes. Leaf and stem separations were made to assess percent crude protein, NDF, and ADF for each legume at each harvest date. The leaf and stem NDF and ADF were determined using methods described by Van Soest et al. (1991). Leaf and stem samples were analyzed for crude protein (CP; micro-Kjeldahl; total N x 6.25) using AOAC (1991) procedures. Two independent assessors visually rated each paddock for percent legume stand. Data were analyzed with PROC GLM, and the LSD means separation test was used to detect differences between treatments (SAS, 2008). Fixed effects were seeding rate and cultivar. Random effects were reps. Differences were considered significant at $P < 0.05$.

RESULTS & DISCUSSION

Experiment 1: Sod Seeded. The period affecting the success rate of growing an annual legume in a bermudagrass sod is establishment of the annual forage, especially those that are broadcast onto the soil surface. Compared with perennials, however, annual legumes tend to have vigorous seedlings that facilitate rapid establishment following rainfall (Skousen et al. 1987). Bermudagrass is a warm-season perennial sod-forming grass that is adapted to a range of soils, climates, and management systems. In other words, these grasses persist because they are tolerant of poor management. The fact that they form dense sods creates a challenge in the establishment of warm-season annual legumes (Muir et al. 2004). A time was chosen (June 16) when a well-established bermudagrass had potentially high growth rates in which to assess the impact of a chemical desiccant and cowpea-seeding rate on establishment and subsequent dry matter production of both cowpea and bermudagrass. Total bermudagrass plus cowpea forage yield during the 58-day, single harvest period was approximately 4,928 kg/ha and the combined total DM was not affected ($P > 0.48$) by the chemical desiccant treatment. The individual bermudagrass and cowpea components, however, were affected by the desiccant application. Bermudagrass yields declined ($P < 0.01$) from 4,724 to 3,558 kg/ha by the chemical desiccant. In contrast, cowpea dry matter production increased ($P < 0.01$) about 9-fold from 168 to 1,476 kg/ha by desiccating the bermudagrass. At the time of harvest, cowpea ranged from 0.6 to 1 m in height and exhibited sufficient rapid growth to produce a canopy cover above the bermudagrass. The untreated bermudagrass likely competed for soil moisture and light that severely restricted successful establishment and growth of the cowpea.

The interaction of seeding rate and bermudagrass sod treatment had an ($P < 0.01$) impact on bermudagrass and cowpea production (Table 1). An approximate 25% reduction in bermudagrass yield was evident at the 168 kg/ha seeding rate of cowpea. Bermudagrass yield in the desiccated areas was reduced by nearly 50% at both the 112 and 168 kg/ha-seeding rate of cowpea. Seeding rate influenced cowpea yield differently in treated and untreated bermudagrass sod. In the untreated sod, cowpea production increased nearly 10-fold in the 56 kg/ha seeding rate plots compared to the 168 kg/ha seeding rate plots. In the chemically desiccated sod, there was a doubling of cowpea yield by seeding either 112 or 168 kg/ha compared with the 56 kg/ha. Cowpea yields from the 56 kg/ha seeding rate were improved more than 20-fold by chemically desiccating the bermudagrass sod compared to the control. Although the magnitude of yield improvement was only 5-fold in the 168 kg/ha seeding rate plots, the total production of cowpea forage increased 416% because of the chemical treatment. If sod-seeding a warm season annual legume such as cowpea or lablab, a desiccant to reduce competition from any warm-season perennial forage is recommended. Untreated aggressive perennial grasses such as bermudagrass will compete for soil moisture and light that can severely restrict successful establishment and growth of legumes.

Table 1. Total DM yield of bermudagrass and cowpea as influenced by seeding rate and desiccant.

	Cowpea seeding rate (kg/ha)			
	0	56	112	168
Forage	DM (kg/ha)			
Bermudagrass				
Untreated	5212 a	4796 a	4740 a	4146 b
Desiccant	4633 a	4157 a	2840 b	2601 b
Cowpea				
Untreated	0 c	52 b	125 ab	495 a
Desiccant	0 c	1156 b	2197 ab	2554 a
Total	4924 a	5080 a	4952 a	4898 a

[1]Means in the same row followed by a different letter differ ($P < 0.01$) according to Newman-Keuls multiple range tests.

In general, cowpea was 60% leaf and 40% stem across all seeding rates. Average crude protein concentration of cowpea leaf was 21% (Table 2) and was not influenced by seeding rate or bermudagrass treatment. Cowpea stems contained an average 8.9% crude protein and were likewise unaffected by any of the treatments. Crude protein concentration of bermudagrass plots suggests some direct transfer of nitrogen from the cowpea to the grass sod. The crude protein concentration of bermudagrass grown alone was 5.1%, whereas, bermudagrass grown in association with either 112 or 168 kg/ha-seeding rate of cowpea was 6.5 and 6.7% ($P < 0.02$), respectively.

Table 2. Crude protein concentration of bermudagrass and cowpea.

	Cowpea seeding rate (kg/ha)			
	0	56	112	168
Forage	Crude protein (%)			
Bermudagrass	5.1 b	5.6 ab	6.5 a	6.7 a
Cowpea Leaf	0 b	21.2 a	21.0 a	21.6 a
Cowpea Stem	0 b	8.9 a	8.9 a	8.8 a

[1]Means in the same row followed by a different letter differ ($P < 0.01$) according to Newman-Keuls multiple range tests.

Calculations were made to quantify crude protein yield (kg/ha) by multiplying dry matter yields and crude protein percentage (Table 3). Total crude protein yield of bermudagrass was unaffected by the seeding rate ($P > 0.65$) and was approximately 247 kg/ha. However, the desiccated bermudagrass produced 28% less ($P < 0.01$) crude protein yield than that of the non-treated bermudagrass. Crude protein yield from cowpea leaf, stem and leaf + stem exhibited similar trends in that forage from the 158 kg/ha seeding rates had greater total crude protein yield than forage from the 0 and 56 kg/ha seeding rates. By combining grass and cowpea into a total crude protein yield, plots seeded to 156 kg/ha cowpea yielded nearly twice ($P < 0.01$) as much total crude protein yield as did the non-seeded bermudagrass only plots.

Table 3. Total crude protein yield from bermudagrass and cowpea forage.

	Cowpea seeding rate (kg/ha)			
	0	56	112	168
Forage	Crude protein yield (kg/ha)			
Bermudagrass	255 a	254 a	243 a	221 a
Cowpea	0 c	109 b	197 ab	253 a
Leaf	0 c	92 b	158 ab	204 a
Stem	0 b	168 b	39 a	49 a
Grass + cowpea	255 c	363 b	440 ab	473 a

[1]Means in the same row followed by a different letter differ ($P < 0.01$) according to Newman-Keuls multiple range tests.

Results of this study indicated that cowpea may be successfully grown in an actively growing bermudagrass sod during the summer months. However, cowpea DM yield was influenced primarily by sod treatment and seeding rate. Bermudagrass crude protein concentration was enhanced at cowpea seeding rates 112 and 168 kg/ha. There appears to be some minimal active transfer of nitrogen from the cowpea to the companion bermudagrass. In a greenhouse study, Redmon et al. (1995) indicated nitrogen transfer occurred between warm-season annual legumes and a warm-season annual grass.

Nitrogen transfer from partridge peas and cowpea to pearl millet was 34% and 32% respectively (Redmon et al. 1995). Other researchers (Wilson et al. 1937; Eaglesham et al. 1981; Dakora et al. 1987) have demonstrated increased levels of DM yield of non-N-fixing plants when grown in association with warm-season legumes, although field studies have not shown consistent results. Dakora et al. (1987) reported greater yields of both cowpea and millet when grown as an intercrop as compared to plants grown in monocultures. However, Van Kessel and Roskoski (1988) were unable to detect any N transfer from cowpea to corn in a field trial using the ^{15}N dilution method.

Experiment 2: Prepared Seedbed and Legume Cultivar Evaluation. On the first harvest, DM production of all legumes was increased when seeding rate increased from 28 to 112 kg/ha (Table 4). Dry matter production of all legumes was not different among seeding rates for the second harvest. Total seasonal DM production of all legumes was increased when seeding rate increased from 28 to 112 kg/ha. The total seasonal DM yield from 112 kg/ha seeding rate was double that from 28 kg/ha seed. Percent stand was greater from 112 kg/ha seeding rate at the first harvest. Second harvest percent stand was not different among seeding rates. On the first harvest, cowpea produced more DM than the other legumes at the 28 kg/ha seeding rate (Table 5). There were general trends for DM yield to be least at the 28 kg/ha seeding rate compared to 56 or 112 kg/ha seeding rate. Muir et al. (2001) evaluated Combine and Iron and Clay cowpea varieties in a two-year study and reported that Iron and Clay cowpea yielded 4,308 kg DM/ha over two harvests, and Combine cowpea produced 2,152 kg DM/ha in a single harvest. Foster et al. (2009) reported cowpea production of 2,000 and 4,000 kg/ha over a growing season in north Florida.

Table 4. Yield (DM) and percent stand for legumes planted at three seeding rates.

	Harvest 1		Harvest 2		Total
Seeding rate (kg/ha)	DM yield (kg/ha)	Stand (%)	DM yield (kg/ha)	Stand (%)	DM yield (kg/ha)
28	956 a	37 a	2717 a	67 a	3577 a
56	1626 b	57 a	3723 ab	78 ab	5142 b
112	2154 b	83 c	4730 b	90 a	6792 c

[1]Means in the same row followed by a different letter differ ($P < 0.05$) according to LSD means separation.

At the second date, November 11, Rongai seeded at 112 kg/ha had more than twice as much DM production as the other legumes. Dry matter yield per hectare of lablab varies with rainfall, soil condition and time of seeding, but work in Australia suggested that 4,000 kg/ha was not unusual (Mayer et al. 1986; Cameron 1988). In this study there were general trends for DM yield to decrease when seeding rate was increased from 56 to 112 kg/ha for lablab. This suggests that an increase in plant density could create competition leading to a decrease in DM yield. Specific seasonal versus total DM production objectives for these legumes, which may include hay, silage, grazing, green manure, or wildlife browse, will determine the choice of seeding rate to be used. Nutritive value analyses were generally similar among legumes with leaf components having greater nutritive value compared to stems (Table 6). One of the most important aspects of nutritive value was the crude protein concentration in leaves at both harvest dates, which remained high and relatively constant at about 25 to 28%. Murphy and

Colucci (1999) reported the average concentrations of CP over a 147-day growing season in the leaves to be 24.7%. In general, tropical legumes tend to be greater in crude protein and lower in fiber than tropical grasses (Van Soest, 1994).

Table 5. Yield (DM) from four tropical legumes planted at three seeding rates.

		Cultivar			
Harvest Date	Seed Rate (kg/ha)	Cowpea	Rongai	TX 98-1	Rio Verde
		DM yield (kg/ha)			
7/7	28	1740 a[1], A[2]	385 b, B	680 b, B	1019 ab, A
7/7	56	1847 a, A	1110 a, B	1294 a, A	2255 a, A
7/7	112	2439 a, A	2208 a, A	2300 a, A	1710 a, A
11/11	28	2972 ab, A	4405 a, B	2087 ab, B	1407 b, A
11/11	56	2416 b, A	4514 a, B	3924 a, A	4038 a, A
11/11	112	3239 b, A	8631 a, A	3198 b, AB	3849 b, A
Total	28	4675 a, A	4766 a, B	2460 b, B	2408 b, B
Total	56	4031 a, A	5303 a, B	5301 a, A	5933 a, A
Total	112	5617 b, A	10643 a, A	5640 b, A	5266 b, AB

[1]Means in the same row followed by a different letter differ ($P < 0.05$) according to LSD means separation.
[2]Means in a column, within a harvest date, followed by a different letter differ ($P < 0.05$) according to LSD means separation.

Table 6. Nutritive value of leaf and stem components of four tropical legumes.

			Cultivar			
Harvest date	Plant part	NUTR[1]	Cowpea	Rongai	TX 98-1	RioVerde
			% DM basis			
7/7	Leaf	Crude protein	28.7	27.2	27.4	26.0
7/7	Stem	Crude protein	8.4	9.6	8.9	9.7
7/7	Leaf	NDF	47.0	53.4	50.0	48.6
7/7	Stem	NDF	56.1	57.2	58.1	56.8
7/7	Leaf	ADF	22.0	29.2	28.1	27.9
7/7	Stem	ADF	43.4	42.6	43.2	41.4
11/11	Leaf	Crude protein	24.0	24.1	25.5	25.5
11/11	Stem	Crude protein	13.7	10.2	11.4	10.6
11/11	Leaf	NDF	49.6	48.1	47.2	37.5
11/11	Stem	NDF	43.6	49.9	55.5	51.8
11/11	Leaf	ADF	24.4	27.6	26.7	22.2
11/11	Stem	ADF	28.3	35.1	38.7	36.3

[1]NUTR = nutritive value; NDF = neutral detergent fiber; ADF = acid detergent fiber

CONCLUSIONS

These studies also showed that seeding rate could influence dry matter yield of cowpea and lablab whether sod seeding or seeding into a prepared seedbed. Results from the cowpea seeding rate experiment showed a decrease in bermudagrass production when a desiccant was used prior to sod-seeding a warm season annual legume. We can conclude that for sod seeding into bermudagrass a desiccant should be used to reduce competition for light and moisture. In the chemically desiccated sod, cowpea dry matter yield increased as seeding rate increased from 56 kg/ha to 112 and 168 kg/ha. For prepared seedbed, dry matter yield and percent stand of cowpea were greatest at 112 kg/ha seeding rate. In the second study, there were general trends for DM to decrease when seeding rate was increased to 112 kg/ha for lablab. Overall seeding rate recommendations for cowpea drilled at 56 kg/ha or broadcast at 112 kg/ha. Our recommended lablab seeding rate was 56 kg/ha. For implementation of these results some potential management practices to ensure success with incorporating cowpea or lablab may include: (1) early planting of legumes (May to early June in northeast Texas); (2) mechanical disturbance or chemical desiccation of bermudagrass sod; (3) application of non-nitrogen fertilizer; (4) single harvest of forage if for hay or silage; (5) attention to stubble height and rainfall patterns if for multiple harvests.

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