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RESEARCH

Forage Accumulation, Nutritive Value, and Persistence of 'Mulato II' Brachiariagrass in Northern Florida

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ABSTRACT

'Mulato II' [*Brachiaria* spp.] is a warm-season grass with excellent nutritive value adapted to tropical regions; however, its herbage production and persistence in subtropical locations is unknown. Grazing and clipping studies were conducted in 2008 and 2009 in Marianna and Gainesville, FL, respectively. The treatments for the grazing study were beef heifers (*Bos* spp.) grazing Mulato II, 'Tifleaf 3' pearl millet [*Pennisetum glaucum* (L.) R. Br.], or 'Hayday' sorghum-sudangrassgrass [*Sorghum bicolor* (L.) Moench] pastures on a continuous stocking rate. In 2008, there were no differences in herbage allowance (HA) (0.9 kg dry matter [DM] kg^{-1} live weight [LW]), average daily gain (ADG) (0.5 kg d^{-1}), and gain per hectare (168 kg) among treatments. However, Mulato II had greater HA (2.0 vs. 0.7 kg DM kg^{-1} LW) and ADG (0.78 vs. 0.41 kg d^{-1}) than Tifleaf 3 and Hayday and similar gain per hectare (302 kg) in 2009. The treatments for the clipping study were Mulato II, evaluated as an annual and perennial, 'Tifton 85' bermudagrass (*Cynodon* spp.), Tifleaf 3 pearl millet, and Hayday sorghum-sudangrass. In 2008, Hayday and Tifleaf 3 established more rapidly than Mulato II; however, Mulato II grew later in the fall. In 2009, the perennial treatments (Mulato II and Tifton 85) had overall greater herbage accumulation than the annual treatments. In the clipping study, Tifton 85 had greater ground cover than Mulato II perennial in 2009 (73 vs. 36%) and 2010 (73 vs. 12%). Mulato II may be used as a high quality, short-lived perennial warm-season grass in subtropical areas.

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Abbreviations: ADG, average daily gain; AU, animal units; CP, crude protein; DM, dry matter; HA, herbage allowance; HAR, herbage accumulation rate; HM, herbage mass; IVDOM, in vitro digestible organic matter; LW, live weight.

GRASSES in the *Brachiaria* (Trin.) Griseb. genus are the most widely grown forages in tropical America, occupying over 80 million ha (Boddey et al., 2004). 'Mulato' was the first released hybrid in the *Brachiaria* genus and originated from crossing ruzigrass [*Urochloa ruziziensis* (R. Germ. & C. M. Evrard) Crins (syn. *Brachiaria ruziziensis* Germain and Evrard); clone 44-6] and palisadegrass {*Urochloa brizantha* (Hochst. ex A. Rich.) R. D. Webster [syn. *Brachiaria brizantha* (A. Rich.) Stapf]; CIAT 6297}. Subsequently, 'Mulato II' was released because it had greater seed production and similar forage production and nutritive value as Mulato. Mulato II is the result of three generations of crosses and screening conducted by the International Center for Tropical Agriculture (CIAT) in Cali, Colombia, including original crosses between ruzigrass × signalgrass [*Urochloa decumbens* (Stapf) R. D. Webster] (cv. Basilisk; apomictic tetraploid) (Argel et al., 2007). Mulato II is apomictic and a vigorous, semierect grass. Plant height, without the inflorescence, ranges from 90 to 100 cm and the plant architecture is characterized by 9 to 10 leaves per stem, arranged horizontally, to form a dense, leafy plant canopy.

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Vendramini et al. (2010) compared herbage accumulation and nutritive value of 10 different species and cultivars of warm-season grasses in South Florida and concluded that Mulato II was among the species with greatest in vitro true digestibility (670 g kg^{-1}). Inyang et al. (2010b) harvested Mulato II at 4-wk intervals from September to November in South Florida and observed that crude protein (CP) ranged from 100 to 180 g kg^{-1} and in vitro digestible organic matter (IVDOM) from 640 to 700 g kg^{-1}. These attributes favor use of Mulato II as an alternative high nutritive value warm-season grass for Florida's forage-livestock systems. However, Mulato II and brachiariagrasses in general are adapted to tropical regions that rarely experience temperatures below 0°C. It is not known if Mulato II can survive in cooler subtropical regions that experience frequent frosts and freezes during winter, usually located between latitude 25 and 30° N.

Warm-season grasses in this region that currently serve as a source of high quality forage to livestock include bermudagrass [*Cynodon dactylon* (L.) Pers.], pearl millet, and sorghum-sudangrass. Bermudagrasses are important warm-season perennials in the United States with approximately 15 million ha used for livestock grazing and hay (Taliaferro et al., 2004). Tifton 85 bermudagrass is a hybrid between a South African bermudagrass and 'Tifton 68' stargrass (*Cynodon nlemfuensis* Vanderyst) that is taller and had larger culms, broader leaves, and darker color than other bermudagrass hybrids (Burton et al., 1993). Vendramini et al. (2010) observed that Tifton 85 had similar CP concentration (approximately 120 g kg^{-1}) and in vitro true digestibility to Mulato II (approximately 670 g kg^{-1}) but with greater neutral detergent fiber digestibility (570 vs. 530 g kg^{-1} for Tifton 85 and Mulato II, respectively). Pearl millet and sorghum-sudangrass are upright growing, leafy, drought tolerant, and responsive to N fertilization (Fribourg, 1995). They can be harvested as hay or silage or grazed by ruminants with greater nutrient requirements. Rapid growth rates over a relatively short period make grazing management of warm-season annual grasses difficult (McCartor and Rouquette, 1977). McCartor and Rouquette (1977) reported that the stocking rate required to maintain a given grazing pressure varied from 3.7 to 11.3 animals ha^{-1} during a 90-d grazing season, and consistent liveweight gains were difficult to maintain with summer annuals. Hill et al. (1999) observed that beef heifers grazing 'Tifleaf 2' pearl millet had average daily gain (ADG) of 0.68 kg d^{-1} and gain per hectare of 534 kg in an 84-d grazing study. According to Fontaneli et al. (2001), sorghum had CP and IVDOM concentrations of 146 and 678 g kg^{-1}, and they suggested seeding 3 to 6 wk apart as a good strategy for improving yield distribution and producing high nutritive value forage for nearly 5 mo.

Based on the literature, it is likely that Mulato II has similar nutritive value to Tifton 85, pearl millet, and sorghum-sudangrass, but the herbage accumulation and persistence of Mulato II in subtropical areas is unknown. The objectives of this study were (i) to compare herbage characteristics and animal performance of beef heifers grazing Mulato II, Tifleaf 3, or Hayday and (ii) to evaluate herbage accumulation, nutritive value, and persistence of Mulato II in a subtropical area with recurring freezing temperatures during the winter. A grazing and a clipping study were conducted to address objectives 1 and 2, respectively.

MATERIALS AND METHODS

Grazing Study

The study was conducted at the North Florida Research and Education Center, Marianna, FL (30°52′ N, 85°11′ W, 34 m altitude). The animals were cared for using acceptable practices (FASS, 1999) approved by the University of Florida. The periods of the study were from 25 July through 19 Sept. 2008 (56 d) and 14 July to 22 Oct. 2009 (100 d). The soil at the research site was a Fuquay coarse sand (loamy, kaolinitic, thermic Arenic Plinthic Kandiudults) and Orangeburg loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults). Before initiation of the grazing trial, mean soil pH (in water) was 6.2. Mehlich-I (0.05 M HCl and 0.0125 M H_2SO_4) extractable P, K, Mg, and Ca concentrations in the Ap1 horizon (0- to 15-cm depth) were 41, 320, 70, and 275 mg kg^{-1}.

Treatments were three forage species, Tifleaf 3 pearl millet, Hayday sorghum-sudangrass, and Mulato II, arranged in a completely randomized design with three replicates. Pastures (0.6-ha experimental units) were established on 12 June 2008 and 3 June 2009 in a prepared seedbed with seeding rates of 11, 33, and 33 kg ha^{-1} for Mulato II, Tifleaf 3, and Hayday, respectively. The pastures were fertilized with 78 kg N, 10 kg P, and 68 kg K ha^{-1} approximately 3 wk after planting. An additional 67 kg N ha^{-1} was applied in August of both years. The N fertilizer source was ammonium nitrate. The pastures were sprayed on 15 July 2008 with 2-4 D [(2,4-dichlorophenoxy) acetic acid] at a dose of 1.0 kg a.i. ha^{-1} to control broadleaf weeds.

Pastures were stocked continuously using a variable stocking rate. Two heifers (Angus crossbred) with initial body weight of 461 ± 49 and 392 ± 33 kg for 2008 and 2009, respectively, were assigned as testers to each experimental unit such that body weight was similar (±5 kg) across all experimental units. "Put and take" heifers of comparable age and weight to the testers were used to maintain similar forage stubble height (approximately 30 cm) across experimental units. This height was selected because Clapp and Chamblee (1970) observed increased herbage accumulation and regrowth vigor when pearl millet and sorghum-sudangrass were harvested at a 25-cm instead of an 8-cm stubble height. In addition, Inyang et al. (2010a) observed that Mulato pastures stocked at 8 heifers ha^{-1} had stubble height of approximately 30 cm, which increased herbage accumulation rates and gain per hectare when compared to pastures stocked at 12 heifers ha^{-1} and grazed to a stubble height of approximately 10 cm.

Pasture and Animal Responses

Pastures were sampled just before initiation of grazing and every 14 d during the grazing season. Herbage mass was determined by clipping four random, 0.25-m^2 quadrats in each experimental unit to a 5-cm stubble height. The forage was dried at 60°C and herbage mass (HM) (kilograms dry matter [DM] per hectare) calculated. Because cattle were resident on these pastures at all times, a cage technique was used to measure herbage accumulation. Three 1-m^2 cages were used per experimental unit, and they were placed in the pasture at the initial sampling date. After 28 d, the cages were moved to a new location where pasture canopy height was similar to the pasture average. Herbage accumulation rate (HAR) was calculated as the change in HM during the 28 d that the cage was in a single location within the pasture. Herbage allowance (HA) was calculated as the average HM divided by the average total heifer liveweight during that month (Sollenberger et al., 2005). Average stocking rate was calculated using the number of animal units (AU) (450 kg live weight) divided by the grazing period.

Hand-plucked samples to analyze for herbage CP and IVDOM were collected at approximately 30 randomly chosen sites from each pasture at the initiation of grazing and every 14 d thereafter. The objective of this sampling technique was to represent the diet consumed by the grazing animal. Herbage was composited across sites within an experimental unit, dried at 60°C for 48 h in a forced-air oven to constant weight, and ground in a Wiley mill (Model 4, Thomas-Wiley Laboratory Mill, Thomas Scientific, Swedesboro, NJ) to pass a 1-mm stainless steel screen. Samples were analyzed for IVDOM using the two-stage technique described by Tilley and Terry (1963) and modified by Moore and Mott (1974). Nitrogen concentration was determined using a micro-Kjeldahl method, a modification of the Al block digestion technique described by Gallaher et al. (1975). Crude protein was determined by multiplying N concentration by 6.25.

Cattle were weighed at initiation of the experiment and every 28 d thereafter. Weights were taken at 0800 h following a 16-h feed and water fast. Average daily gain was calculated for each 28-d period and for the entire grazing season. Gain per hectare in each 28-d period was determined based on the ADG of the testers multiplied by the number of heifers within the pasture during that period and adjusted to a hectare basis.

Statistical Analysis

Response variables were ADG, gain per hectare, HM, HAR, HA, CP, and IVDOM. The data were analyzed using PROC MIXED of SAS (SAS Institute, 1996) with forage species and month as fixed effects. Month was analyzed as a repeated measure. Replicate and its interactions were considered random effects. The data were analyzed by year because experimental periods differed between years. Treatments were considered different when $p < 0.10$. Interactions not discussed were not significant ($p > 0.10$). The means reported are least squares means, and they were compared using PDIFF (SAS Institute, 1996).

Clipping Study

The study was located at the University of Florida Beef Research Unit, Gainesville, FL (29°44′ N, 82°16′ W, 48 m altitude). The experiment was conducted from June 2008 to June 2010. The soils at the research site are Chipley sand (Thermic, coated Aquic Quartzipsamments) or Adamsville fine sand (uncoated, hyperthermic, Aquic Quartzipsamments). Before initiation of the study, mean soil pH (in water) was 6.1. Mehlich-I extractable P, K, Mg, and Ca in the Ap1 horizon (0- to 15-cm depth) were 82, 49, 72, 473 mg kg^{-1}, respectively.

Treatments were Mulato II "annual" (planted in 2008 and 2009), Mulato II "perennial" (planted in 2008 only), Tifton 85 (planted in 2008), and Tifleaf 3 pearl millet and Hayday sorghum-sudangrass (both planted in 2008 and 2009) arranged in a randomized complete block design with four replicates. The annual treatment for Mulato II was included to compare the use of this grass with warm-season annual species pearl millet and sorghum-sudangrass. The perennial Mulato II treatment was included to compare persistence and productivity over time with Tifton 85 bermudagrass.

Plots were 5 by 5 m with a 1-m alley between plots. Seeded grass was planted on 10 June 2008 and 2009 at seeding rates of 11 kg ha^{-1} for Mulato II and 33 kg ha^{-1} for Tifleaf 3 and Hayday. Tifton 85 was planted on 26 June 2008 using 100 plugs per plot (i.e., on 50-cm centers). Each plug was a 10-cm diameter rooted clump of bermudagrass dug from a well-established stand.

Fertilizer was applied at the rate of 40 kg N and K ha^{-1} on 26 June 2008 to speed establishment. An additional 120 kg N ha^{-1} was divided into three equal applications of 40 kg N ha^{-1} in July, August, and September 2008. In 2009, the perennial grass plots (Mulato II and Tifton 85) were fertilized with 40 kg N and K ha^{-1} on 27 March and 40 kg N ha^{-1} in June, July, and August; annual treatments received 40 kg N and K ha^{-1} on 25 June and 40 kg N ha^{-1} in July and August. Thus, all plots received a total of 160 kg N ha^{-1} in 2008. In 2009, the perennial treatments received 160 kg N ha^{-1} but the annual treatments received 120 kg N ha^{-1} due to later initiation of growth. Bentazon ([3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide]) was applied to all plots at 1.0 L a.i. ha^{-1} on 10 July 2008 for control of sedge (*Cyperus* spp.), and 2, 4-D [(2,4-dichlorophenoxy) acetic acid] was applied to all plots at 1.0 kg a.i. ha^{-1} on 21 July 2008 and at 2.0 kg a.i. ha^{-1} on 25 August 2008 for control of broadleaf weeds. The Mulato II annual plots were sprayed with 2,4-D at 1.0 kg a.i. ha^{-1} on 20 July 2009.

There were different harvest dates because of varying time to establish these species and differences in growing season among species. In general, perennials were harvested every 5 to 6 wk throughout the summer, with slightly longer intervals during cool autumn weather. Initial and regrowth harvests of annuals occurred when average height was approximately 50 cm. Harvest dates for 2008 and 2009 are presented in Table 1. At each harvest date, borders were trimmed around the edges of all plots and an area of 2.88 m^2 was harvested with a sickle-bar mower from the center of the plot to a 10-cm stubble height. Total fresh weight was determined and a subsample taken for determination of DM concentration and another taken for determination of botanical composition. Subsamples were dried at 60°C for 48 h and ground to pass a 1-mm screen in a Wiley mill (Udy Corporation, Fort Collins, CO). Laboratory analyses for CP and IVDOM concentrations were conducted as described in the grazing study. The total CP and IVDOM presented were weighed values [(Σ monthly herbage accumulation $\times$ crude protein or in vitro digestible organic matter concentration)/total herbage accumulation].

Percent ground cover of the planted grass was estimated in May 2009 and 2010 as a measure of persistence. A 2- by 0.5-m frame, divided into 100 10- by 10-cm quadrats, was placed at three locations in each plot. At each location where the frame was placed, cover was estimated visually in 25 10- by 10-cm quadrats. Cover was the average of the 75 estimates per plot.

Table 1. Harvest dates for Mulato II, Tifton 85, Tifleaf 3, and Hayday plots in Gainesville, FL, in 2008 and 2009. Both Mulato II treatments were identical in 2008 having been planted in June that year.

	Year									
	2008					2009				
Harvest dates	Mulato II perennial	Tifton 85	Tifleaf 3	Hayday	Harvest dates	Mulato II annual	Mulato II perennial	Tifton 85	Tifleaf 3	Hayday
17 July			X	X	5 June			X		
14 Aug.	X	X	X	X	25 June		X			
18 Sept.	X	X	X	X	15 July			X	X	X
28 Oct.	X	X	X		6 Aug.		X		X	
					20 Aug.	X		X		X
					17 Sept.		X		X	
					1 Oct.	X		X		X
					13 Nov.	X	X			
Total harvests	3	3	4	3		3	4	4	3	3

Statistical Analysis

Response variables were herbage accumulation, CP, IVDOM, and percent ground cover. The data were analyzed using PROC MIXED of SAS (SAS Institute, 1996), by year, with forage species and month as fixed effects. In Year 1, there was no Mulato II perennial treatment because both annual and perennial plots were planted in Year 1. In Year 2, both annual and perennial treatments were represented in the analysis. Month was analyzed as a repeated measure. Replicate and its interactions were considered random effects. The data were analyzed by year because of the different number of treatments in the 2 yr and because there were different numbers and timing of harvests in 2008 and 2009. Treatments were considered different when $p < 0.10$. Interactions not discussed were not significant ($p > 0.10$). The means reported are least squares means were compared using PDIFF (SAS Institute, 1996).

RESULTS AND DISCUSSION

Grazing Study

Herbage Mass and Accumulation Rate

There was no difference in HM ($p = 0.59$, SE = 0.3, mean = 1.5 Mg ha^{-1}) and HAR ($p = 0.18$, SE = 21, mean = 139 kg ha^{-1} d^{-1}) among treatments in 2008. Herbage mass was greater in July (2.0 Mg ha^{-1}) than August and September (1.3 Mg ha^{-1}) primarily because grazing had not yet been initiated before the first forage evaluation in July. The establishment of the experimental units was not optimal in 2008 because of excessive rainfall (Table 2; 249 vs. 140 mm for June 2008 and 30-yr average, respectively) that resulted in decreased HM and HAR when compared to 2009. The visually estimated proportion of Mulato II, Tifleaf 3, and Hayday in the stand was 62, 81, and 83%, respectively, in 2008, and 78, 93, and 93%, respectively in 2009.

In 2009, there was a treatment × month interaction effect for HM and HAR (Table 3). The interaction occurred because Mulato II pastures increased HM between July and August while HM of the annuals decreased. Mulato II had similar HM to Tifleaf 3 in July but greater HM than the other treatments on August and September. In addition, Mulato II was the only species with measurable HM in October. The criterion adopted to manage the "put and take" animals was to maintain the stubble height of all species at 30 cm; however, Mulato II likely had a denser canopy, which resulted in greater HM than the other treatments at similar stubble height in August and September 2009.

Herbage accumulation rate was greater for Tifleaf 3 than Mulato II and Hayday in July to August but it was similar among treatments in August to September. Below-average rainfall in September 2008 (Table 2) reduced the length of growing season of all species in that year. In contrast, rainfall was average in September 2009 and extended the growing season of Mulato II until October, resulting in HM and HAR of 3.0 Mg ha^{-1}and 94 kg ha^{-1} d^{-1}, respectively. The warm-season annual forages started flowering and decreased HAR in later summer and early fall, while Mulato II, a perennial, maintained growth with warm temperatures and favorable rainfall.Nutritive Value

There was no difference in CP ($p = 0.31$, SE = 11, mean = 181 g kg^{-1}) and IVDOM ($p = 0.30$, SE = 8, mean = 627 g kg^{-1}) among treatments in 2008. In 2009, there was a treatment × month interaction for CP and IVDOM concentrations (Table 4). The CP and IVDOM of Mulato II decreased from July to August, likely because of the greater HM and HAR, which caused a dilution of N and likely was associated with increasing stem proportion in HM. The CP concentrations were similar among forage species in July; however, Tifleaf 3 had the greatest CP concentrations in August and September. Mulato II and Hayday had greater IVDOM concentrations than Tifleaf 3 in July and August, but the increase in IVDOM concentration in Tifleaf 3 and Mulato II in September resulted in these treatments having greater IVDOM than Hayday in September 2009.

Herbage Allowance and Animal Performance

There was no difference in HA ($p = 0.46$, SE = 0.07, mean = 0.89 kg DM kg^{-1} live weight [LW]), ADG ($p = 0.15$, SE = 0.12, mean = 0.89 kg d^{-1}), stocking rate ($p = 0.12$, SE = 0.4, mean = 6.1 AU ha^{-1}), or gain per hectare ($p = 0.25$, SE = 44,

Table 2. Temperature and rainfall in Gainesville and Marianna, FL, in 2008 and 2009 and the 30-yr average.

	Gainesville						Marianna					
	Temperature (°C)			Rainfall (mm)			Temperature (°C)			Rainfall (mm)		
Months	2008	2009	30-yr avg.	2008	2009	30-yr avg.	2008	2009	30-yr avg.	2008	2009	30-yr avg.
May	23.3	22.8	24.1	5.0	188	71	24.2	23.4	22.2	37	232	83
June	25.3	26.5	26.7	134	94	173	26.6	28.0	25.3	229	70	140
July	25.9	26.1	27.4	161	218	147	27.0	26.7	27.1	102	98	163
August	25.9	26.0	27.4	267	132	163	26.2	26.3	27.0	235	81	151
September	24.5	24.9	26.3	33	103	135	25.0	25.2	27.0	18	132	132
October	19.0	22.0	22.0	99	53	64	18.6	20.9	22.5	130	86	81

Table 3. Herbage mass and herbage accumulation rate of Mulato II brachiariagrass, Tifleaf 3 pearl millet, and Hayday sorghum-sudangrass grazed by beef heifers in Marianna, FL, in 2009.

	Month				
Treatment	July	August	September	October	SE
	Herbage mass (Mg ha^{-1})				
Mulato II	2.4b†AB‡	5.7aA	2.2bA	3.0b	0.6
Tifleaf 3	3.0aA	1.9bB	1.3bB	–	
Hayday	2.1aB	1.1bB	1.1bB	–	
SE		0.4			
	July–August	August–September	September– October		
	Herbage accumulation rate (kg ha^{-1} d^{-1})				
Mulato II	150bB	235a	94c		20
Tifleaf 3	240A	235	–		
Hayday	138bB	182a	–		
SE		35			

†Means within a row followed by the same lowercase letter are not different ($p > 0.10$). The lack of lowercase letter within a row indicates lack of significance.

‡Means within a column followed by the same uppercase letter are not different ($p > 0.10$). The lack of uppercase letter within column indicates lack of significance.

mean = 176 kg) among treatments in 2008. The lack of difference is attributed primarily to the similar HM and the superior nutritive value of the forage species tested in this study.

In 2009, HA and ADG were greater for Mulato II than Tifleaf 3 and Hayday (Table 5). Those differences between years were likely occurred because of improved establishment of the experimental units in 2009 compared to 2008. Mulato II had greater HM than Tifleaf 3 and Hayday at similar stubble heights, which resulted in greater HA. It was necessary to graze a greater number of animals to maintain the target stubble height on Hayday and Tifleaf 3 pastures, which resulted in greater SR at those treatments (9.2, 8.4, and 4.2 AU ha^{-1} for Hayday, Tifleaf 3, and Mulato II, respectively; Table 5). Inyang et al. (2010b) observed that heifers grazing Mulato had decreased ADG with HA below 1.4 kg DM kg^{-1} LW. Those levels of HA were observed at stocking rates above six 350-kg body weight heifers per hectare. Therefore, it is likely that heifers grazing Mulato II had sufficient forage to express their potential ADG and conversely, the heifers grazing Tifleaf 3 and Hayday had decreased HA and limiting amounts of forage, which resulted in decreased ADG. McCartor and Rouquette (1977) observed that average daily gain of yearling cattle grazing pearl millet was maximized at HA of 3.3 kg DM kg^{-1} LW. However, Hernández Garay et al. (2004) observed a year effect on the relationship between ADG and HA of yearling bulls grazing stargrass pastures, indicating that climatic conditions my impact HM, HAR, and HA.

Table 4. Treatment × month interaction effect on crude protein and in vitro digestible organic matter concentrations of Mulato II, Tifleaf 3 pearl millet, and Hayday sorghum-sudangrass grazed by beef heifers in Marianna, FL, in 2009.

	Month				
Treatment	July	August	September	October	SE
	Crude protein (g kg^{-1})				
Mulato II	215a†	163bB‡	211aB	200a	11
Tifleaf 3	200b	188bA	259aA	–	
Hayday	222a	169bAB	194abB	–	
SE			12		
	In vitro digestible organic matter (g kg^{-1})				
Mulato II	672aA	628bA	670aA	650a	21
Tifleaf 3	591bB	521cB	645aA	–	
Hayday	650aA	578bA	574bB	–	
SE		21			

†Means within a row followed by the same lowercase letter are not different ($p > 0.10$). The lack of lowercase letter within row indicates lack of significance.

‡Means within a column followed by the same uppercase letter are not different ($p > 0.10$). The lack of uppercase letter within column indicates lack of significance.

Despite the differences in HA and ADG, and the extended grazing season of Mulato II, there was no difference in gain per hectare among heifers grazing Mulato II, Tifleaf 3, or Hayday in 2009 (Table 5). This was due to a greater average stocking rate used to maintain the Tifleaf 3 and Hayday at similar stubble heights to Mulato II (Table 5).

Table 5. Herbage allowance, average daily gain, stocking rate, and gain per hectare of beef heifers grazing Mulato II, Tifleaf 3 pearl millet, and Hayday sorghum-sudangrass pastures in Marianna, FL, in 2009.

Response variable	Treatment			SE
	Mulato II	Tifleaf 3	Hayday	
Herbage allowance (kg ha^{-1})†	2.0a‡	0.8b	0.6b	0.2
Average daily gain (kg d^{-1})	0.78a	0.43b	0.39b	0.08
Average stocking rate§ (no. of 450-kg heifers ha^{-1})	4.2c	8.4a	9.2a	0.8
Gain ha^{-1} (kg)	295	295	317	13

†Herbage allowance is the average herbage mass (kg ha^{-1} per experimental period)/average animal live weight (kg ha^{-1} per experimental period).

‡Means within a row followed by the same lowercase letter are not different ($p > 0.10$).

§Mulato II pastures were grazed for 100 d and Tifleaf 3 and Hayday for 84 d.

Table 6. Herbage accumulation, crude protein, and in vitro digestible organic matter concentrations of Mulato II annual, Tifleaf 3 pearl millet, Hayday sorghum-sudangrass, and Tifton 85 bermudagrass in Gainesville, FL, in 2008.

Response variable and treatment	Months				Total†	SE
	July	August	September	October		
Herbage accumulation			Mg ha^{-1}			
Mulato II perennial	–	1.2b‡C§	2.6aA	1.4bA	5.2B	0.3
Tifleaf 3	1.9a	2.1aB	1.5aB	0.8bB	6.3A	
Hayday	1.6a	1.5aBC	0.7bC	–	3.8C	
Tifton 85	–	2.7aA	1.5bB	0.7cB	4.9B	
SE			0.3			
Crude protein			g kg^{-1}			
Mulato II perennial	–	148aAB	109bB	159aB	131AB	6
Tifleaf 3	100dA	137bB	118cB	203aA	131AB	
Hayday	84cB	155aA	132bA	–	121B	
Tifton 85	–	137bB	122cAB	172aB	137A	
SE			6			
In vitro digestible organic matter			g kg^{-1}			
Mulato II perennial	–	654bA	646b	727aA	669A	9
Tifleaf 3	576cB	615bB	633b	705aB	618C	
Hayday	650A	645AB	645	–	647B	
Tifton 85	–	630bB	624b	662aC	632B	
SE			10			

†Total herbage accumulation in 2008. Crude protein and in vitro digestible organic matter were weighed values [(Σ Monthly herbage accumulation × crude protein or in vitro digestible organic matter concentration)/total herbage accumulation].

‡Means within a row followed by the same lowercase letter are not different ($p > 0.10$). The lack of lowercase letter within row indicates lack of significance.

§Means within a column followed by the same uppercase letter are not different ($p > 0.10$). The lack of uppercase letter within column indicates lack of significance.

Clipping Study

Herbage Accumulation

There was a treatment × month interaction for herbage accumulation in the establishment year of 2008 (Table 6). The interaction occurred because Tifleaf 3 and Hayday established more quickly than the other treatments and were ready for first harvest in July, while the other species were harvested for the first time in August. Tifleaf 3 had the greatest total annual herbage accumulation, followed by Mulato II and Tifton 85. Hayday had the least herbage accumulation among the treatments in 2008 (Table 6).

In 2009, there was a treatment × month interaction for herbage accumulation (Table 7). The interaction occurred because of different seasonal patterns of forage growth among the species tested. The perennial treatments, Mulato II perennial and Tifton 85, were planted in 2008 and the regrowth of the existing plants resulted in earlier harvest in 2009. The earlier growth of Mulato II perennial and Tifton 85 resulted in more total harvests (4 vs. 3) and greater total annual herbage accumulation than for Tifleaf 3 and Hayday (Table 1). The above average rainfall in May 2009 (Table 2) also favored the earlier growth of Tifton 85 and Mulato II. Similar to 2008, Mulato II annual was later to establish than Tifleaf 3 and Hayday; it was first harvested in July 2009. Mulato II annual and perennial grew longer into the autumn in 2009 (November) compared with the annuals and Tifton 85. Similar responses were observed in the 2009 grazing study in Marianna. Hayday was harvested in July, August, and October and had the least total annual herbage accumulation among the treatments. Total annual herbage accumulation was the greatest for Mulato II perennial and Tifton 85, followed by Tifleaf 3. Mulato II annual and Hayday had the least total annual herbage accumulation among the treatments.

Nutritive Value

In 2008, there was a treatment × month interaction effect on CP and IVDOM concentrations (Table 6). Hayday had

Table 7. Herbage accumulation, crude protein, and in vitro digestible organic matter concentrations of Mulato II annual, Mulato II perennial, Tifleaf 3 pearl millet, Hayday sorghum-sudangrass, and Tifton 85 in Gainesville, FL, in 2009.

Response variable and treatment	Month						Total[†]	SE
	June	July	August	September	October	November		
Herbage accumulation	Mg ha^{-1}							
Mulato II annual	–	–	1.3b[‡]BC[§]	–	2.0aA	0.8cB	4.1C	0.4
Mulato II perennial	4.0aA	–	3.0bA	2.8bA	–	1.5cA	11.3A	
Tifleaf 3	–	1.7B	1.6B	2.1B	–	–	5.4B	
Hayday	–	1.4B	1.1C	–	0.9B	–	3.4C	
Tifton 85	2.7bB	3.6aA	2.9bA	–	1.5cAB	–	10.7A	
SE			0.3					
Crude protein	g kg^{-1}							
Mulato II annual	–	–	121aA	–	111abB	100bA	112A	7
Mulato II perennial	94bB	–	105abB	115a	–	78cB	100AB	
Tifleaf 3	–	107A	117A	117	–	–	113A	
Hayday	–	71cB	90bC	–	140aA	–	96B	
Tifton 85	147aA	80dB	99cBC	–	117bB	–	107AB	
SE			5					
In vitro digestible organic matter	g kg^{-1}							
Mulato II annual	–	–	670bB	–	690aA	695aA	684A	10
Mulato II perennial	640b	–	660aB	660aA	–	650abB	652B	
Tifleaf 3	–	690bA	710aA	640cB	–	–	676A	
Hayday	–	680aA	635bC	–	680aA	–	665A	
Tifton 85	630a	540bB	540bD	–	520bB	–	560C	
SE[§]			8					

[†]Total herbage accumulation in 2008. Crude protein and in vitro digestible organic matter were weighed values [(Σ Monthly herbage accumulation × crude protein or in vitro digestible organic matter concentration)/total herbage accumulation].

[‡]Means within a row followed by the same lowercase letter are not different ($p > 0.10$). The lack of lowercase letter within row indicates lack of significance.

[§]Means within a column followed by the same uppercase letter are not different ($p > 0.10$). The lack of uppercase letter within column indicates lack of significance.

the greatest CP concentrations in August and September and there was no difference among Mulato II perennial, Tifleaf 3, and Tifton 85. Average annual CP concentration of Tifton 85 was greater than Hayday but similar to Mulato II perennial and Tifleaf 3. There was no difference in average annual CP concentrations among Hayday, Mulato II perennial, and Tifton 85 (Table 6).

Mulato II perennial had the greatest average annual IVDOM concentrations, followed by Hayday and Tifton 85. Tifleaf 3 had the least average annual IVDOM concentrations among the treatments.

There was a treatment × month interaction effect for CP and IVDOM concentrations in 2009 (Table 7). In June, Tifton 85 had greater CP concentrations than Mulato II perennial; however, Tifton 85 was among the treatments with the least CP concentrations in the subsequent months. Tifleaf 3 was the greatest or among the greatest CP concentrations is July and August. In September there was no difference in CP concentrations between Mulato II perennial and Tifleaf 3. Hayday had greater CP concentrations than Mulato II annual and Tifton 85 in October; however, Mulato II annual had the greatest CP in November. Tifleaf 3 and Mulato II annual had greater average annual CP concentrations than Hayday and Tifton 85.

The IVDOM concentrations of Mulato II annual and perennial were similar across months and were 640 g kg^{-1} or greater. With the exception of June, Tifton 85 had the least IVDOM among treatments during 2009. The Tifton 85 IVDOM concentrations in this study are similar to the results observed by Vendramini et al. (2008) harvesting Tifton 85 with 28-d regrowth in Florida (530 g kg^{-1}). Tifleaf 3, Hayday, and Mulato II annual had the greatest average annual IVDOM concentrations, followed by Mulato II perennial. Tifton 85 had the least average annual IVDOM concentrations among the treatments (Table 7).

Persistence

There was greater ground cover on 6 May 2009 for Tifton 85 than Mulato II perennial ($p < 0.10$, SE = 3, mean = 73 vs. 36% for Tifton 85 and Mulato II perennial, respectively). The reduced cover of Mulato II is indicative of its slower recovery from winter and may have been due in part to the above average number of freeze events during the winter of 2008/2009 (Fig. 1). The stand of Mulato II perennial did recover (82%) in 2009. however, to the extent that it was able to achieve greater herbage accumulation than Tifton 85 during June 2009 and similar herbage accumulation over the entire growing season (Table 7). In 2010, cover was assessed on Mulato II plots that had been planted in 2008 (termed Mulato perennial) and plots planted in 2009 (the Mulato II annual treatment in 2009). Mulato II annual and perennial had 10 and 12% cover in May 2010, while Tifton 85 had 73% cover ($p < 0.001$, SE = 6). The severe decrease in Mulato II stand can

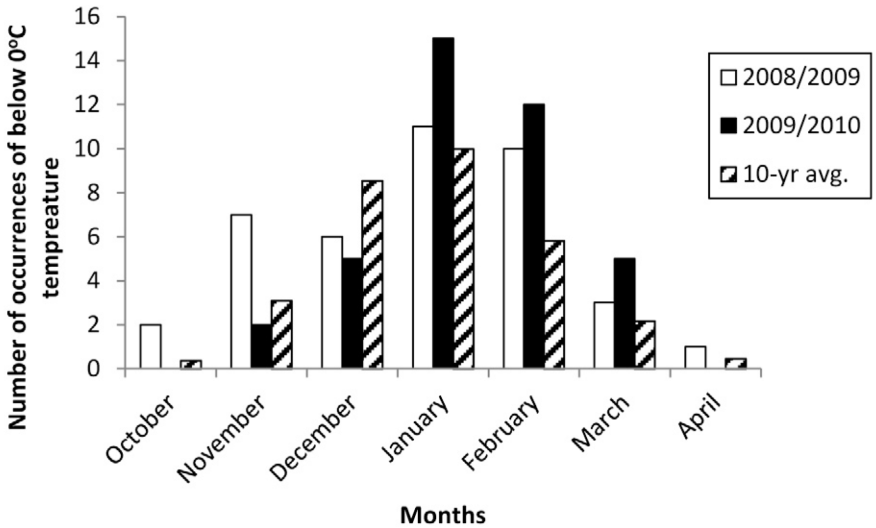

Figure 1. Number of days with one or more occurrences of below 0°C temperature in Gainesville, FL, during the winters of 2008/2009 and 2009/2010.

be attributed to the much greater than average number of freeze events during January through March 2010 (Fig. 1). During this period, there was an all-time record of 13 consecutive days with daily low temperatures below 0°C.

SUMMARY AND CONCLUSIONS

In the grazing study, Mulato II was slower to establish than Tifleaf 3 and Hayday, but it had a longer autumn grazing period. Forage nutritive value was variable across months. Continuous stocking to maintain a uniform stubble height did not result in uniform HM among treatments in 2009, and the greater HM of Mulato II pastures resulted in greater HA and ADG of beef heifers than for the annual grasses. Average stocking rate required to achieve a 30-cm stubble height was greater for the annuals; therefore, even though ADG was less, gain per hectare was similar among the three grasses.

In the clipping study, Mulato II annual was again slower to establish but it had an extended autumn growing season. In 2009, the perennial species (Mulato II perennial and Tifton 85) produced forage earlier and had greater herbage accumulation than the annual treatments. Mulato II was slower to regrow following winter than Tifton 85, as evidenced by much lower percent ground cover for Mulato II after the 2008/2009 winter; however, it did recover after onset of warm temperatures and total annual herbage accumulation was similar to that of Tifton 85. The ground cover of Mulato II plots, going through either their first or second winter, was significantly reduced after an unusually severe 2009/2010 winter, and stand losses in this year carried into the 2010 warm season.

Considering the differences in forage characteristics observed in only 1 yr of the grazing study, we conclude that Mulato II is at least as high in forage quality as the warm-season annual grasses Tifleaf 3 and Hayday. The slower establishment of Mulato II may decrease animal performance earlier in the growing season when forage quantity is frequently limiting in grazing systems. If seed prices are competitive, it may be an alternative warm-season annual forage for beef cattle in the Gulf Coast region of the southern United States. This data indicates that there is significant risk associated with use of Mulato II in perennial systems because, at least in years with severe cold, stands can be depleted to a point that replanting would be necessary.

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