CARIBBEAN FOOD CROPS SOCIETY

44

Forty Fourth
Annual Meeting 2008

Miami, Florida, USA

Vol. XLIV – Number 2

Plenary Session and Oral Presentations

MEETING HOST:

UF UNIVERSITY of FLORIDA IFAS

TECHNICAL SESSIONS
PAPERS PRESENTED ORALLY
Tuesday, July 15, 2008
and
Wednesday, July 16, 2008

FORAGE AND LIVESTOCK

2008 Proceedings of the Caribbean Food Crops Society. 44(2):77-83. 2008

Production of Eastern Gamagrass Accessions Grown under Greenhouse Conditions.

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ABSTRACT.
The development of adapted acid-tolerant plants is important in the southeastern United States. Eastern gamagrass (*Tripsacum dactyloides*) is a warm-season perennial native to the Americas, capable of high potential productivity and moderate to high forage quality, for use as grazed or preserved forage. It produces peak growth during hot, dry weather when cool season plants are dormant. Eastern gamagrass has also been reported to penetrate acidic claypan by tolerating low Ca, high Al and low soil pH. As result, eastern gamagrass is being considered as a potential barrier and forage crop in the southeast United States. A study was conducted at the George Washington Carver Agricultural Experiment Station at Tuskegee University, to measure the performance of eastern gamagrass accessions of varying forage potential under greenhouse conditions. Accessions were chosen based on their probable suitability as forage crops, as well as to reflect a broad geographic and genetic spectrum of eastern gamagrass found in the southern US. Single shoots were transplanted and fertilized with 20-20-20 (NPK). After three months of establishment, plants were harvested to 25 cm height every 35 days and forage yield and quality measured. Data on plant height, dry matter yield, and regrowth was recorded. Crude protein, mineral composition, and fiber were used as quality factors. Data indicated that most accessions attained their greatest height at harvest 3. Florida 2 (FL2) produced the tallest plants on average (121.0 cm) prior to the first harvest. Texas 3 (TX3) had the highest daily growth rate before harvest two and produced the tallest plants on average prior to the second harvest (127.8 cm), while TX4 produced the shortest plants on average (95.7 cm). Plant dry weight for the various accessions ranged from 12.0 to 83.5 g/pot while crude protein ranged from 13.7 to 17.3%. These results indicate that the quality of these eastern gamagrass accessions were above the NRC requirements for finishing cattle. A comprehensive review of these eastern gamagrass populations could identify accessions that exhibit specific establishment and growth pattern that are suitable for the southern US.

KEYWORDS: eastern gamagrass, forage production, accession

INTRODUCTION

The development of adapted acid-tolerant forages is important in the southeastern United States. Eastern gamagrass [*Tripsacum dactyloides, L.*] is a warm-season perennial bunchgrass found in the Midwestern and eastern United States. Eastern gamagrass occurs naturally from Massachusetts on the Atlantic coast, west to Nebraska, Oklahoma, and Kansas, and south to Florida and Texas in the United States, Brazil in South America (Newell and deWet, 1974). Eastern gamagrass is capable of penetrating acidic claypan, tolerating low calcium (Ca), high aluminum (Al) and low soil pH (Foy et al., 1999). Due to high potential productivity of eastern gamagrass as well as its moderate to high forage quality, there is considerable interest in its use as cut and stockpiled forage (Rhoden et al., 2002). Reported traits of the species that would be valuable in a sustainable agriculture system include high protein content, high yields, high palatability and digestibility, and peak growth during hot, dry weather when cool season pasture plants are dormant. As result, eastern gamagrass is being considered as a potential barrier and forage crop in the southeast United States. According to Krizek et al. (1998), eastern gamagrass is capable of high productivity with moderate to high forage quality. Eastern gamagrass is a very versatile and widely adaptable grass, and could easily be incorporated into sustainable development programs for marginal lands for pasture as well as for preserved forage. One remarkable trait is that it closes canopy very rapidly after establishment and therefore, very effective as an erosion deterrent. Eastern gamagrass is considered to be tolerant of certain acidic soil types. It has been found to penetrate hardpans and claypans by tolerating acidic Al-toxic soil and/or nutrient solutions in both greenhouse and field studies (Foy, 1997; Foy et al., 1999; Rhoden et al., 2000a). Burns et al. (1996) compared eastern gamagrass with switchgrass and flaccidgrass when preserved as hay and found that the hay quality of eastern gamagrass was adequate to meet the energy and protein requirements of many ruminants. Rhoden et al. (2000a) obtained crude protein (CP) content as high as 19.6% in highly fertilized eastern gamagrass grown in the greenhouse. Furthermore, eastern gamagrass also shows promise as a dual-purpose grain and forage crop. Eastern gamagrass produces small kernels roughly 6 % the size of corn kernels. Bailey and Sims (1998) estimated the protein content of eastern gamagrass grain to be 30 % as well as having a 90 % digestibility. To this end, the Plant Material Centers in the southeast are making progress towards the selection and development of eastern gamagrass cultivars that are suitable for such conditions. These centers and universities are presently screening large populations of eastern gamagrass for suitable ecotypes that are capable of high-quality forage and productivity. Therefore, the objective of this study was to measure the performance of 12 eastern gamagrass accessions under greenhouse conditions and to evaluate their forage potential.

MATERIALS AND METHODS

This study was conducted in the greenhouse facilities of the George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, Alabama. Twelve accessions of eastern gamagrass were vegetatively established and selected for uniformity within each accession. A day/night temperature of 30/25°C $\pm$ 2.5°C was maintained in the greenhouse for the length of the study. A nutrient solution of 20-20-20 (NPK) was given at a rate of approximately 56 kg/ha. The initial harvest was made when plants were at the boot stage, and subsequent harvests every 35 days thereafter. The plants were cut back to 25 cm height, and data on plant height and vigor were recorded for all plants.

Data on shoot growth and regrowth were based on linear measurements and biomass collected for dry matter analysis. Weights were recorded for total dry matter yield, and divided into blade, sheath and stem yields. Each sample collected was separately ground and ashed. Ashing was done overnight and acid detergent fiber (ADF), neutral detergent fiber (NDF), CP, total digestible nutrients (TDN) determined.

RESULTS AND DISCUSSION

The data from Table 1 indicates that most accessions attained their greatest height at harvest 3. Plant height varied among accession lines based on locations, but not significantly. There was significant location ×accession × harvest interaction, however.

Table 1. Foliage height of 12 eastern gamagrass accessions prior to harvest (cm)

Accession	Harvest 1	Harvest 2	Harvest 3	Average
TX1	106.50	109.83	115.50	110.61
TX2	104.42	114.00	129.67	116.03
TX3	113.00	127.83	134.00	124.94
TX4	89.00	95.67	131.00	105.22
FL1	101.00	100.00	99.17	100.06
FL2	121.00	118.50	123.17	120.89
FL3	119.67	122.83	122.67	121.72
FL4	113.82	113.74	115.19	114.25
AR1	95.33	104.67	123.83	107.94
AR2	93.33	98.33	118.50	103.39
AR3	101.00	108.67	121.67	110.45
AR4	96.49	103.94	121.33	107.25

Arkansas accessions were shortest compared to those from Texas and Florida, which also showed greater variation among accession lines for plant height. Florida accessions showed little variation in plant height across harvest periods, with less than a 1% increase in height from harvest 1 to 3. Florida 1 declined in height as with passing harvest period. Florida 2 and FL 4 also achieved lesser height at harvest 2, while FL 3 was shorter at harvest 3 compared to harvest 2. Arkansas and Texas accessions, however, showed consistent increases in plant height from one harvest period to another, reaching maximum height at harvest three.

Prior to the first harvest, FL2 produced the tallest plants, averaging 121 cm, followed very closely by accession seven (FL3) (119.67 cm), while TX 4 had the shortest plants (89 cm). Accession three (TX3) had the highest daily growth rate before harvest two and produced the tallest plants on average (127.83 cm), while accession four (TX4) produced the shortest plants on average (95.67 cm). Accession three (TX3) showed the highest daily individual growth rate (3.11 cm/day) between harvest two and three to produce the tallest plants on average (134 cm) prior to the third harvest. Accession five (FL1) produced the shortest plants on average (99.17 cm). When averaged over the three harvests, FL 1 produced the shortest plants and TX 3 produced the tallest (Table 1). Some of the plant heights achieved in this study are slightly less than some of the accessions reported in literature. Texas 1 achieved foliage height between 106 and 115 cm (110 cm avg.), over three harvests in this study. Snider (1995) reported peak foliage height of 122 cm for TX1, and AR3, which achieved foliage height between 96 and 121 cm (107 cm avg.) over three harvests in this study.

Florida accessions showed the most variation for dry matter production within accession. Arkansas accessions had the lowest dry matter production, for all three harvests, while Florida accessions had the highest production. Accessions irrespective to locations exhibited similar trends across the three harvest periods. The amount of dry matter produced on a per plant basis was lowest for harvest 3. The data indicated that for harvest 3, all accessions produced the significantly lower amount of dry matter, as compared to harvest 1 and 2 (Table 2). Texas and Arkansas accessions however, showed a larger reduction in dry matter production for harvest 3, than Florida accessions. The AR 1 plants had the lowest overall dry matter yield, while FL 2 out-yielded all the other accessions, followed closely by FL 3. This is consistent with of researchers who have noted that it is common that high yielding eastern gamagrass varieties are usually associated with tall plants (Rhoden et al 2000b).

Table 2. Dry matter production of 12 eastern gamagrass accessions grown under greenhouse conditions [kg/ha]

Accession	Harvest 1	Harvest 2	Harvest 3	Total Yield
TX1	3413.28	3338.88	2658.24	9410.40
TX2	3429.12	3428.16	1320.96	7998.24
TX3	3653.28	3436.32	1589.28	8678.88
TX4	3185.28	3002.40	1107.36	7295.04
FL1	3496.80	3217.92	2446.08	9160.80
FL2	4314.24	3508.80	3927.84	11750.88
FL3	4054.08	4229.28	3299.52	11582.88
FL4	3915.36	3654.72	3210.24	10780.32
AR1	3287.04	2792.16	746.88	6826.08
AR2	3134.40	3334.56	1691.04	8160.00
AR3	2952.00	3049.44	1593.12	7594.56
AR4	3126.72	3068.16	1348.32	7543.20

Dry matter production per pot was converted to hectare production equivalent. The yields in this study compared favorably with, and in fact are at the higher end of yields reported by Faix et al. (1980) in the establishment year in southern Illinois, except

AR1 and TX4 (Table 2). All accessions in this study produced higher DM yields than those reported for 'Pete' eastern gamagrass by Fine et al. (1990) during the establishment year, at Woodward, OK, and production by Foy et al (1999) after liming in an acid soil. All accessions compared favorably with 4-, 6-, 8-, and 10-week DM yields achieved by Mashingo et al. (2002). All accessions also yielded higher than reports given by McLaughlin et al (2004) over a three year period (4.76 metric tons/ha avg.).
While plant height and yield are essential criteria for evaluating eastern gamagrass, quality is critical to determining its worth as a forage. The CP content of forage samples in this study was high. Average reported crude protein ranged from 13.69 % (TX 2) to 17.31% (TX 1) (Table 3). These numbers were higher than those reported by Faix et al (1980) (11% avg. over 3 years), and McLaughlin et al. (2004).

Table 3. Crude fiber, neutral detergent fiber, acid detergent fiber and total digestible nutrients of eastern gamagrass accessions. (Harvest 3)

Accession	CP	Crude Fiber	NDF	ADF	TDN
	%	----------------------	%	--------------------------	
TX1	17.31	33.22	74	33	49.14
TX2	13.69	32.12	71	33	50.90
TX3	14.88	32.92	73	34	49.73
TX4	13.81	33.72	75	34	48.55
FL1	16.69	32.92	73	34	49.73
FL2	13.88	33.32	74	34	49.14
FL3	15.50	32.92	73	36	49.73
FL4	15.36	33.05	73	35	49.53
AR1	16.75	32.52	72	35	50.31
AR2	17.00	34.52	77	38	47.38
AR3	16.19	35.32	79	36	46.21
AR4	16.65	34.12	76	36	47.97

In addition to protein, forages provide the fiber needed for cud chewing, rumination, and rumen health. At harvest 3, Arkansas accessions showed the most variation for percent crude fiber followed by those from Texas, and Florida accessions which showed very little variation (Table 3). Arkansas accessions had the highest percent crude fiber on average, followed by Florida and Texas accessions, which were very similar on average. Percent crude fiber ranged from 32.12 (TX 2) to 35.32 (AR 3) at harvest 3. The highest NDF of 79% was obtained from AR 3, and TX 2 the lowest NDF content (71%). AR 2 samples contained 38% ADF and TX 1 and TX2 contained 33% ADF. At harvest 3, Arkansas accessions showed the most variation for percent total digestible nutrients (TDN) followed by those from Texas, and then Florida accessions which showed very little variation. Arkansas accessions had the lowest percent TDN on average, as opposed to those from Florida and Texas, which were higher and very similar. Total digestible nutrients ranged from 46.21% (AR 3) to 50.90% (TX 2)

(Table3). Faix et al. (1980) found the total digestibility of eastern gamagrass to average approximately 50 % over a period of three years.

The results showed a decline in biomass with successive harvests consistent with limited fertilization. Even though satisfactory biomass was obtained in this study under limited resource conditions, the biomass potential of eastern gamagrass is even greater under optimal growing conditions. The CP content of all accessions used in this study was well above the 7% needed for brood cows or 10.5% minimum needed for finishing cattle. Therefore, none of the accessions would require protein supplementation in order to meet the nutritional requirements to maintain growth and development in cattle. Texas1 and AR 2 had the highest CP, and would be recommended for feeding, based solely on CP content. All accessions also met or exceeded crude protein requirements for maintaining mature horse and stallions, and for light- and moderate- working horses on a dry matter basis. Further comprehensive review of these populations could identify accessions that exhibit specific establishment and growth pattern that are suitable for different regions. Planting productive accessions would reduce the need for annual forage replanting especially on sloping croplands that would be prone to high rates of soil erosion. Those accessions possessing stiff, erect stems also show promise as vegetative hedges and/or barriers that could reduce runoff and the resultant sediment and nutrient losses.

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