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Performance of two forage sorghum hybrids in southwest Puerto Rico[1]

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ABSTRACT

Two forage sorghum hybrids (*ATx 623 × GL* and *FS25A*) were grown from April 1985 to February 1987 at the Agricultural Experiment Station of the University of Puerto Rico at Lajas, Puerto Rico to determine the influence of maturity stage increases of 10 days (from the 45th to the 85th day) and how the presence and severity of foliar diseases affect the dry forage and crude protein yields. Dry matter content was higher for *FS25A* (16.1%) than for *ATx 623 × GL* (14.9%) whereas total yield for dry matter (DMY) was higher for *ATx 623 × GL* (3.84 t/ha) than for *FS25A* (3.51 t/ha). Both content and yield of dry matter increased with maturity stage in both genotypes. The sorghum hybrids did not differ significantly in crude protein content (CPC), but crude protein yield (CPY) was higher for *ATx 623 × GL* (421.6 kg/ha) than for *FS25A* (358.9 kg/ha). CPC declined with increased plant maturity. Foliar diseases appeared to limit DFY and CPY in both sorghum hybrids. Downy mildew, leaf blight, rust, grey leafspot, and zonate leafspot appeared seasonally. Leaf blight and downy mildew were the most prevalent from January to May, grey leafspot from May to September, and zonate leafspot from September to November. Rust was severe during all seasons.

RESUMEN

Edades de corte e incidencia de enfermedades de dos sorgos forrajeros y sus rendimientos en materia seca y proteína bruta

Se llevó a cabo un estudio con dos híbridos de sorgo forrajero (*ATx 623 × GL* y *FS25A*) de abril de 1985 a febrero de 1987 en la Subestación Experimental Agrícola de Lajas para medir la influencia sobre la producción de etapas de corte cada 10 días (desde el 45to al 85to día) y cómo la incidencia de enfermedades afecta el rendimiento de forraje seco y proteína bruta. El contenido medio global de materia seca fue mayor en

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FS25A (16.1%) que en *ATx 623 × GL* (14.9). Lo contrario ocurrió con el rendimiento de forraje seco, ya que se obtuvo un rendimiento mayor con *ATx 623 × GL* (3.84 t./ha.) que con *FS25A* (3.51 t./ha.). El rendimiento de forraje seco y el contenido de materia seca aumentaron a medida que el forraje maduró. Las diferencias entre ambos híbridos en contenido medio de proteína bruta no fueron significativas. No obstante, la media ponderada para el rendimiento de proteína bruta total fue mayor para *ATx 623 × GL* (421.6 kg./ha.). El contenido y el rendimiento total de proteína bruta disminuyeron significativamente a medida que la etapa de corte aumentó de 45 a 85 días. Los rendimientos de forraje seco y de proteína bruta total también disminuyeron en ambos híbridos debido a la incidencia de enfermedades. Estas enfermedades fueron añublo lanoso ("downy mildew"), tizón ("leaf blight"), roya ("rust"), y mancha foliar ("zonate leafspot"). La época del año fue un factor determinante para la presencia de estas enfermedades. De enero a mayo la enfermedad más prevaleciente fue el añublo lanoso. Sin embargo, de mayo a julio predominó la mancha cercospórica y de septiembre a noviembre la mancha foliar.

INTRODUCTION

Dairying is at present the leading agricultural enterprise in Puerto Rico. During 1987-88 it contributed $178.2 million to the gross agricultural income, far exceeding the traditional main crops, which grossed $59.2 million (9).

Although successful dairying depends on many factors, feeding, which is highly dependent on pastures and forages is of paramount importance. Land dedicated to pasture and forage production in Puerto Rico decreased from 56,222 to 44,857 ha (140,000 to 112,000 acres) during the 10-year interval from 1975 to 1985 (8). Of the latter, 41,448 ha (103,000 acres) are used for grazing, and the rest primarily for green chopping. Grazing is the least expensive and most practical feeding system. However, pasture production is affected by periods of prolonged drought, slow-growing season, and inadequate management practices. These adverse factors reduce forage production and make it difficult to consistently satisfy the herd demand, thus tending to lower milk production. As a solution to this problem many dairy farmers increase supplementary feeding, which involves mainly the use of high-energy concentrate feeds. Most of the concentrate ingredients used are not produced in Puerto Rico; they are expensive items.

A locally produced high-energy forage crop with adequate dry matter content could be an alternative to reduce feed costs. Forage sorghum may fulfill these requirements because of its rapid establishment (3), high yield (18, 19, 20, 22) and its availability in forage and grain types. It is also easily harvested both mechanically and by hand. Moreover, the insular Puerto Rico climate and soils are potentially suited for year round forage-grain production. The objectives of the present study were threefold: to determine dry matter and crude protein yields of two sorghum hybrids at five cutting stages; to determine their chemical composition; and to establish the seasonal occurrence of their foliar diseases in southwest Puerto Rico.

MATERIALS AND METHODS

This study was performed from April 1985 to February 1987 at the AES-UPR, Lajas substation, located in the semiarid southwestern Lajas Valley. Two forage sorghum hybrids *ATx 623* × *GL* and *FS25A* were planted in a Vertisol soil in plots measuring 6.1 × 6.1 m. There were four replications of each treatment arranged in a split-plot design. Each plot consisted of 6 rows spaced 7.6 m apart. They were 6.1 m long with approximately 360 plants per row. A commercial fertilizer formulation 15-10-10 was applied to all plots at the rate of 75 kg elemental N/ha at planting and after each harvest. The planted area was treated with Propazine[6], a preemergent herbicide, administered as a surfactant at 2.8 kg/ha (2.3 kg ai). Overhead irrigation was applied as needed until the plants attained a height of about 25 cm (roughly 30 days post-planting). Furrow irrigation was used thereafter. Sevin 80S was applied at the rate of 1.7 kg/ha to control insects. Plants were harvested at 45-, 55-, 65-, 75- and 85-day intervals with each harvest repeated three times per site. The four center rows of each plot were used. A sample was weighed for green forage yield (GFY). Each sample was ground in a Wiley mill to pass a 1-mm sieve. They were analyzed for crude protein content (CPC) by the Kjeldahl procedure (2). Analyses were also performed for neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose (C), lignin (L), and silica (Si) by Harry's method (5). Crude protein yield (CPY) was calculated from DFY and CPC. Disease incidence and severity was monitored from germination to final harvest. Data were subjected to statistical regression analysis (11) and variation among means was measured following the Duncan New Multiple Range Test (23).

RESULTS AND DISCUSSION

Significant differences were obtained for dry matter and crude protein as a function of harvest stage (tables 1-6, figures 1-4). Varietal differences also emerged. Mean values for DMC indicated that percent dry matter ranged from 10.9 to 20.1 in response to increasing plant maturity (fig. 1). Cultivar *FS25A* was consistently higher in DMC than *ATx 623* × *GL* (table 1). Dry matter content did not vary appreciably as a function of repeated harvest, i.e., cuttings 1, 2 and 3 (table 2). This is not consistent with previous findings by Sotomayor and Tellek (20). Modest differences in dry matter content were reported by Sotomayor and Santiago (17) working with nine sorghum F_1 hybrids, and by Torres et al. (25) in 11 sorghum crosses. Somewhat greater differences were reported for sorghum silage hybrids in Georgia (16).

[6]Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

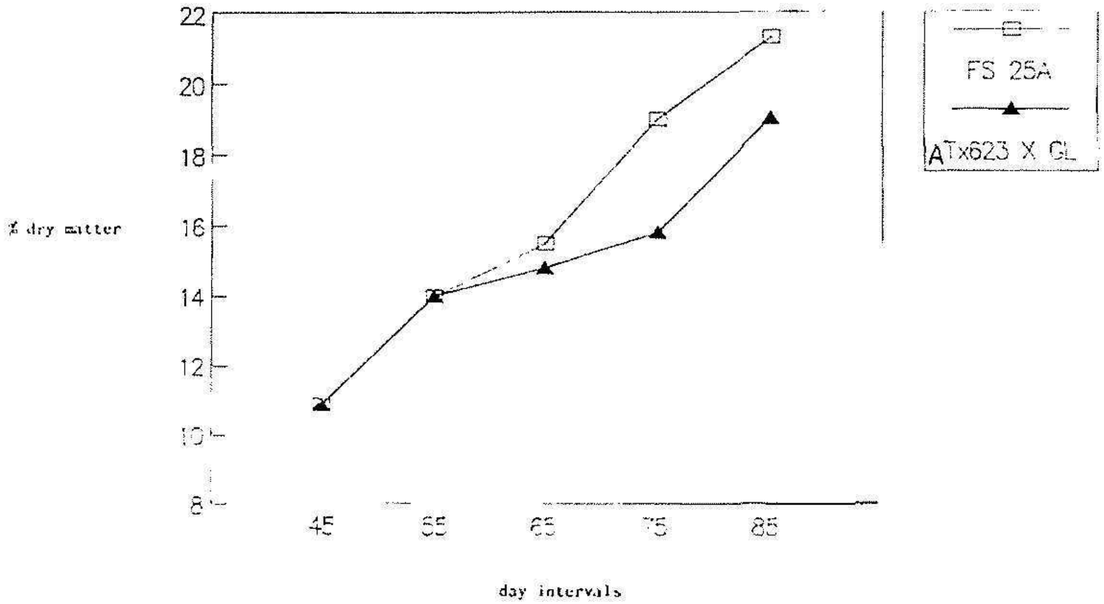

FIG. 1—Mean dry matter content of two forage sorghum hybrids FS25A and ATx 623 × GL cut at 10-day intervals from 45 to 85 days.

Dry forage yield ranged from 1.4 to 5.8 t/ha (0.57 to 2.33 t/ha) as stage increased from 45 to 85 days (table 3). This trend was predictable. Cultivar differences were not significant, although *ATx 623 × GL* gave higher yields as a function of repeated harvest (fig. 2). Higher mean yield was obtained for the second cutting (5.5 t/ha, table 3) which was 323% and 145% higher than third (3.8 t/ha) and first cutting (1.7 t/ha), respectively. Disease incidence and severity was pronounced at the 75-day harvest period.

Important efforts have been made to develop higher-yielding sorghum forage hybrids for the tropics (2). Enormous differences in DFY

TABLE 1.—*Performance pooled values for dry matter yield (DMY), crude protein content (CPC), and crude protein yield (CPY) for two sorghum forage hybrids,* ATx 623 × GL *(A) and* FS25A *(B), in three cuttings (1, 2, 3)*

Parameter	Hybrid	Cutting[1] 1	2	3	Grand mean
DMC (%)	A	14.6	15.0	15.1	14.9
	B	15.6	16.3	16.5	16.1
DMY (T/ha)	A	1.86	5.71	3.94	3.84
	B	1.6	5.23	3.68	3.51
CPC (%)	A	11.3	12.4	11.9	11.9
	B	12.1	11.9	12.0	12.0
CPY (kg/ha)	A	190.8	652.1	421.9	421.6
	B	173.1	530.1	372.1	358.9

[1]Cutting number 1 corresponds to seedling planting, and numbers 2 and 3 to first and second ratoons.

TABLE 2.—*Percent dry matter content (DMC) of two sorghum forage hybrids,* ATx 623 × GL *(A) and* FS25A *(B), harvested in three cuttings (1, 2, 3), at five intervals post-planting (45, 55, 65, 75, and 85 days)*

Cutting interval	Sorghum cutting numbers[1]									
	1 Hybrid			2 Hybrid			3 Hybrid			
Days	A	B	Combined mean	A	B	Combined mean	A	B	Combined mean	Grand mean
45	10.6d[2]	10.4d	10.5d	11.0c	11.0c	11.0d	11.0c	11.3d	11.1d	10.9d
55	13.6c	13.6c	14.2c	14.2c	14.2c	14.2c	14.4b	14.1c	14.3c	14.0c
65	14.6bc	14.8c	14.7c	14.9b	15.7c	15.3c	14.9b	15.9c	15.4c	15.1c
75	15.6b	18.1b	16.8b	15.8b	19.3b	17.6b	16.1b	19.6b	17.9b	17.4b
85	18.5a	20.8a	19.6a	19.1a	21.2a	20.2a	19.3a	21.7a	20.5a	20.1a

[1]Cutting number 1 corresponds to seedling planting; numbers 2 and 3, to first and second ratoons.
[2]Mean values in the same column bearing unlike letters differ significantly (P = 0.05).

TABLE 3.—*Tons per hectare dry matter yield (DMY) of two sorghum forage hybrids,* ATx 623 × GL *(A) and* FS25A *(B), in three cuttings (1, 2, 3), at five intervals post-planting (45, 55, 65, 75, and 85 days)*

Cutting interval	Sorghum cutting numbers[1]									
	1 Hybrid			2 Hybrid			3 Hybrid			
Days	A	B	Combined mean	A	B	Combined mean	A	B	Combined mean	Grand mean
45	0.85b[2]	0.40c	0.63d	2.64d	1.82e	2.23d	1.79d	0.90e	1.39d	1.40d
55	1.60b	1.04b	1.32c	4.96c	3.31d	4.13c	3.38c	2.40d	2.89c	2.80c
65	1.93a	1.71b	1.82c	5.91c	5.52c	5.72b	4.04b	4.03b	4.04b	3.90b
75	2.12ab	2.20ab	2.16ab	6.30b	7.06b	6.68b	4.59b	5.02b	4.81b	4.60b
85	2.79a	2.68a	2.74a	8.73a	8.44a	8.58a	5.93a	6.05a	5.99a	5.80a

[1]Cutting number 1 corresponds to seedling planting; numbers 2 and 3, to first and second ratoons.
[2]Mean values in the same column bearing unlike letters differ significantly (P= 0.05).

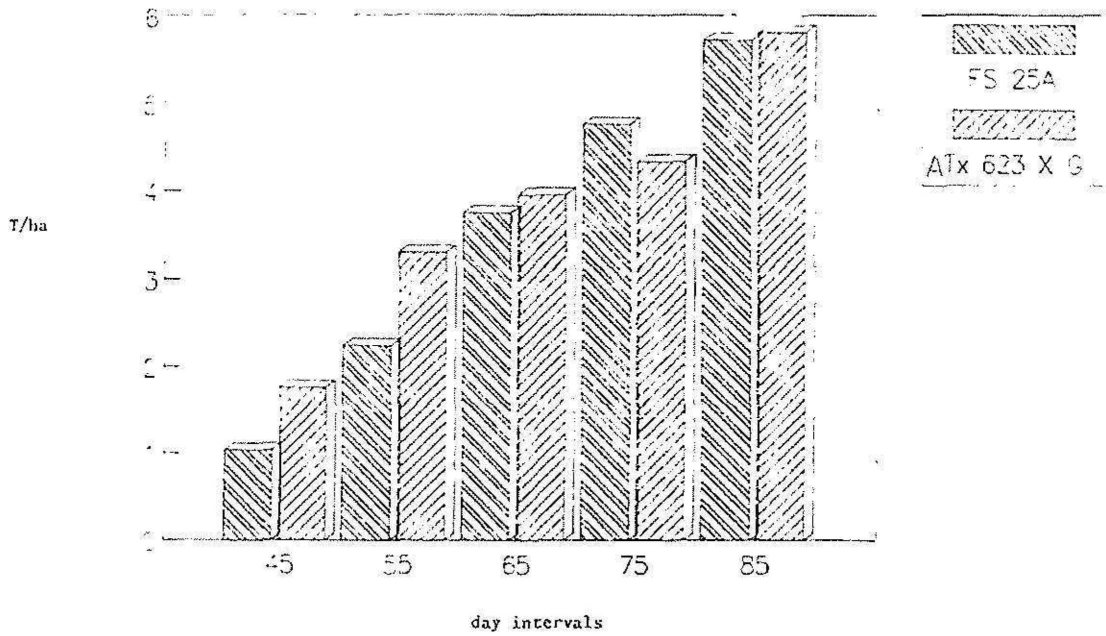

FIG. 2—Mean dry matter yield of two forage sorghum hybrids FS25A and ATx 623 × GL cut at 10-day intervals from 45 to 85 days.

values among cultivars have been reported in Puerto Rico (12). Whereas an increase in DFY is expected with increasing maturity (15) several factors can alter the expected gains (17). An extended growth and development period for a typical sorghum cultivar, given a favorable environment, should result in higher DFY values (14). Green yield reported by Torres et al. (25) fluctuated from 114 to 70 t/ha whereas those reported by Alsina et al. (1) for sweet sorghum fluctuated from 36.5 to 19.7 t/ha, harvested at three seed maturity stages (milk, hard dough and dry). Photoperiod and temperature can encourage higher yields of sorghum (14). Crude protein content generally declined with increasing harvest stage (table 4; figure 3). This was a predictable trend (3, 20, 24, 25). However, differences were not significant between cuttings among hybrids.

Sorghum crude protein content typically varies among plant organs and tissues. Pizarro et al. (15) reported that CPC on the leaves was three times higher than stem CPC in mature plants. However, the CPC of leaves was reduced from 17.4% at 63 days to 9.8% at 138 days. Variety can also be an important factor. Owen and Kuhlman (12) reported different trends in sorghum CPC attributable to differences in varieties at three different stages of maturity. The *Atlas* variety increased from 7.75 to 9.32% at milk and soft dough, respectively, but was reduced to 6.63% at hard dough stage, whereas in variety Rot the CPC was reduced from 9.91 to 8.92% from milk to soft dough, respectively. In a Georgia statewide evaluation of 13 sorghum hybrids for silaging, the CPC mean was 8.8% with fluctuations from 6.6 to 12.8% (16).

TABLE 4.—*Percentage crude protein contents (CPC) of two sorghum forage hybrids,* ATx 623 × GL *(A) and* FS25A *(B), harvested in three cuttings (1, 2, 3), at five intervals post-planting (45, 55, 65, 75, and 85 days)*

Cutting interval	Sorghum cutting numbers[1]									
	1 Hybrid			2 Hybrid			3 Hybrid			
Days	A	B	Combined mean	A	B	Combined mean	A	B	Combined mean	Grand mean
45	16.4a[2]	16.8a	16.6a	17.1a	17.8a	17.4a	17.2a	17.9a	17.6a	17.2a
55	13.0b	13.5b	13.2b	14.0b	11.4b	12.7b	14.9b	13.9a	14.4b	13.5b
65	10.4c	11.9c	11.2c	12.0c	11.7b	11.9bc	10.0b	10.1c	10.1c	11.0c
75	9.1	9.2cd	9.1c	9.8c	10.2bc	10.0c	9.3b	9.4c	9.4c	9.5c
85	7.8c	8.9d	8.4c	8.9c	8.4c	8.7c	7.9b	8.4c	8.2c	8.4c

[1] Cutting number 1 corresponds to seedling planting; numbers 2 and 3, to first and second ratoons.

[2] Mean values in the same column bearing unlike letters differ significantly (P = 0.05).

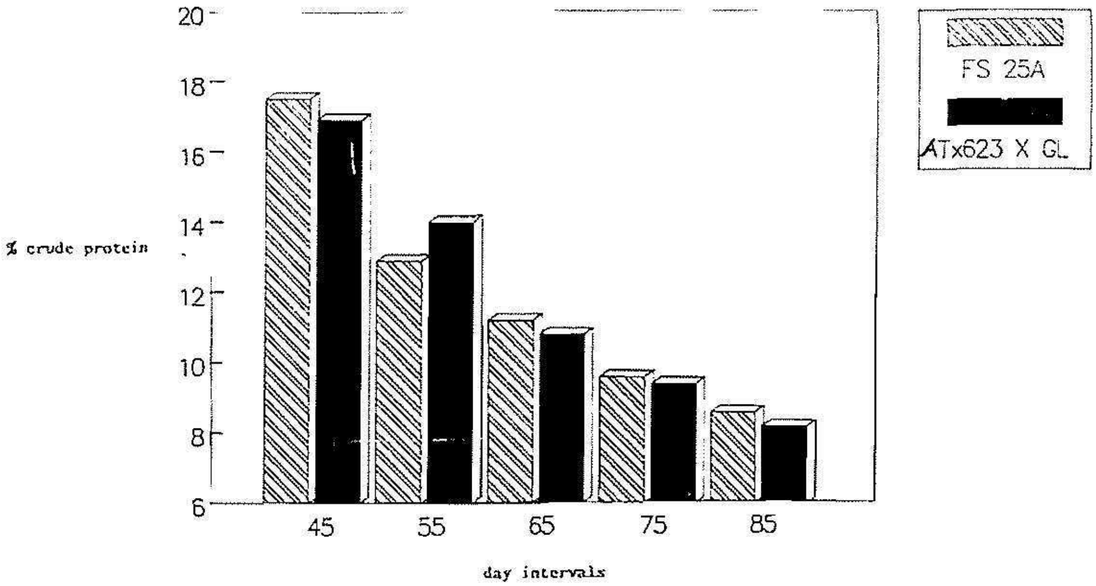

FIG. 3—Mean crude protein content of two forage sorghum hybrids FS25A and ATx 623 × GL cut at 10-day intervals from 45 to 85 days.

Another factor which reportedly influences sorghum CPC is the plant's N supply. An increase of 34% was reported by Sotomayor et al. (21) when N fertilizer was increased from zero to 80 g/ha. Pizarro et al. (15) reported that CPC stabilized at 3 to 5% when the plant matured in 140 to 280 days.

Crude protein yield was higher for *ATx 623* × *GL* (421.6 kg/ha) than for *FS25A* (358.9 kg/ha) (table 1). Yield was lowest at the first cutting interval (table 5). Disease incidence might have influenced protein yield

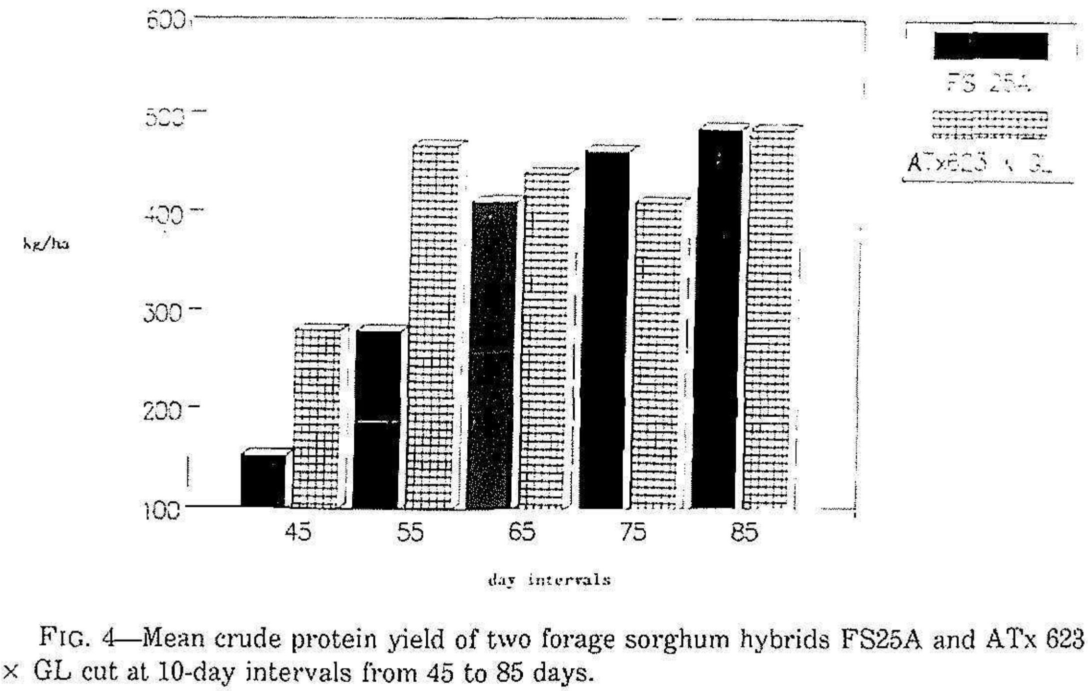

FIG. 4—Mean crude protein yield of two forage sorghum hybrids FS25A and ATx 623 × GL cut at 10-day intervals from 45 to 85 days.

TABLE 5.—*Kilogram per hectare crude protein yield (CPY) of two sorghum forage hybrids,* ATx 623 × GL *(A) and* FS25A *(B), harvested in three cuttings (1, 2, 3), at five intervals post-planting (45, 55, 65, 75, and 85 days)*

Cutting interval	Sorghum cutting numbers[1]									
	1 Hybrid			2 Hybrid			3 Hybrid			
Days	A	B	Combined mean	A	B	Combined mean	A	B	Combined mean	Grand mean
45	138.0b[2]	68.6b	103.3c	453.9d	229.6d	341.8c	301.8c	161.6a	231.7c	255.6c
55	206.2a	140.6b	173.4b	690.6b	377.4c	534.0c	508.5a	321.8c	415.2b	344.2b
65	199.8a	208.8ab	204.3a	718.4a	623.8b	671.1b	405.0b	404.9b	404.9b	426.8ab
75	190.9a	203.4ab	197.1ab	622.0c	717.1a	669.6b	426.0b	474.0ab	450.0b	438.9ab
85	218.9a	244.2a	231.5a	775.4a	702.6a	739.0a	468.2a	503.1a	485.6a	485.4a
Combined mean			181.9			591.1			397.5	390.2

[1]Cutting number 1 corresponds to seedling planting; numbers 2 and 3, to first and second ratoons.
[2]Mean values in the same column bearing unlike letters differ significantly (P = 0.05).

at the 75-day harvest. Previous studies have shown variation in CPY from 670 to 54 kg/ha among forage sorghum hybrids (24). Variations in CPY were also reported between cuttings, from 850 kg/ha at the second ratoon to 360 kg/ha at the third ratoon (24). Sotomayor and Santiago (17) reported mean CPY of 2,002 kg/ha and fluctuations from 2,712 to 1,391 kg/ha. Padilla and Ruiz (13) compared performance of forage sorghum alone, with sunflower alone, and as an intercrop. The CPY obtained by sorghum alone was 730 kg/ha, whereas the mean CPY for the sunflower-sorghum intercrop was 963 kg/ha; sunflower alone contributed 1,090 kg/ha.

The mean contents of NDF, ADF, C and L did not differ (P = .05) among cuttings or hybrids (table 6). However, Si was significantly higher for *ATx 623 × GL* than *FS25A*. From these results for lignin and silica contents it is expected that *FS25A* is higher in nutritive value than *ATx 623 × GL*.

Both *ATx 623 × GL* and *FS25A* were periodically examined for the presence of foliar diseases, and their progressive severity was recorded. Sorghum downy mildew [(*Peronosclerospora sorghi*), (Weston and Uppal) C. G. Shaw], leaf blight (*Helminthosporium turcicum*, Pass), rust (*Puccinia purpurea*, Cooke), grey leafspot (*Cercospora sorghi*, Ell. and Ev.) and zonate leafspot (*Gloeocercospora sorghi* D. Bain & Edg.) appeared to be the major foliar diseases present. Disease severity varied among seasons and hybrids. Downy mildew was most prevalent from January to May. *ATx 623 × GL* was very susceptible to local lesions and moderately-resistant to systemic infections, the latter a more damaging

TABLE 6.—*Mean values for neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose (C), lignin (L), and silica (Si) contents of two sorghum forage hybrids at three cuttings*

Parameter	Variety	Contents of DM (%), at cutting			Variety grand mean
		1	2	3	
NDF	Atx 623 × GL	67.9	69.4	69.4	68.9
	FS25A	69.6	68.1	68.1	68.6
ADF	ATx 623 × GL	44.2	45.3	45.3	44.9
	FS25A	42.5	42.6	42.4	42.5
C	ATx 623 × GL	29.9	30.1	31.5	30.5
	FS25A	29.9	29.6	28.5	29.3
L	ATx 623 × GL	10.0	9.9	10.3	10.1
	FS25A	9.3	9.2	10.3	9.6
Si	Atx 623 × GL	3.8	3.5	3.5	3.6
	FS25A	3.0	3.0	2.6	2.9

form of the disease. Levels of systemic infections did not exceed 20%, which is regarded as an acceptable level in grain sorghum in Texas (4). During the same period leaf blight was moderately severe in *FS25A* and moderate in *ATx 623 × GL*). From May to July, rust and grey leafspot became the dominant diseases, whereas downy mildew and leaf blight had all but disappeared. *FS25A* was more susceptible to both rust and grey leafspot diseases than *ATx 623 × GL*.

From September to November, zonate leafspot became the most prevalent and damaging disease. Moderately-severe grey leafspot and rust occurred on both hybrids during the fall rainy season. Unlike other diseases, zonate leafspot killed entire leaves and plants. *ATx 623 × GL* appeared more susceptible in terms of number of lesions per leaf and leaf tip necrosis. *FS25A* exhibited lesions 3 to 5 times as large as *ATx 623 × GL*. These diseases appear limiting factors to both sorghum hybrids and probably lower DFY and CPY values. Rust can lower grain yield potential by 20 to 60% under normal conditions on susceptible sorghum cultivars in Puerto Rico (6).

Previous field studies have shown that sorghum is susceptible to insect pests and diseases. Rust anthracnose, zonate leafspot, and leaf blight have been reported (18, 19), but little information has appeared relative to their seasonal variations. Liu and Ramírez-Oliveras (10) reported mild downy mildew on sorghum in 1978. Hepperly and Craig (7) discovered a sorghum downy mildew race at Lajas and concluded the disease was established there previously. Reduced yields of irrigated sorghum were attributed to disease depredation (26).

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