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Summary

The objectives of this study were to determine the forage yield, nutritive value, and water use efficiency of teff grass (*Eragrostis tef*) under field conditions as compared to sorghum sudangrass and forage pearl millet. Water use efficiency was determined by regressing above-ground biomass on crop water use between sampling periods. Yield was determined by quadrat area clippings of above-ground biomass. Nutritive value was determined using wet chemical analysis. Cultivars showed significant differences in biomass production at all sampling dates in both years. Teff grass demonstrated potential to provide producers with a fast-growing and competitive forage crop by reaching optimum yields at an earlier date than other commonly grown forages.

Introduction

This study was conducted in 2016 and 2017 to determine if teff grass could be established as a summer forage in Kansas. Native to Ethiopia, teff grass is a fine-stemmed, warm-season annual that uses the C₄ photosynthetic pathway. Providing producers with alternative forages offers greater flexibility in diversifying their rotations. Our objectives were to determine the forage yield, nutritive value, and water use efficiency of teff grass under field conditions as compared to sorghum sudangrass and forage pearl millet.

Procedures

Field sites were established at the Kansas State University Northwest Research-Extension Center in Colby, KS, on a Keith silt loam in 2016 and on a Richfield silt loam in 2017. Four commonly available teff varieties, along with sorghum sudangrass and forage pearl millet, were planted on June 8, 2016, and May 31, 2017, in 30- × 20-ft plots at rates of 10 lb/a for teff and 20 lb/a for sorghum sudangrass and pearl millet. Teff grass was sown to a depth of 0.25 in., whereas sorghum sudangrass and forage pearl millet were sown to a depth of one in. Plots were arranged in a randomized complete block design with four replicates. Fertilizer applications included 61 lb/a nitrogen (N) and 30 lb/a phosphorus in both years. Weed management in 2016 included one application of dicamba (Sterling Blue 6 oz/a) and 2,4-D-LV6 (6 oz/a) and another application of 2,4-D-LV6 (16 oz/a). In 2017, one application of 2,4-D-LV6 (10 oz/a) was made. In both years hand hoeing was required to maintain clean plots. Plots were irrigated (2 in. in 2016, 1.2 in. in 2017) after planting to aid emergence in both years. Apart from that, no irrigation was applied during the 2016 and 2017 growing seasons.

Above-ground biomass was measured by harvesting plants within a 30- × 30-in. quadrat. In 2016, harvest began on all plots once the majority of teff grass plots had reached late boot stage. All plots were harvested on the same day every 4–5 days from 40–58 days after planting (DAP). In 2017, each plot was harvested once it reached late boot stage. Teff grass varieties were harvested from 41–63 DAP, whereas sorghum sudangrass and forage pearl millet were harvested from 63–82 DAP. In order to compare cultivars, 2017 data will be examined by days after boot stage (DAB), with the initial harvest being zero DAB. Dry matter yield was determined after samples were dried to a constant weight at 120°F. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined via wet chemical analysis of ground samples. Crude protein (CP) was calculated by multiplying total N (%) by 6.25. Stored soil water was measured using neutron thermalization. Soil water depletion was determined by the difference in stored soil water between two sampling periods. Crop water use (CWU) was determined by the summation of soil water depletion plus precipitation. No corrections were made for drainage, runoff, or evaporative losses. Water use efficiency (WUE) was determined by regressing above-ground biomass on CWU between sampling periods. Precipitation data were obtained from the Kansas Mesonet. Leaf area index (LAI) was measured using a LI-COR LAI-2000 instrument.

Results

Environmental Conditions

The growing seasons extended from planting to 58 and 82 DAP in 2016 and 2017, respectively. Total precipitation for each growing season was 4.3 in. in 2016, and 7.4 in. in 2017. Average maximum/minimum air temperatures for each growing season were 87.7/60.2°F in 2016 and 91.5/63.6°F in 2017.

Crop Development

Emergence was recorded at 6 DAP in 2016 and 9 DAP in 2017. In 2017, one pearl millet plot was removed from the study due to poor stand development. In 2016, all teff varieties reached the late boot stage within 41–48 DAP (Table 1). Sorghum sudangrass and pearl millet reached the late boot stage at 72 and 58 DAP, respectively. In 2017, all teff varieties reached the late boot stage within 41–43 DAP (Table 2). Sorghum sudangrass and pearl millet reached the late boot stage at 63 DAP.

Biomass and Crop Water Use

Cultivars showed significant differences in biomass production at all sampling dates in both years. In 2016, there were only two sampling dates (44 and 58 DAP) at which all teff varieties were similar. The highest-producing teff variety, Excalibur, was similar to sorghum sudangrass in biomass production at every sampling date except for 40 DAP and 58 DAP (Figure 1A). Excalibur was only similar to pearl millet in biomass production at one sampling date: 40 DAP (Figure 1A). Crop water use only differed at two dates (54 and 58 DAP). Excalibur showed WUE similar to that of sorghum sudangrass at 54 DAP (Table 1).

In 2017, teff varieties produced similar biomass at every sampling date except 15 DAB. Teff variety Excalibur was similar to pearl millet in biomass production at every sampling date except for zero DAB (i.e., the date of the initial harvest) and 20 DAB

(Figure 1B). Sorghum sudangrass produced significantly more biomass than all other cultivars at every sampling date (Figure 1B). Crop water use has yet to be determined for the 2017 growing season.

Nutritive Value

Cultivars differed in CP and NDF at nearly every sampling date in both years. In 2016, teff variety Corvallis and pearl millet had the greatest CP content at 54 DAP (Table 1). In 2017, teff variety Moxie and pearl millet had the highest above-ground biomass CP content for clippings by quadrat area at 15 DAB (Table 2). The ADF varied the least among cultivars in both years (Figure 1E and F). Pearl millet had lower NDF values than Haymore and Excalibur teff varieties in 2016 at 54 DAP (Table 1).

Canopy Formation

Cultivars differed in LAI at all dates in both years with the exception of 10 DAB in 2017 (Figure 1C and D). Teff varieties differed at every sampling date in 2016 except 54 and 58 DAP. Sorghum sudangrass showed significantly less LAI than pearl millet and teff at all dates in 2016 (Figure 1C). All cultivars were more similar in 2017.

Conclusion

Teff grass can be a competitive forage crop in Kansas. In 2016, teff grass variety Excalibur had dry matter yield and water use efficiency similar to sorghum sudangrass. In 2017, variety Excalibur had dry matter yield similar to pearl millet. Teff grass showed nutritive values similar to sorghum sudangrass and pearl millet in both 2016 and 2017. Since significant variation occurred amongst teff varieties, further research evaluating available varieties of teff grass would greatly help producers in choosing which variety to grow.

Table 1. Forage performance indicators at 54 days after planting in 2016¹

Cultivars	Biomass	Crop water use	Water use efficiency	Leaf area index	Crude protein	Acid detergent fiber	Neutral detergent fiber	Days to boot stage
	t/a	in.	lb biomass A ⁻¹ in ⁻¹ water	ft ² ft ⁻²	----- % -----			
Corvallis	1.9 d	6.69 ab	570 c	4.99 b	16.8 a	30.3	58.8 bc	43
Haymore	1.7 cd	6.69 ab	510 c	4.87 b	14.7 b	32.2	60.3 a	41
Moxie	1.8 bcd	7.24 ab	500 bc	5.36 b	16.3 a	31.0	59.2 abc	48
Excalibur	2.1 bc	6.92 ab	610 ab	5.17 b	13.8 b	32.6	60.1 ab	43
SS	2.4 ab	6.49 b	740 a	3.61 c	13.8 b	31.7	58.7 bc	72
PM	2.7 a	7.44 a	730 a	7.30 a	17.4 a	30.1	57.5 c	58

¹Results are presented for four varieties of teff grass as well as sorghum sudangrass (SS) and forage pearl millet (PM).

Note: Means with different letters within a column are significantly different according to a least significant difference test ($\alpha = 0.05$).

Table 2. Forage performance indicators at 15 days after boot stage in 2017

Cultivars	Biomass	Crop water use	Water use efficiency	Leaf area index	Crude protein	Acid detergent fiber	Neutral detergent fiber	Days to boot stage
	t/a	in.	lb biomass A ⁻¹ in ⁻¹ water	ft ² ft ⁻²	----- % -----			
Corvallis	1.8 d	†	†	4.3	10.7 b	33.6 b	62.2 b	41-43
Haymore	2.5 bcd	†	†	4.6	9.5 b	36.1 a	65.1 a	41
Moxie	1.9 cd	†	†	4.7	11.7 ab	33.8 b	61.1 b	41-43
Excalibur	2.7 bc	†	†	5.0	8.8 b	35.4 a	62.5 b	41-43
SS	4.2 a	†	†	4.3	10.9 ab	35.8 a	61.9 b	63
PM	2.8 b	†	†	4.5	13.0 a	35.3 a	62.7 b	63

¹Results are presented for four varieties of teff grass as well as sorghum sudangrass (SS) and forage pearl millet (PM).

Note: Means with different letters within a column are significantly different according to a least significant difference test ($\alpha = 0.05$).

† Means not yet calculated. Data are still being analyzed.

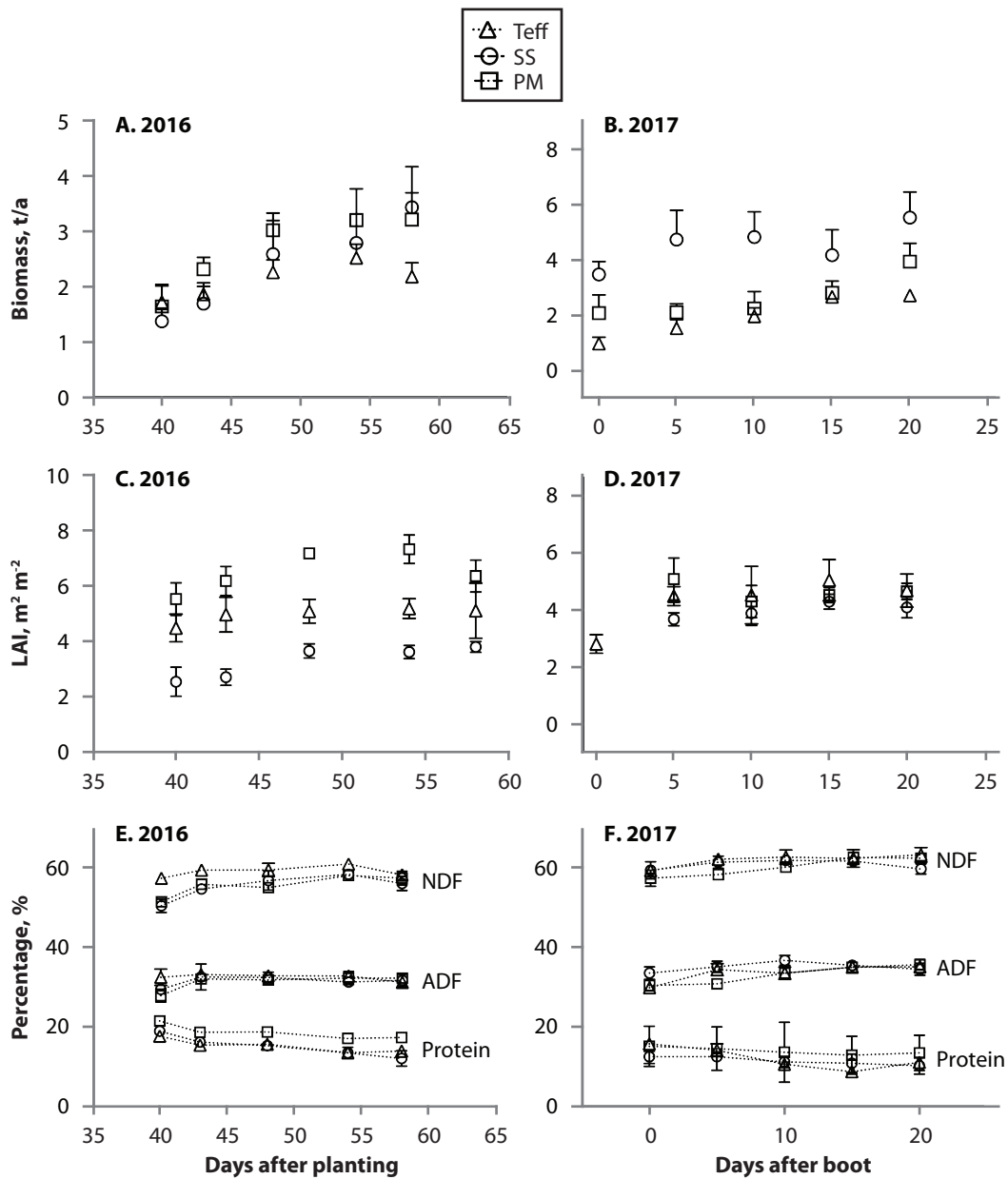


Figure 1. Above-ground biomass, leaf area index (LAI), and nutritive values for teff grass, sorghum sudangrass (SS), and forage pearl millet (PM) in 2016 and 2017. In both years, teff grass is represented by the variety Excalibur.