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Water Use and Productivity of Teff, a Dairy Quality Forage Crop

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Water Use and Productivity of Teff, a Dairy Quality Forage Crop

Abstract

Teff grass can be a competitive summer annual forage in Kansas. Teff grass is a rapidly growing, high quality forage that could be a good option for producers in water-limited areas with a short growing season. The cultivar 'Excalibur' exhibited superior biomass (4280 lb/a) and crop water productivity (610 lb/a-in.), among teff cultivars. This study also indicated that biomass productivity and crop water productivity of sorghum sudangrass (696 lb/a-in.) tended to be greater than that of forage pearl millet (528 lb/a-in.). Further research into teff grass should focus on integration of teff into irrigation management systems with restricted water supply.

Keywords

teff, forage crops, water use, limited irrigation

Authors

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Summary

Teff grass can be a competitive summer annual forage in Kansas. Teff grass is a rapidly growing, high quality forage that could be a good option for producers in water-limited areas with a short growing season. The cultivar 'Excalibur' exhibited superior biomass (4280 lb/a) and crop water productivity (610 lb/a-in.), among teff cultivars. This study also indicated that biomass productivity and crop water productivity of sorghum sudangrass (696 lb/a-in.) tended to be greater than that of forage pearl millet (528 lb/a-in.). Further research into teff grass should focus on integration of teff into irrigation management systems with restricted water supply.

Introduction

Water-efficient forage crops can contribute to limited irrigation management systems. Teff grass (*Eragrostis tef* [Zucc.] Trotter) is a dairy-quality forage crop (Saylor, 2018) with limited water requirements during a short mid-summer growing season. The water use of teff grass has not been determined in the U.S. Our objective was to determine forage yield, crop water use, and crop water productivity of teff grass, under field conditions and in comparison with sorghum sudangrass (*S.* × *drummondii* [(Nees ex. Steud.) Millsp. & Chase]) and forage pearl millet (*P. glaucum* [L.] R.Br.).

Procedures

Field sites were established at the Kansas State University Northwest Research-Extension Center in Colby, KS, (39°23'36.3"N 101°03'47.7"W) in 2016 and 2017. The plots were established on a Keith silt loam (fine-silty, mixed, superactive, mesic Aridic Argiustolls) in 2016 and on a Richfield silt loam (fine, smectic, mesic Aridic Argiustolls) in 2017. In both years, tillage included passes with a field cultivator and a cultipacker to prepare a firm seedbed. Four commonly available teff varieties, along with sorghum sudangrass and pearl millet, were planted on June 8, 2016, and May 31, 2017, in 20- × 30-ft plots at rates of 10 lb/a for teff, and 20 lb/a for sorghum sudangrass and forage pearl millet. Areas of poor emergence were reseeded by hand to ensure adequate crop stands. Teff grass was sown no deeper than 15 mm, while sorghum sudangrass and forage pearl millet were sown no deeper than 30 mm. Fertilizer applications included 61 lb N/a as 32-0-0 and 30 lb P/a as 10-34-0 in both years. Weed management in 2016 included one application of dicamba and 2,4-D-LV6 (post-emerge) and another application of 2,4-D-LV6. In 2017, one application of 2,4-D-LV6 (post-emerge) was made. In both years, hand hoeing was required to maintain weed-free plots. Plots were

irrigated (2.0 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.

Aboveground biomass (AGB) 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. Above-ground biomass was determined after samples were dried to a constant weight. Stage of development was recorded at each biomass sampling.

Stored soil water (SSW) was measured using neutron thermalization and calculated, in 12-in. increments for the 9 ft soil profile. Soil water depletion (SWD) was calculated from the difference in the equivalent depths of successive SSW determinations for sampling periods beginning with crop emergence (15 DAP) and thereafter corresponding to biomass sampling. Cumulative water use (CWU) was calculated using the soil water balance (CWU = SWD + precipitation + irrigation), with no corrections for drainage or evaporation. Berms were installed around each plot to control for runoff using a "ditcher"; a type of row cultivator in 2016 but not in 2017. Crop water productivity (CWP, lb/a-in.) was determined each sampling period by dividing AGB by CWU.

Experimental design was randomized complete block design with 4 blocks as replicates, conducted in two environments (years). Treatment design was split-in-time, analyzed as repeated measure (Littell et al., 2006). The whole plot effect was annual forage cultivar (four varieties of teff grass, sorghum sudangrass, and pearl millet), the split-in-time effect was the sampling period. Analysis of variance was performed using the MIXED procedure (SAS Institute, Cary, NC, version 9.4, 2012) for AGB, CWU, and CWP. Entry and sampling period were treated as fixed effects. Non-trivial random effects included combinations of year, replication (year), year × cultivar, year × sampling period and year × cultivar × sampling period. As sampling intervals were not uniform, the covariance structure of residual error effects was evaluated with the spatial autocorrelation models 'Power,' 'Gaussian,' and 'Spherical.' Criteria included successful model convergence and minimized Bayesian information criterion and corrected Akaike's information criterion.

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 4.29 in. during 2016, and 7.40 in. during 2017. Average maximum/minimum air temperatures for each growing season were 104/51°F in 2016 and 93/64°F in 2017. No disease or pest was observed in either year.

Crop Development

Crops emerged six DAP in 2016 and nine DAP in 2017. In 2017, one pearl millet plot was terminated due to poor establishment and growth. All teff varieties reached the late boot stage within 41–48 DAP in 2016, and 41–43 DAP in 2017. Sorghum sudangrass and pearl millet reached the late boot stage at 72 and 58 DAP in 2016, respectively, and at 63 DAP in 2017. Accordingly, comparisons among the three species were limited to a narrow sampling interval corresponding to late panicle emergence for teff, early boot for forage pearl millet and whorl stage for sorghum sudangrass.

Biomass, Water Use, and Crop Water Productivity

No differences were detected in biomass productivity, water use, crop water productivity nor canopy formation among the three species, when evaluated at similar sampling periods (Table 1), despite substantial numerical differences. In contrast, teff cultivars differed in biomass, when analysis was restricted to the four teff varieties. Excalibur had greater biomass productivity than the other cultivars; water use of Moxie tended to be greater than that of Haymore. Biomass productivity and water use increased during the sampling intervals for teff cultivars (Table 2).

References

Saylor, B.A., D. H. Min, and B. J. Bradford. 2018. Productivity of lactating dairy cows fed diets with teff hay as the sole forage. J. Dairy Sci. 101:5984–5990 https://doi.org/10.3168/jds.2017-14118.

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Table 1. Productivity and water use of teff, sorghum sudangrass, and forage pearl millet, Colby, Kansas, 2016 and 2017

Species	Biomass	CWU	CWP
	lb/a	inch	lb/a-in.
Teff	4450	9.17	485
Sorghum sudangrass	6850	11.18	696
Forage pearl millet	5370	11.57	528

CWU = crop water use.
CWP = crop water productivity.

Table 2. Productivity and water use of teff cultivars, Colby, KS, 2016 and 2017

Cultivar	Biomass	CWU	CWP
	lb/a	inch	lb/a-in.
Corvallis	3220	7.05	492
Haymore	3470	6.89	528
Moxie	3590	7.68	503
Excalibur	4280	7.48	610
Sampling period			
1	2160	4.49	512
2	2940	5.51	578
3	3660	6.93	560
5	4290	8.90	490
6	4610	9.80	560

CWU = crop water use.
CWP = crop water productivity.