A PRELIMINARY EVALUATION OF THE FORAGE POTENTIAL OF TEFF

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ABSTRACT

Warm-season annual grasses capable of producing high quality forage during the summer are needed in the Great Plains. Teff [*Eragrostis tef* (Zucc.) Trotter] is noted for rapid production of high quality forage in Africa. Eight accessions of teff planted at Brookings, SD on 10 July 1984 averaged 4868 and 9646 kg/ha of dry matter (DM) when harvested on 25 Aug. and 27 Sept., respectively. Mean crude protein percentage (CP) of 2 morphologically dissimilar accessions was similar and ranged from 19.2% on 25 Aug. to 14.8% on 27 Sept. Two accessions with excellent leafiness and freedom from lodging in the 1984 trial were evaluated for forage yield and quality over 4 planting dates (10 May, 27 May, 6 June, 20 June) in 1985. DM yield at early head for the 6 June planting (4750 kg/ha) was significantly greater than DM yields of 10 and 27 May plantings (3943 and 3315 kg/ha, respectively). CP at early head of the 20 June planting was 17.3 and 16.3% for brown- and white-seeded accessions, respectively, compared to 12.3% for both accessions in the 27 May planting. *In vitro* dry matter disappearance (IVDMD) was significantly higher for May (63.5%) than June (59.4%) plantings harvested at early head. Forage yields of the May plantings were significantly higher at mature seed (8184 kg/ha) than early head (3629 kg/ha), but CP and IVDMD dropped from 12.7 to 6.2 and 63.5 to 45.8%, respectively. The data suggest teff has potential value as a hay crop or supplementary summer pasture for the Great Plains.

INTRODUCTION

Teff [*Eragrostis tef* (Zucc.) Trotter] is a major cereal crop of Ethiopia (Mengesha et al. 1965) and has been grown in other African countries as a hay crop (Bogdan 1977). Whyte et al. (1959) reported teff was widely grown for hay in northern Republic of South Africa. Bogdan (1977) pointed out that seeds of teff germinated quickly; seedlings grew rapidly; and 2t DM/ha of 15.5% crude protein forage were produced 9 weeks after sowing in Kenya. A brown-seeded, fine-stemmed, leafy variety of teff yielded 9287 kg/ha of forage over a 5-year study in South Africa (Hall 1948). Lusigi et al. (1984) considered annual *Eragrostis* sp. to be very desirable for cattle and sheep in northern Kenya. Morris (1980) found *in vivo* digestibility of vegetative cell walls of teff to be intermediate between *Lolium perenne* and *Heterolepus contortus.*

Over much of the Great Plains, there is a need for high quality pasture or hay species that are productive during the summer months. Since teff is noted for rapid production of high quality forage, the objective of this study was to evaluate several accessions for forage yield and quality in spring and summer sowings in eastern South Dakota.

MATERIALS AND METHODS

Eight accessions of teff (obtained from Plant Germplasm Introduction and Testing, USDA/ARS, Pullman, WA) were broadcastseeded on 10 July, 1984 at a rate of 12 kg/ha on 1.0 m^2 plots in a randomized complete block design with two replications. Seed was not available for larger plots and more replications. The soil was a Vienna loam, nearly level [fine-loamy, mixed Udic Haploborolls]. On 25 Aug., 1984, 0.5 m^2 segments of each plot were harvested and plant material was dried at 40 C until constant weight to obtain forage yield. Growth stages of accessions ranged from boot to early head. An aftermath harvest was made on 9 Sept. and remaining 0.5 m^2 plot segments were harvested on 27 Sept. after a hard frost, at the time the filling seeds ranged from soft to hard dough stages. Stubble height was 10 cm.

Two accessions (1 brown- and 1 white-seeded) that exhibited excellent forage yield, leafiness, and freedom from lodging in the 1984 trial were evaluated for forage yield and quality in 1985. These accessions were broadcastseeded on four dates (10 May, 27 May, 6 June, 20 June) at a rate of 12 kg/ha on 1.0 m^2 plots in a randomized complete block design with four replications. The soil was as described for the 1984 trial. The 10 and 27 May plantings were harvested (0.5 m^2 segments/plot) initially on 19 July when plants had reached early head, while 6 and 20 June plantings were harvested at early head on 5 and 20 Aug., respectively. An aftermath harvest was taken for the May plantings on 20 Aug. Remaining 0.5 m^2 plot segments of the May plantings were harvested for mature seed and forage on 14 Sept.

Dried forage was weighed, bulked across replications, and random samples were ground to 2.0 mm and stored for analysis. For plants of two morphologically distinct accessions (a short, fine-stemmed, brown-seeded type with diffuse panicles and a tall, coarse-stemmed, white-seeded type with dense cylindrical panicles) in the 1984 trial, total N, ether extract, acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), silica, and ash were determined in duplicate. Total Kjeldahl N, ether extract, ADF, ADL, and ash were determined as outlined by A.O.A.C. (1984). Total N was multiplied by 6.25 to determine crude protein percentage. NDF was determined in duplicate by methods of Goering and Van Soest (1970); silica was determined in duplicate by methods of Volk and Weintraub (1958). *In vitro* dry matter disappearance in the 1985 trial was determined in triplicate by a modified Tilley and Terry method (Terry et al. 1978).

Seed yields were obtained by hand threshing panicles on a rubber threshing board and separating caryopses from chaff with a South Dakota Seed Blower Model B.

RESULTS AND DISCUSSION

Overall mean dry matter forage production for the eight accessions evaluated in 1984 averaged 4868±892, 704±166, and 9646±1407 kg/ha for the first (25 Aug.), 9 Sept. aftermath, and seed-filling (27 Sept.) harvests, respectively. Quality component data for two morphologically distinct (brown- and white-seeded) accessions were quite similar (Table 1). Crude protein (CP) percentages of the first and aftermath harvests were similar, but a significant decrease was noted between vegetative and seed-filling (27 Sept.) stages. NDF, ADF, and ADL were higher for the 27 Sept. harvest than the 9 Sept. aftermath, and ether extract decreased with maturity. Morris (1980), working in South Africa, found NDF of teff leaf and stem dry matter to be 63 and 68%, respectively, 68 days after planting, which are slightly higher than whole plant values found in this study (Table 1). She also observed vegetative cell falls of teff were over 70% digested in nylon bags in the rumen, compared to 85% for *Lolium perenne* and 50% for the tropical grass *Heteropogon contortus.* Silica content of 9 Sept. aftermath and 27 Sept. seed-filling harvests were similar.

For the first harvest in 1985, significant differences were found among planting dates for forage yield (Table 2), IVDMD, and ash (Table 3). The general trend for both accessions harvested at early head was for forage yield and CP to increase and IVDMD to decrease with planting date (Tables 4 and 5). Mean dry matter forage yield of the 6 June planting, harvested at early head in August, was significantly greater than those of the May plantings harvested at the same stage on 19 July; however, the reverse was true for IVDMD. Ash increased significantly with delay in planting date (Table 4). Smith (1975) found oats grown in environmental chambers with cool temperatures (21/15 C day/night) contained high concentrations of IVDMD, whereas highest concentrations of CP and ash occurred in herbage grown in hot (32/26 C day/night) temperatures. He also observed IVDMD, crude protein, and ash were generally influenced more by temperature prevailing before

TABLE 1

Quality Component Means and Standard Deviations of Two Distinct Accessions of *Eragrostis tef* grown at Brookings, South Dakota in 1984

Quality Component	Seed Color	Harvest		
		25 Aug.	9 Sept. regrowth	27 Sept.
		- - -	- % -	- - -
Crude protein	Brown	17.60±0.10	21.60±0.30	14.78±0.26
	White	20.80±0.20	21.10±0.20	14.73±0.08
Ash	Brown	9.47±0.08	11.50±0.05	10.65±0.10
	White	11.36±0.02	11.51±0.02	11.95±0.06
NDF	Brown	-	56.00±0.60	61.05±0.35
	White	-	53.60±0.40	61.10±0.21
ADF	Brown	-	30.10±0.10	34.35±0.13
	White	-	29.40±0.80	35.87±0.06
ADL	Brown	-	2.39±0.06	3.66±0.08
	White	-	2.31±0.10	3.75±0.01
Silica	Brown	-	4.06±0.03	4.21±0.11
	White	-	3.92±0.16	3.92±0.37
Ether extract	Brown	2.97±0.17	2.81±0.09	2.18±0.16
	White	3.47±0.06	3.21±0.20	2.11±0.11

TABLE 2

Analyses of Variance of Forage Yield at Early Head and Seed Yield of Two Accessions of *Eragrostis tef* at Brookings, South Dakota in 1985

Source of Variation	Forage Yield		Seed Yield	
	df	Mean Squares	df	Mean Squares
Accession (A)	1	1803450	1	664142**
Plant Date (P)	3	3375567*	1	289
A x P	3	241750	1	116623
Reps within P	12	782642	6	194705
Error	12	624537	6	75385

*, **Significant at the 0.05 and 0.01 levels, respectively.

TABLE 3

Analysis of Variance of Forage Quality Components and IVDMD of Two Accessions of *Eragrostis tef* Harvested at Early Head at Brookings, SD in 1985

Source of Variation	df	Mean Squares		
		CP	IVDMD	Ash
Accession (A)	1	1.52**	4.69	0.30*
Plant Date (P)	3	15.57**	40.27**	3.90**
A x P	3	0.22*	1.25	0.07
Error[1]	8	0.04	2.82	0.03

*, **Significant at the 0.05 and 0.01 levels, respectively.

[1]Error df for IVDMD were 16.

TABLE 4

Effect of Planting Date on Forage Yield and Quality of Two Accessions of *Eragrostis tef* harvested at Brookings, South Dakota in 1985

Planting Date	Harvest Date	Forage Yield	Quality Parameters[1]	
			IVDMD	Ash
		kg/ha	- - -%-	- -
10 May	19 July	3943ab	64.76a	7.85a
27 May	19 July	3315a	62.30a	7.77a
6 June	5 Aug.	4750c	59.07b	8.88b
20 June	20 Aug.	4558bc	59.77b	9.86c

[1]Means in the same column that are followed by a different letter are significantly different by LSD (0.01).

initial panicle emergence than temperatures during later stages. The present experiments also showed a significant difference between accessions for CP and ash, and the accession by planting date interaction was significant for crude protein (Table 3).

Although the second planting (27 May) was made 17 days after the first (10 May), they reached early head at approximately the same date (19 July). Germination and seedling growth studies of

TABLE 5

Planting Date x Accession Means for Crude Protein Percentage of Two Accessions of *Eragrostis tef* Harvested at Early Head at Brookings, South Dakota in 1985

Planting Date	Harvest Date	Accession Seed Color[1]	
		Brown	White
		%	
10 May	19 July	13.5c	12.6c
27 May	19 July	12.3d	12.3c
6 June	5 Aug.	14.4b	13.8b
20 June	20 Aug.	17.3a	16.3a

[1]Means in the same column that are followed by a different letter are significantly different by LSD (0.01).

teff, utilizing 15, 20, and 25 C constant temperatures and 15/30 and 20/30 C alternating temperatures, indicated more rapid germination and seedling growth at the highest constant and alternating temperatures (Boe, unpublished data, Plant Science Dept., SDSU, Brookings, SD).

Mean dry matter forage yields of the 9 Sept. aftermath of the 10 and 27 May 1985 plantings were 2715 and 2533 kg/ha for brown- and white-seeded accessions, respectively. Regrowth occurred as lateral shoots from axillary buds at nodes below cutting height. Overall mean CP, IVDMD, and ash were 12.7, 55.4, and 9.2%, respectively, indicating a reduction in overall quality compared to first harvest forage (Tables 4 and 5). Such a reduction in quality has been reported for aftermath harvests of other forage grasses. Anderson and Matches (1983) found CP and IVDMD of switchgrass regrowth to be lower than first harvest herbage and Sullivan et al (1956) reported higher lignin levels in aftermath as compared to first harvest herbage of common cool-season pasture grasses.

Overall mean dry matter forage (not including seed) yield of the 10 and 27 May plantings harvested for mature seed was 8184 kg/ha, with 6.2% CP and 45.81% IVDMD. These data indicated a significant increase in forage yield, but significant decrease in quality as the grass matured from early head to mature seed stages. Smith (1960) reported percentages of protein and ash of oat forage declined from early growth to maturity, and Cherney and Marten (1982) found IVDMD of four small grain crop forages ranged from 80 to 58% as maturation ranged from flag leaf to dough stage. Both Smith (1960) and Cherney and Marten (1982) reported increases in dry matter yield with increased maturation of annual small grain forages.

A significant difference was found between accessions for seed yield of the May plantings (Table 2). Mean seed yields for brown- and white-seeded accessions were 2322 and 1032 kg/ha, respectively, indicating high yields of mature seed can be produced in South Dakota.

Results obtained from this 2-year pilot study concur with Bogdan's (1977) observations on the rapid growth and desirable forage characteristics of teff. Teff can be grown successfully in eastern South Dakota and it should be evaluated as a hay crop or supplementary pasture in other parts of the Great Plains.

LITERATURE CITED

Anderson, B. and A. G. Matches. 1983. Forage yield, quality, and persistence of switchgrass and caucasian bluestem. Agron. J. 75:119-24.

Association of Official Analytical Chemists. 1984. Official methods of analysis. 14th Ed. AOAC, Washington, D.C.

Bogdan, A. V. 1977. Tropical pasture and fodder plants. Longman, Inc., N.Y.

Cherney, J. H. and G. C. Marten. 1982. Small grain crop forage potential; I. Biological and chemical determinants of quality and yield. Crop Sci. 22:227-30.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis; apparatus, reagents, procedures, and some applications. USDA Agr. Handbook No. 379.

Hall, M. 1948. Five hundred varieties of herbage and fodder plants. Bulletin 39 of the Commonwealth Bureau of Pasture and Field Crops, Aberystwyth, Great Britain.

Lusigi, W. T., E. R. Nburunziza, and S. Masheti. 1984. Forage preferences of livestock in the arid lands of northern Kenya. J. of Range Man. 37:542-48.

Mengesha, M. H., R. C. Pickett, and R. L. Davis. 1965. Genetic variability and interrelationship of characters in teff **Eragrostis tef** (Zucc.) Trotter. Crop Sci. 5:155-57.

Morris, E. J. 1980. The cell wall of **Eragrostis tef:** variations in chemical composition and digestibility. Agric. Sci. (Camb.) 95:305-11.

Smith, D. 1960. Yield and chemical composition of oats for forage with advanced maturity. Agron. J. 52:637-38.

Smith, D. 1975. Influence of temperature on growth of Froker oats for forage. II. Concentrations and yields of chemical constituents. Can. J. Plant Sci. 55:897-901.

Sullivan, J. T., T. G. Phillips, M. E. Loughlin, and V. G. Sprague. 1956. Chemical composition of some forage grasses. **II.** Successive cuttings during growing season. Agon. J. 48:11-14.

Terry, R. A., D. C. Mudell, and D. G. Osborn. 1978. Comparison of two **in vitro** procedures using rumen liquor-pepsin or pepsin-cellulose for prediction of forage digestibility. J. Brit. Grassland Soc. 33:13-18.

Volk, R. J. and R. L. Weintraub. 1958. Microdetermination of silicon in plants. Anal. Chem. 30:10-11.

Whyte, R. D., T. R. G. Moir, and J. P. Cooper. 1959. Grasses in agriculture, FAO agriculture studies No. 42, FAO, Rome.