TEFF (*Eragrostis tef*), AN IRRIGATED WARM SEASON ANNUAL FORAGE CROP

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Introduction

The purpose of this trial was to examine the use of teff as a warm season forage crop in Malheur County, Oregon. In years when water is short, if an emergency crop is needed due to crop failure, or producers desire a quick-growing annual forage in mid-summer, few options are available to them. Teff is a warm season annual grass that has the potential to be a viable alternative but further research is needed on this new crop for the Treasure Valley. Based on observations, teff has been reported to grow well in warm mid-summer weather, but has almost no frost tolerance. However, little research has been done on teff as a forage crop until very recently. As a potential forage crop, growers need to know teff's growth response to irrigation and nitrogen fertilization.

Materials and Methods

The experiment was planted on June 23, 2005 on a Nyssa silt loam soil at the Malheur Experiment Station on a field that was fallow the previous year. Seedbed preparation included disking and cultivating. Seed was broadcast by using an Earthway Hand Spreader Model 3500 at a rate of 3 lb/acre. The treatment design was a split-plot, the main plots were irrigation rate and the subplot was nitrogen (N) rate. Irrigation treatments included plots centered 2.5, 7.5, 12.5, and 17.5 ft from the line-source sprinkler. Nitrogen treatments were applied at the rates of 0, 80, and160 lb of N (ammonium nitrate)/acre, split in half and applied on June 23 (at planting) and August 16 (just after the first harvest). Treatments were replicated four times. A soil test taken prior to planting showed 74 lb/acre N in the top 2 ft, 88 lb phosphate (P_2O_5), 1,896 lb potash (K_2O), 108 lb sulfate (SO_4)/acre, and 1.5 percent organic matter.

To monitor soil moisture content, neutron probe tubes were placed 1.5 ft from the end of the plots at 2.5, 7.5, 12.5, and 17.5 ft from the line source and in the 160 lb/acre N treatment in 3 replications. Measurements were taken with the Neutron Probe model 503 DR hydroprobe (Boart Longyear, Martinez, CA) (Figs. 1-3).

Teff was harvested when seed heads were beginning to emerge. Harvest of the first cutting occurred on August 15 and the second harvest occurred on September 12, 2005. Plots were harvested using a Jari sickle bar mower set to cut the teff at a height of 3 inches. Plots were 20 ft long by 2.5 ft wide. A sample of approximately 1.0 lb of forage was taken from each plot and oven dried to determine moisture and calculate dry matter (DM) yield.

Dried samples were ground to 2-mm-sieve size in a Wiley Mill (Arthur H. Thomas Co.) and to 1-mm-sieve size in a Udy Mill (UDY Corp.) before being analyzed in a near infrared spectrophotometer (NIRS) (NIRSystems) to determine forage quality.

Treatment significance was based on an Analysis of Variance (ANOVA) F test at the P = 0.05 level. If this analysis indicated significant treatment effects, then Least Significant Difference (LSD) values were calculated based on alpha at 0.05. Because of inherent design limitations with line-source sprinkler systems, irrigation treatments could not be randomized; consequently, a valid error term is not available to the main plot effect of irrigation rate. Therefore, caution must be used in interpretation of irrigation effects.

Weed control included hand weeding of barnyard grass and the use of bromoxynil (Bronate®) at 1 pt/acre (which is the labeled rate for wheat) to control broadleaf weeds. No crop injury was apparent after spraying.

The experiment was irrigated with a microsprinkler irrigation system using R10 Turbo (Nelson Irrigation Corp.) sprinkler heads. Sprinkler heads were placed every 12.5 ft instead of the standard 25 ft to get more uniform coverage. Irrigation began on June 24 and it became apparent that the plots furthest from the sprinkler were not getting enough water to germinate. Another line was temporarily installed parallel to and 25 ft from the original line to provide adequate moisture for germination. This line was installed on July 6 and removed on July 29 after emergence had occurred over the entire area. Irrigations were applied approximately every 2 days or less from planting until emergence. After emergence irrigation occurred 3 times a week. A rate of 20 percent above the estimated evapotranspiration (ET_c) value for grass pastures was applied to the plots closest to the line-source sprinkler. To monitor the soil moisture, neutron probe tubes were installed in the upper, middle, and lower portions of the field in the 160 lb N treatment. Irrigation rates were measured using catch cups that were placed in a 3.13-ft by 5-ft grid from the line source out to the farthest plots. Irrigations were fairly uniform. Total irrigation rates ranged from 6 inches to 17 inches for the duration of the experiment (Table 1).

Results and Discussion

The teff did not emerge well from the dry soil; this may have been caused by poor seed-to-soil contact from broadcasting the seed with no incorporation or by the lack of adequate irrigation during germination. Irrigation treatment effects throughout the experiment can be found in Figs. 1-3 and the summary in Table 1.

Teff has a very small seed and this made it difficult to plant at the 3 lb/acre rate using our equipment.

For the first harvest, increasing the N rate increased hay yield significantly from 1.5 ton/acre in the control to 1.9 and 2.0 ton/acre (dry matter basis) for the 80 and 160 lb N/acre treatments, respectively (Table 2). There were no significant N by irrigation interactions in this experiment. There was no significant yield difference between N rate treatments for the second harvest (Table 3). Yield and total N from the combined harvests tended to increase with the higher N rates but was not significant.

Interestingly, increasing N rate from 80 to 160 lb/acre significantly decreased feed quality of the first harvest by decreasing crude protein 1.7 percent, decreasing total digestible nutrients (TDN) 1.7 percent, and increasing acid detergent fiber (ADF) 2.3 percent. Neutral detergent fiber (NDF), relative feed value (RFV), and relative feed quality (RFQ) were not significantly affected by N rate.

Currently RFQ is perceived as the best indicator of feed quality of grasses such as teff, and ranged from 102 to 112 during the first harvest. In the second harvest, RFQ ranged from 120 to 140, which is significantly higher, but came at the expense of reduced yield. Plants were much smaller on the second harvest date, possibly due to the shorter photoperiod that stimulates earlier head formation or possibly due to the cooler weather that was beginning to occur.

Irrigation had a significant effect on everything we measured except yield and relative feed quality on the first harvest. Again, since irrigation was not randomized, caution must be used in interpretation of irrigation effects. During the second harvest of teff, yield increased from 0.44 to 1.1 ton/acre as water was increased from 1.4 to 3.0 inches, respectively. When combining both harvests, teff yield and total N uptake increased with increasing irrigation to 13.4 inches of water (Table 4). When irrigating beyond 13.4 inches, yield declined and total N experienced a significant decline from 177 to 132 lb/acre. This reduction in total N uptake at the highest irrigation rate may have been due to N leaching beyond the root zone, in addition to the effect of decreased yield.

In general, as the irrigation rate increased, crude protein, ADF, NDF, TDN, RFV, and RFQ decreased in quality. This tradeoff between yield and quality is commonly observed in forages but may have been accentuated here due to the potential N leaching effect at the highest irrigation rate as discussed above.
In this trial, teff was harvested when approximately 25 percent of the heads had emerged. Teff has such small heads that you must look closely to determine its growth stage. Teff also has the tendency to lodge, which can make harvesting more difficult. Also, waiting to cut until the teff is headed out appears to delay regrowth. Based on other reports, we suspect that cutting it below 3 inches will probably slow regrowth even more.

Conclusion

Teff appears promising as an annual forage grass. Teff grew well during the warm summer weather in Malheur County. It responded well to limited irrigation, but excessive irrigation did not improve yield and tended to decrease some quality parameters. Applying N at 80 lb/acre improved yield at first cutting only, but did not significantly affect quality parameters. Increasing N rate further from 80 to 160 lb/acre did not further increase yield significantly at first cutting. Neither the 80 nor the 160 lb/acre N rate improved yield at second cutting. Increasing N rate during the first harvest from 80 to 160 lb/acre had a small negative effect on crude protein, ADF, and TDN. Nitrogen rate had no effect on quality of the second harvest.

For a first cutting, this trial indicates growers might expect about 2.25 tons/acre of hay (assuming baling and storing at 12 percent moisture). If timely planting and harvest occur, it appears two full cuttings are possible in Malheur County. Planting date can vary widely depending on the likelihood of late spring frosts.

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Table 1. Irrigation and precipitation received by treatments during growth of teff, Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

Distance from sprinkler	From planting to 1st harvest	From 1st harvest to 2nd harvest	From planting to 2nd harvest
ft	Inches of precipitation plus irrigation applied		
2.5	13.3	3.8	17.1
7.5	10.4	3.0	13.4
12.5	7.6	2.2	9.8
17.5	4.7	1.4	6.1

Table 2. Teff yield and quality results for the first harvest (August 16) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

Treatment Irrigation + precipitation	Yield*	Crude protein	ADF	NDF	TDN	RFV	RFQ
inches	ton/acre	%					
4.7	1.2	20.0	30.0	55.0	59.9	112	112
7.6	2.0	18.5	32.5	57.7	58.0	103	110
10.4	2.0	17.6	34.2	59.2	56.7	98	106
13.3	1.9	13.7	37.9	62.6	53.9	88	102
LSD (0.05)	NS	1.8	2.0	2.1	1.5	6	NS
Nitrogen lb/acre							
0	1.5	17.6	33.4	58.4	57.3	101	108
80	1.9	18.0	32.6	57.6	57.9	103	108
160	2.0	16.3	34.9	59.8	56.2	97	107
LSD (0.05)	0.3	1.8	2.0	NS	1.5	NS	NS

*Yield is presented on 100 percent dry matter basis. To convert to 88 percent dry matter divide yield by 0.88.

Table 3. Teff yield and quality results for the second harvest (September 12) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

Treatment Irrigation + precipitation	Yield*	Crude protein	ADF	NDF	TDN	RFV	RFQ
inches	ton/acre	%					
1.4	0.4	16.8	28.4	53.3	61.1	117	140
2.2	0.7	18.0	29.7	54.0	60.0	114	122
3.0	1.1	18.1	31.0	55.0	59.1	110	118
3.8	1.1	14.5	34.5	57.1	56.5	101	120
LSD (0.05)	0.3	1.3	1.9	2.2	1.4	8	7
Nitrogen							
0 lbs/acre	0.9	16.6	31.1	55.2	59.0	109	125
80 lbs/acre	0.8	17.1	30.6	54.6	59.3	111	125
160 lbs/acre	0.8	16.8	30.9	54.6	59.2	111	125
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

*Yield is presented on 100 percent dry matter basis. To convert to 88 percent dry matter divide yield by 0.88.