

# Research in the Klamath Basin 2009 Annual Report

## Forage Yield, Forage Quality, and Seed Production of Teff in Response to Three Herbicides, 2009

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### Introduction

As we described previously and elsewhere in this annual report, teff (*Eragrostis tef* [Zucc.], *Poaceae*) is a warm season ( $C_4$ ) annual tropical grass that can produce good quality forage during a short summer time frame, and thus has the potential to be a viable crop choice when forage producers: a) desire a quick-growing, high quality mid-summer annual forage; b) foresee less-than full season irrigation water supply; c) need an emergency crop due to crop failure; or d) need a one-year forage rotation crop between alfalfa stands. We began growing teff in a quasi-commercial field setting in 2003, and began more rigorous testing of teff's agronomic requirements in 2005 after

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unprecedented response from a popular press article about our early efforts indicated widespread national interest in this ‘new’ alternative forage crop (Zenk, 2005; Roseberg et al., 2006).

Despite the promising results seen thus far, there are no commercial herbicides registered for use on teff. In past years, we have sprayed research seedings of teff with commercial herbicides to control things like volunteer potatoes and other broadleaf weeds. It is unknown if these applications affected teff’s forage or seed yields. Until recently, most interest in teff has focused on its qualities relative to the seed used in human food (mainly injera, a staple of Ethiopian cuisine), but not its forage qualities. 2009 was the first year of this effort, with the longer-term goal of accumulating sufficient data to warrant herbicide registration for use in larger-scale commercial teff production.

### **Objective**

To evaluate the effect of several common broadleaf herbicides on teff’s crop growth, forage yield, forage quality, and seed yield.

### **Procedures**

The forage and seed production tests were laid out as duplicate trials laid out within the same field at the Klamath Basin Research & Extension Center (each trial having the same entries, treatments, and randomization). Thus, the forage trial was managed for two cuttings (typical in this climate) and the seed trial was allowed to grow uncut until seed harvest. VAT-1 seed was planted over the entire field at about ¼ inch depth at a seeding rate of 17.7 lb/ac with a John Deere grain drill on June 9 and June 10, 2009. The total seeding rate was much higher than normal for teff because rainfall partway through the seeding on June 9 resulted in seed drill malfunction (plugging) in some rows. To ensure a uniform stand, we repeated the seed drilling the following day, resulting in a higher total seeding rate than is typical for this area. The entire field was fertilized with 58 lb/ac N, 16 lb/ac P, and 63 lb/ac S banded at seeding (applying a custom blend of 19.7-5.6-0-21.5 fertilizer at 293 lb/ac) through the grain drill.

The six herbicide treatments were arranged in a randomized complete block design with two replications of each six herbicide treatments. Herbicide treatments were applied by a commercial ground rig spray boom on July 7. Half of each spray strip was used for the forage measurements; the other half remained untouched until seed harvest. Repeated observations were made within each treatment strip (eight forage yield and quality measurements and four seed yield measurements within each strip), resulting in 16 data points for the forage yield and quality measurements and eight data points for the seed yield measurements.

The herbicide treatments were as follows: Control (no herbicide applied) [Treatment 1]; Fluroxypyr (applied at 0.125 lb ae/ac) [Treatment 2]; Dicamba (applied at 0.25 lb ae/ac) [Treatment 3]; 2,4-D (applied at 0.7125 lb ae/ac) [Treatment 4]; a mix of Dicamba and 2,4-D (applied at 0.25 and 0.7125 lb ae/ac, respectively) [Treatment 5]; and

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a mix of Fluroxypyr, 2,4-D, and Dicamba (applied at 0.125, 0.7125, and 0.25 lb ae/ac, respectively) [Treatment 6].

Precipitation and other weather data were measured by the US Bureau of Reclamation Agricultural Meteorological (AgriMet) automated weather station at KBREC (US Bureau of Reclamation, 2009). Rainfall amounts totaled 1.84 inch in June, 0.17 inch in July, 0.20 inch in August, and none in September before the second harvest date.

Irrigation was applied with wheelines. A total of 9.38 inches of irrigation was applied on 6 dates between seeding date and first cutting, with another 5.04 inches of irrigation applied on 3 dates between first and second cutting.

### *Forage Trial*

For the forage yield trial, cutting date was chosen based on overall physiological maturity of the plots, thus the plots were cut when seedheads were just beginning to emerge. Therefore, the forage trial was harvested for the first time on August 4, and for the second time on September 9.

Within a few days after the first harvest, Solution 32 was applied at a rate of 62 lb N/ac through the irrigation water to the entire field.

Forage fresh weights were measured immediately in the field and samples were collected from each plot for drying to correct yields to a dry weight basis as well as perform forage quality analysis. After drying and weighing, samples were ground to 2-mm-sieve size in a Wiley Mill (Arthur H. Thomas Co.) before being analyzed in a near infrared spectrophotometer (NIRS) (NIRSystems, FOSS, NA, Minneapolis, MN) to determine forage quality. Quality testing at KBREC was accomplished using the NIRS and equations developed by the NIRS Consortium, Madison, WI (NIRS Consortium, 2007). We used NIRS equations developed for other grasses due to the limited data available for teff. Reported forage quality parameters included crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), relative feed value (RFV) and relative forage quality (RFQ).

### *Seed Trial*

For the seed yield trial, plots were harvested when seedheads reached maturity. Plots were harvested on September 29, using a BCS rototiller with a sickle-bar attachment. Whole plants were cut down approximately 4 inches above the soil surface, and then put into sacks and stored in a dry place until threshing could be performed. After testing and comparing various procedures, it was decided to thresh the bundles through a stationary Hege plot combine (collecting all the seed and chaff on a tarp), and then running the collected material through a hammer mill (using a #1/2 screen). Seed cleaning was then completed via two passes through a desktop-sized Clipper seed cleaner. On the first pass, the Clipper had a #8 screen on top and a #6x38 screen on bottom, and on the second pass it had a #24 screen on top and a #6x38 screen on bottom.

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Seed yield, plant height, and percent lodging were all measured or calculated for the seed yield trial.



## *Statistical Analysis*

Statistics on yield and quality data were calculated using SAS<sup>®</sup> for Windows, Release 9.1 (SAS Institute, Inc.) software. Treatment significance was based on the F test at the  $P = 0.05$  level. If this analysis indicated significant treatment effects, least significant difference (LSD) values were calculated based on the student's  $t$  test at the 5% level. For this report, the experiment was analyzed as a randomized complete block design with repeated measures within each treatment plot, as described above.

## **Results & Discussion**

### *Forage Yield Results*

For a few days immediately after herbicide application, the teff did not show any obvious visual responses to the herbicide treatments. Over a period of two to three weeks, the areas receiving 2, 4-D seemed to grow slightly more slowly, resulting in a more upright plant and less 'drooping' where 2,4-D was applied compared to the other herbicides. The control treatment seemed to grow slightly faster and thus 'droop over' more than any of the other treatments. Color did not vary with treatment. The visual effects did not seem to persist until harvest and were visible only at certain times of the day or under certain lighting conditions.

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Weed pressure was minimal for the duration of this study, even in the control treatment, suggesting that any observed differences in forage yield or quality were due to effects of herbicides *per se* and not due to weed competition.

First cutting dry matter yield ranged from 2.73 ton/ac to 3.04 ton/ac, with a mean of 2.94 ton/ac (Table 1). Herbicide ‘Treatment 5’ was the highest yielding entry for first cutting, but only ‘Treatment 6’ had a statistically significant lower yield. Second cutting dry matter yield ranged from 0.72 ton/ac to 1.27 ton/ac, with a mean of 1.03 ton/ac (Table 2). The yields of ‘Treatment 2’ and ‘Treatment 3’ were statistically significantly greater than the other treatments at second cutting. The yield of ‘Treatment 5’ was significantly lower than all other treatments at second cutting.

Annual total dry matter yield ranged from 3.69 ton/ac to 4.22 ton/ac, with a mean of 3.97 ton/ac. ‘Treatment 3’ had the highest annual total yield, while ‘Treatment 6’ had the lowest. The control, ‘Treatment 1’, had an intermediate yield for first cutting second cutting, and annual total yield (Tables 1 and 2).

Mean yields for first cutting, second cutting, and annual total yield were similar to our 2009 teff seed brand and accession trials. However, these yield responses cannot be directly compared due to the higher seeding rate in the herbicide study, as well as slightly different management such as irrigation, field location, and seeding/harvest timing.

### *Forage Quality Results*

At first cutting, differences due to herbicide treatment were not statistically significant for any of the quality parameters as measured by NIRS (Table 1). CP ranged from 12.8 to 13.7%, with a mean of 13.3%. ADF ranged from 37.6 to 38.2, with a mean of 38.0. NDF ranged from 59.7 to 60.8, with a mean of 60.2. RFV ranged from 91 to 93, with a mean of 92. RFQ ranged from 99 to 102, with a mean of 101. First cutting CP and RFV values tended to be lower than the concurrent 2009 teff seed brand trial values, while ADF, NDF, and RFQ tended to be higher.

At second cutting, herbicide treatment differences were significant for all quality parameters (Table 2). CP ranged from 17.7 to 18.7%, with a mean of 18.3%. ADF ranged from 34.0 to 35.5, with a mean of 34.6. NDF ranged from 54.6 to 56.2, with a mean of

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55.6. RFV ranged from 99 to 106, with a mean of 104. RFQ ranged from 95 to 100, with a mean of 97. Second cutting ADF and RFV values tended to be lower than the 2009 teff seed brand trial values, while CP and NDF tended to be higher, and RFQ was about equal.

Treatments 3 and 5 (both including dicamba) had lower CP and higher fiber (thus lower RFV) than the other treatments. However, although 'Treatment 6' also contained dicamba, its quality values were not lower than for the other treatments. The difference in the way RFV and RFQ are calculated may explain some of the reason why the responses to herbicide treatments may not always be the same for RFV and RFQ. Whereas RFV is a relatively simple calculation derived from ADF and NDF, RFQ is a more complicated calculation derived from non-fibrous carbohydrate, crude protein, fatty acids, nitrogen-free NDF, 48-hour *in vitro* digestibility, and NDF (Undersander and Moore, 2002). Thus, the RFQ calculation attempts to estimate animal intake more accurately than RFV by including additional important nutritive qualities in the equation.

### *Seed Yield and Morphological Results*

In addition to seed yield, growth characteristics such as plant height and percent lodging were measured during the growing season (Table 3). Observed differences in seed yield and percent lodging due to herbicide treatment were statistically significant, but plant height differences were not. Seed yields ranged from 459 to 723 lb/ac, with a mean of 532 lb/ac. The seed yield of 'Treatment 1' (control) was significantly greater than the yield for all other treatments. 'Treatment 6' (combination of all three herbicides) had the lowest seed yield, although the difference from other treatments receiving herbicide was not statistically significant. Heights were very consistent between treatments, ranging only from 39.9 to 41.2 inches, with a mean of 40.5 inches. This trial experienced an unusually high degree of lodging in all treatments, probably due to the abnormally high seeding rate and windy conditions as seedheads approached maturity. Percent lodging ranged from 88.1 to 93.8%, with a mean of 91.2%.

### **Conclusions**

The different herbicide treatments did not seem to adversely affect teff forage yields in this study. In fact, the control treatment yielded near or below the mean yield for both cuttings. Differences in forage quality were not significant at first cutting, the cutting nearest in time to when the herbicides were applied. There were differences in quality at second cutting. There were hints that quality was slightly reduced where dicamba was applied, but these patterns were not strong or completely consistent among all treatments. Seed yields were significantly higher for the control treatment than for all the herbicide treatments. This suggests that even though herbicide use doesn't seem to decrease forage yields or quality, (and may even increase yield in some cases despite the absence of weeds), it did appear to decrease seed yields in this case. It would be beneficial to repeat this study at a more typical seeding rate to make sure that the

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excessive lodging resulting from the unusually high plant population didn't have an effect on the results of the study.

## References

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**Table 1. Teff Herbicide Tolerance: 2009 Forage yield and quality- first cutting.**  
Klamath Basin Research & Extension Center, Klamath Falls, OR.

Herbicide Treatment	Treatment Number	Dry Forage Yield			Crude Protein				RFQ	
		lb/ac	ton/ac	Rank	(%)	ADF	NDF	RFV	RFQ	Rank
Control	1	5722	2.86	5	12.8	38.1	60.2	92	102	3
Fluroxypyr	2	5962	2.98	4	13.5	37.6	59.8	93	102	1
Dicamba	3	6009	3.00	3	13.7	37.7	59.7	93	102	2
2,4-D	4	6044	3.02	2	13.3	37.9	60.1	92	102	3
Dicamba + 2,4-D	5	6079	3.04	1	13.3	38.2	60.8	91	100	5
Fluroxypyr + 2,4-D + Dicamba	6	5460	2.73	6	13.1	38.7	60.2	91	99	6
Mean		5885	2.94		13.3	38.0	60.2	92	101	
<b>P value</b>		<b>0.026</b>	<b>0.026</b>		<b>0.444</b>	<b>0.317</b>	<b>0.452</b>	<b>0.509</b>	<b>0.386</b>	
LSD(0.05)		422	0.21		NSD	NSD	NSD	NSD	NSD	
CV (%)		10.0	10.0		9.1	3.7	2.6	4.4	5.6	

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**Table 2. Teff Herbicide Tolerance: 2009 Forage yield and quality- second cutting and annual yield total.**  
Klamath Basin Research & Extension Center, Klamath Falls, OR.

Herbicide Treatment	Treatment Number	Dry Forage Yield			Crude Protein				RFQ		Annual Total Dry Forage Yield		
		lb/ac	ton/ac	Rank	(%)	ADF	NDF	RFV	RFQ	Rank	lb/ac	ton/ac	Rank
Control	1	2063	1.03	3	18.5	34.0	54.9	106	100	1	7785	3.89	4
Fluroxypyr	2	2422	1.21	2	18.5	34.1	54.9	106	99	2	8385	4.19	2
Dicamba	3	2432	1.22	1	17.7	35.1	56.2	102	98	3	8440	4.22	1
2,4-D	4	2053	1.03	4	18.7	34.3	55.2	105	96	5	8097	4.05	3
Dicamba + 2,4-D	5	1432	0.72	6	17.9	35.7	58.1	98	95	6	7511	3.76	5
Fluroxypyr + 2,4-D + Dicamba	6	1883	0.94	5	18.4	34.6	54.6	106	97	4	7375	3.69	6
Mean		2040	1.02		18.2	34.6	55.6	104	97		7932	3.97	
<b>P value</b>		<b>&lt;0.001</b>	<b>&lt;0.001</b>		<b>0.037</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>0.008</b>		<b>0.001</b>	<b>0.001</b>	
LSD(0.05)		302	0.15		0.8	0.7	1.0	3	3		566	0.28	
CV (%)		20.9	20.9		5.8	2.9	2.5	3.5	3.9		10.1	10.1	

**Table 3. Teff Herbicide Tolerance: 2009 Seed yield and crop morphology.**  
Klamath Basin Research & Extension Center, Klamath Falls, OR.

Herbicide Treatment	Treatment Number	Seed Yield (lb/ac)	Height (inch)	Lodging %	Seed Yield Rank
Control	1	723	40.1	88.1	1
Fluroxypyr	2	508	40.7	89.1	3
Dicamba	3	478	41.2	90.3	4
2,4-D	4	472	40.9	88.8	5
Dicamba + 2,4-D	5	550	40.2	93.8	2
Fluroxypyr + 2,4-D + Dicamba	6	459	39.9	91.2	6
Mean		532	40.5	90.2	
<b>P value</b>		<b>0.006</b>	<b>0.410</b>	<b>0.006</b>	
LSD(0.05)		142	NSD	3.1	
CV (%)		26.3	4.8	4.8	