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Research Article

EVALUATION OF RELEASED TEF (*ERAGROSTIS TEF* [ZUCC.] TROTTER) VARIETIES AT SOUTHWESTERN PART OF ETHIOPIA

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ABSTRACT

Objective: The objective of the study was to evaluate performance and identify high yielding and stable variety for southwestern part Ethiopia and recommend identified varieties for large scale production.

Experimental Materials: Eight nationally released tef varieties were included in the study. The materials were obtained from Debre Zeit Agricultural Research Center (DZARC).

Design and Trial Management: The experiment was conducted during the 2019 main cropping season at six locations, namely: Melko, Gechi, Omonada, Kersa, Mana, and Gooma weredas of Southwestern Ethiopia. The trial was conducted using randomized complete block design with three replications at all locations under rain-fed conditions. Sowing was done manually. Spacing between plots was 1 m, whereas that between replications was 1.5 m and the total plot size was 2 m × 2 m. Seed rates were based on the recommendation which was 15 kg/ha.

Result and Discussion: Analysis of variance revealed the presence of significant ($P < 0.05$) differences among eight tef varieties of traits of days to heading, days to maturity, plant height, panicle length, lodging index, above ground biomass, and grain yield across locations. This indicated the presence of performance variation among the tested varieties for grain yield and it is possible to identify high yielder varieties for possible use in these locations.

Conclusion and Recommendation: In general, varieties Dagim and Kora were high yielding and stable across locations and variety Gibe, Tesfa, and Negus were stable and low yielders across locations. The high yielding and stable varieties were recommendable for large scale production in southwestern part of Ethiopia. The experiment used data collected for only one season, which may limit the strength of its recommendation. However, the results are crucial in directing the breeding decision following additional season evaluation of the varieties in the same locations.

Keywords: GEI, Locations, Performance, Tef varieties.

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INTRODUCTION

Tef. (*Eragrostis* tef [Zucc.] Trotter) is a member of the grass family *Poaceae* and genus *Eragrostis.* The genus *Eragrostis* constitutes about 350 species of which only tef is cultivated for human consumption (Watson and Dallwitz, 1992). Fifty-four *Eragrostis* species are found in Ethiopia, out of which 14 are known to be endemic. Worldwide, Africa contributes 43% of the genus, while South America contributes 18%. Likewise, 12%, 10%, 9%, 6%, and 2% of the genus *Eragrostis*is from Asia, Australia, Central America, North America, and Europe, respectively (Seyfu, 1997). Tef is an allotetraploid species with a base chromosome number of 10 (2n = 4x = 40) with genome size of 730 Mbp (Mulu *et al*., 1996). It is self-pollinated with chasmogamous and hermaphroditic flowers. It has very low degree of out-crossing, that ranges from 0.2–1.0% (Seyfu, 1997). Ethiopia is the center of both the origin and diversity of tef (Vavilov, 1951), and over the years the crop species has co-evolved with Ethiopians. This is because Ethiopia harbors not only a wealth of diversity in the crop species, but also it is believed to be the center of origin for its domestication, including the existence of the possible wild progenitors. As one of the biggest genus in the grass family, the genus *Eragrostis* contains over 350 species (Watson and Dallwitz, 1992).

Tef is adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 m.a.s.l. and even it can be grown in an environment unfavorable for most cereal, while the best performance occurs between 1100 and 2950 m.a.s.l. in Ethiopia (Hailu and Seyfu, 2000). It is the major food crop in Ethiopia where it is annually cultivated on more than 3 million hectares of land by 6.3 million small-scale farmers on more than 30% of the total area allocated to cereal crops (CSA, 2014). The importance of tef in Ethiopia is mainly due to its preference by both farmers and consumers. Farmers, above all, grow tef due to its tolerance to several biotic and a biotic stress especially to the poorly drained vertisols, a dominant soil type in the central highlands where other cereals can hardly survive without the use of proper drainage system over 50 million people in Ethiopia.

Tef was produced in Southwestern Ethiopia in large amount and its productivity is highly influenced by diseases, acidity, and others (Tegegn, 2020). Head smudge is one highly affecting production and productivity of tef in southwestern part of Ethiopia. To develop varieties which were tolerant to biotic and abiotic stresses, conducting adaptation trial was important and time saving. Nationally released tef varieties were tested at different locations before large scale production. The objective of the experiment was to evaluate performance and identify high yielding and stable variety for southwestern part Ethiopia and recommend identified varieties for large scale production.

MATERIALS AND METHODS

Experimental materials

Eight nationally released tef varieties were included in the study (Table 1). The experimental materials were obtained from Debre Zeit Agricultural Research Center (DZARC).

Site description

The experiment was conducted during the 2019 main cropping season at six locations, namely: Melko (On station), Gechi, Omonada, Kersa, Somodo, and Gooma weredas of Southwestern Ethiopia (Table 2).

Data collection

Data were collected on traits such as days to heading, days to maturity, plant height (cm), panicle length (cm), lodging index, shoot biomass, and grain yield (kg)/ha. The recorded data were subjected to analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984) using SAS Software (Version 9.3). Mean separation was carried out using least significant difference at 5% levels of significance.

Experimental design and management

The trial was conducted using randomized complete block design with three replications at all locations under rain-fed conditions. Sowing was done manually. Spacing between plots was 1m, whereas that between replications was 1.5 m and the total plot size was 2 m × 2 m. Seed rates was based on the recommendation which was 15 kg/ha. Planting was done on the onset of rain in the respective locations. As per the recommendations, plots were fertilized with 40 kg of N and 60 kg of P_2O_5/hectare for light soils and 60 kg N and 60 kg P_2O_5/hectare for black soils (Vertisols). All DAP was applied at planting, while urea was applied in split half at planting and the remaining half at tillering stage. All other relevant field trial management practices were carried out throughout the experimentation period across all locations as per the recommendations for the respective locations.

RESULTS AND DISCUSSION

ANOVA revealed the presence of significant ($p<0.05$) differences among traits of tef varieties tested at Kersa, Omonada, Melko, Mana, Gooma, and Gechi weredas of Southwestern part of Ethiopia during 2019 cropping season.

Table 1: Description of experimental materials used in the study

Variety name	Year of release	Days to maturity	Grain yield (t/ha)	Remark
Abola	2016	110–118	2.1–2.8	
Dagim	2016	112–115	2.6–3.2	
Kora	2014	110–117	2.5–2.8	
Felagot	2017	108–112	2.2–2.9	
Gibe	1993	114–126	2.0-3.0	
Heber-1	2017	112–124	2.2–2.7	
Tesfa	2017	112–120	2.3–3.0	
Negus	2017	112–116	2.0–2.6	

Days to heading and Maturity

ANOVA revealed highly significant difference ($p<0.05$) among the eight tef varieties in phenology trait of days to heading at Kersa,Melko and Gooma and non-significant differences($p>0.05$) observed at Mana, Omonada, and Gechi weredas (Table 3). The values of days to heading ranged from 50.4 to 59.94 at Kersa and mana, respectively. Tegegn *et al*. (2020) reported highly significant variations for days to heading and maturity.

Significant differences ($p<0.05$) were observed among tested varieties and locations of the trait of days to maturity (Table 4). The value ranged from 102.2 to 111.2 at Mana and Omonada respectively. Variety, Felagot showed early maturity and Kora showed late maturing. Considering this trait for variety selection is very critical to select early maturing varieties for different agro-ecologies.

Many studies have indicated the presence of substantial variation among tef genotypes for different traits of tef. Tegegn (2019) reported significant variations for days to heading and maturity. Habte *et al.* (2011) reported highly significant genotype variation for days to panicle emergence and maturity, plant height, culm and panicle length, shoot biomass, grain yield, harvest index, lodging index, and thousand seed weight. Similarly, highly significant ($p<0.01$) genotype differences for days to panicle emergence, lodging percentage, thousands kernel weight, grain yield per plant, and grain yield per hectare were also reported by Ayalneh *et al.* (2012).

Plant and panicle length

Variety Kora, followed by Dagim exhibited longest plant height with the respective value of 111.1 and 106.1, respectively (Table 5). The values of panicle length ranged from 31.8 (24) to 43.4 (28) (Table 6). The longest plant height and panicle length recorded at Omonada and shortest at Melko. Similar results were reported by (Kebebew *et al*., 2001b; Tegegn, 2019).

Lodging index

The highest lodging index recorded at Melko and Kersa and lowest at Gechi. The values of lodging ranged from 55.3 to 62.1. High plant lodging index of the tested varieties was due to wind and high rainfall at the time of harvesting (Table 7).

Table 2: Description of experimental sites

Site	Altitude (m.a.s.l)	Coordinates	RF (mm)	Temperature (°C)	Soil type
Gechi	2087	80° 27′ N 360° 21′ E	1700	18	Nitosol
Gooma	1560	7° 51′ N 36°35′E	1764	19.7	Nitosol
Kersa	1780	NA	2000	20.3	Nitosol
Mana	1770	7° 45′ N 36° 45′ E	1624	18.9	Nitosol
Melko	1753	70° 47′ N 360° 47′ E	1639	22	Nitosol
Omonada	1975	70° 41’ N 37° 12′ E	1600	20	Nitosol

Table 3: Mean of days to heading of tef varieties at across locations

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	61	57	51	58	54	57.5	56.42
2.	Negus	60	54	49	54	54	55.5	54.42
3.	Tesfa	60	55.5	51.5	55.5	54	56	55.42
4.	Felagot	60	51	49	55	55	55.5	54.25
5.	Abola	59	54	50	56.5	51	57.5	54.67
6.	Heber-1	59.5	57	51	54.5	55	55.5	55.42
7.	Gibe	60	52	51	56	53.5	57	54.92
8.	Kora	60	57	50.5	56.5	54	55.5	55.58
Mean		59.9	54.7	50.4	55.7	53.8	56.2	
F test		0.001	0.0001	ns	0.0438	ns	ns	
CV (%)		0.41	1.5	2	1.6	2.2	1.9	

ns = non significant ,CV=Coefficient of Variation

Table 4: Mean of days to maturity of eight tef varieties at across locations

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	108	110	104	108	110	106	107.7
2.	Negus	103	108	103.5	108	111	106	106.6
3.	Tesfa	104.5	110	103.5	106.5	111	106	106.9
4.	Felagot	103	110	90	94	110	104	101.8
5.	Abola	107	112	104	104.5	110	105	107.1
6.	Heber-1	108	112	103.5	105	113	115	109.4
7.	Gibe	108	108	105.5	109	115	116	110.3
8.	Kora	108	108	104	107	110	116	108.8
Mean		106.2	109.7	102.2	105.2	111.2	109.2	
F test		0.001	ns	0.001	0.001	0.01	0.001	
CV (%)		0.88	1.5	0.6	1.4	0.889	1.2	

ns = non significant ,CV=Coefficient of Variation

Table 5: Mean of plant height of eight tef varieties at across locations

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	101.9	94.2	106.9	108.1	124	101.2	106.1
2.	Negus	93.7	88.4	95.2	96.5	115.2	87.3	96.1
3.	Tesfa	87.4	86.1	102.2	107.8	107.5	94.5	97.6
4.	Felagot	90.7	70.4	84.6	87.6	100.6	80.7	85.8
5.	Abola	97.3	87.2	101.9	111.2	121	97.6	102.7
6.	Heber-1	94.8	99.8	101.2	119.1	118	101.6	105.8
7.	Gibe	106	68.4	89.9	109.9	110	89.3	95.6
8.	Kora	103.1	100.6	104.5	119.7	129.1	109.8	111.1
Mean		96.8	86.888	98.3	107.5	115.6	95.2	
F test		ns	0.001	0.001	0.001	0.001	0.001	
CV (%)		14.3	5.4	2.8	2.7	2.1	3.5	

ns = non significant ,CV=Coefficient of Variation

Table 6: Mean of panicle length of eight tef varieties at across locations

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	38.5	39.7	43.1	39.4	47.5	40.2	41.4
2.	Negus	35.5	37.2	37.3	37	44.8	37.3	38.2
3.	Tesfa	31.1	35.7	37.8	39.6	39.5	35.4	36.5
4.	Felagot	33.9	25.5	31.6	31.9	36.6	31.1	31.8
5.	Abola	37.5	34.3	39.5	40.4	43.5	39.2	39.1
6.	Heber-1	35.9	42.5	44.1	44.5	45.5	43.3	42.6
7.	Gibe	42.7	29.8	39.3	44.2	42.6	39.5	39.7
8.	Kora	39.2	41.7	44.7	42.5	47.3	45.1	43.4
Mean		36.8	35.8	39.6	39.9	43.4	38.8	
F test		ns	0.01	0.01	0.001	0.01	0.001	
CV (%)		8.6	6.8	5.7	2.4	4.5	3.4	

ns = non significant ,CV=Coefficient of Variation

Table 7: Mean of lodging index of eight tef varieties at across locations

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	56.5	73	57	49	50.5	45.5	55.3
2.	Negus	61.5	69	59.5	52	59.5	52	58.9
3.	Tesfa	62	65	48	47	60.5	57	56.6
4.	Felagot	62	73	54.5	70	61.5	51.5	62.1
5.	Abola	62	63	56	52.5	59	46.5	56.5
6.	Heber-1	54.5	67.5	56	45.5	50	57.5	55.2
7.	Gibe	51.5	70	59.5	81.5	51	55	61.4
8.	Kora	55.5	73.5	55	41.5	69.5	59	59.0
Mean		58.2	69.2	55.6	54.8	57.7	53	
F test		0.01	0.01	0.04	0.001	0.001	0.03	
CV (%)		3.8	2.4	4.7	4.4	4.3	6.6	

ns = non significant ,CV=Coefficient of Variation

Table 8: Mean of shoot biomass of eight tef varieties at across locations (kg/ha)

S. No.	Varieties	Locations						Mean
		Kersa	Melko	Mana	Gooma	Omonada	Gechi	
1.	Dagim	2250	1875	3875	4375	4500	4525	3566.7
2.	Negus	1500	1690	4000	3250	6125	5875	3740.0
3.	Tesfa	2125	3005	3250	3375	5125	4625	3584.2
4.	Felagot	2250	3375	3500	2750	3375	5875	3520.8
5.	Abola	2750	4125	3625	3250	5750	4875	4062.5
6.	Heber-1	2625	3940	4125	2875	4375	6125	4010.8
7.	Gibe	2250	3375	2625	3625	4250	3250	3229.2
8.	Kora	2125	3150	3625	3000	4250	5250	3566.7
Mean		2234.3	3066.8	3578.1	3312.5	4718.7	5050	
F test		ns	0.001	ns	0.01	0.001	0.001	
CV (%)		14.5	5.5	12.5	7.9	8.5	5.3	

ns = non significant ,CV=Coefficient of Variation

Table 9: Mean grain yield of eight tef varieties grain yield (kg/ha)

S. No.	Varieties	Locations						Mean	Overall rank
		Kersa	Melko	Mana	Gooma	Omonada	Gechi		
1.	Dagim	460	395	1100	865	745	1387.5	825.4	2
2.	Negus	385	475	1000	565	740	1500	777.5	4
3.	Tesfa	440	330	625	595	515	1375	646.7	7
4.	Felagot	830	635	750	595	570	1375	792.5	3
5.	Abola	605	455	900	705	640	1250	759.2	6
6.	Heber-1	759.25	570	850	645	655	1125	767.4	5
7.	Gibe	573.1	460	625	775	420	625	579.7	8
8.	Kora	633.05	475	1125	755	715	1250	825.5	1
Mean		585.7	474.4	871.8	687.5	625	1235.9	746.7	
F test		0.001	0.01	0.001	0.03	0.02	0.001		
CV (%)		8.7	10.6	10.8	9.7	11.9	10.6		

ns = non significant ,CV=Coefficient of Variation

Shoot biomass

The varieties exhibited different biomass yield (kg/ha) that ranged from 3229.2 kg to 4062.5 with mean yield of 5250kg/ha. The variety, Abola exhibited high and Gibe low mean above ground biomass respectively. Comparing above ground biomass across locations, high above ground biomass was harvested from Omonada and the lowest from Kersa (Table 8).

Grain yield

ANOVA revealed the presence of significant ($p<0.01$) differences in tef grain yield among eight tef varieties tested at Kersa, Omonada, Melko, Mana, Gooma, and Gechi 2019 cropping season. This indicated the presence of performance variation among the tested varieties for grain yield and it is possible to identify high yielder varieties for possible use in these locations. The popular variety Dagim, ranked seventh at Melko, fifth at Kersa, second at Mana, and first at Gechi, Omonada and Gooma. This rank change of the same variety over locations by the same trait is the consequence of the highly significant GEI. Mean yields of varieties across environments ranged from 474.3 kga/ha to 1235.94 kg/ha with mean grain yield of 746.7 kg/ha. In general, varieties Dagim and Kora were high yielding and stable across locations and variety Gibe, Tesfa and Negus were stable and low yielders across locations (Table 9).

CONCLUSION AND RECOMMENDATION

Tef is adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 m.a.s.l. The objective of the experiment was to identify high yielding and stable varieties across locations. ANOVA revealed the presence of significant ($p<0.05$) differences among eight tef varieties across locations. Tef varieties Dagim and Kora were high yielding and stable across locations and variety Gibe, Tesfa, and Negus were stable and low yielders across locations. The high yielding and stable varieties were recommendable for large scale production in southwestern part of Ethiopia. The experiment used data collected for only one season, which may limit the strength of its recommendation. However, the results are crucial in directing the breeding decision following additional season evaluation of the varieties in the same locations.

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