ISSN 1819-1894

Asian Journal of Agricultural Research

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OPEN ACCESS Asian Journal of Agricultural Research

ISSN 1819-1894
DOI: 10.3923/ajar.2017.98.102

Research Article
Evaluation and Selection of Some Improved Tef (*Eragrostis tef* (*Zucc.*) Trotter) Varieties in Three Districts of Bench Maji Zone, Ethiopia

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Abstract

Background and Objective: Tef [*Eragrostis tef* (Zucc.) Trotter] is a cereal crop resilient to adverse climatic and soil conditions and possessing desirable storage properties. It is, a tetraploid with 40 chromosomes (2n = 4x = 40), belongs to the family *Poaceae* and, together with finger millet (*Eleusinecoracana Gaerth.*), to the subfamily *Chloridoideae*. It was originated and domesticated in Ethiopia. There are about 350 *Eragrostis* species of which E. tef is the only species cultivated for human consumption. The experiment was conducted to identify, select and recommend adaptable, high yielding, insect pest and disease resistant eleven released and one local variety at Bench Maji zone of Southern Nations, Nationalities and Peoples' Region (SNNPR). **Materials and Methods:** Twelve varieties were evaluated in randomized complete block design with 3 replication on station of South Bench, Guraferda and Sheko on main cropping season of 2015 and 2016. The data were subjected to one way analysis of variance using SAS software. **Results:** Analysis of variance revealed that except grain filling period at Guraferda woreda there were significant ($p<0.005$) differences among genotypes for culm length, panicle length, plant height, days to heading, days to maturity, grain filling period, primary panicle brunch, grain yield, biomass yield and harvest index at South Bench, Guraferda and Sheko. Based on the obtained result, three improved tef varieties namely, kora, Boset and Dukemat South Bench, Quncho, Gimbechu and Enatit at Guraferda and also Dukem, Quncho and Gimbechu at Sheko showed better performance for most of the studied characters including grain yield. **Conclusion:** Therefore, these three varieties were selected and recommended for the study area and similar ecologies of Bench Maji zone. On the other hand Magna at South Bench, Degatef at Guraferda and local variety showed lowest grain yield.

Key words: Grain yield, biomass yield, tef, varieties

Citation: Abebe Bogale and Wondwosen Wondmu, 2017. Evaluation and selection of some improved tef (*Eragrostis tef* (*Zucc.*) trotter) varieties in three districts of Bench Maji zone, Ethiopia. Asian J. Agric. Res., 11: 98-102.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tef *(Eragrostis tef* (zucc.) Trotter) is ancient and an important cereal crop in Ethiopia, where domestication took place before the birth of Christ[1]. According to Stallknecht[2], tef originated in Ethiopia around 4000-1000 BC. It was probably cultivated in Ethiopia even before the ancient introduction of emmer wheat and Ebba[3]. The fact that several cultivated and wild species of *Eragrostis*, some of which were considered the wild relatives of tef, are found in Ethiopia and the genetic diversity existing in Ethiopia, indicated that tef originated and was domesticated in Ethiopia[4], has identified Ethiopia as the center of origin and diversity of tef.

In Ethiopia, the five major cereals (tef, wheat, maize, sorghum and barley) occupy almost three-quarters of total area cultivated and represent almost 70% of total value added in recent years[5]. Tef was adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 masl and even it can be grown in an environment unfavorable for most cereal, while the best performance occurs between 1100 and 2950 masl in Ethiopia[6].

Tef is predominantly grown in Ethiopia as a food crop and not as a forage crop. However, when grown as a food, farmers highly value the straw of tef and it is stored and used as a very important source of animal feed, especially during the dry season. Farmers feed tef straw preferentially to lactating cows and working oxen. Cattle prefer tef straw to the straw of any other cereal and its price was higher than that of other cereals[7].

Tef was mainly produced in Amhara and Oromia, with smaller quantities in the Tigray and SNNPR regions. However last 50 year's many researches were done to improve tef in Ethiopia with a primary focus on yield but this could not include whole country; it was only few main tef producing area of the country. In Southern Nation Nationalities and People's Region (SNNPR) there were eleven zones and eight special were das that produce tef. But in South West part of Ethiopia at Bench Maji zone of the in South Bench, Guraferda and Sheko woreda tef cannot be produced and no research was under taken[8]. Therefore, the present study was conducted to evaluate and select adaptable, high yielding improved tef varieties for South Bench, Guraferda and Sheko woreda.

MATERIALS AND METHODS

Description of the study area: The experiment conducted at three locations of Bench Maji zone, namely South Bench, Guraferda and Shekoworeda during 2015 and 2016 main cropping season. The geographical study areas were characterized as semi tropical type with acidic nature of nitosol soil type. The average annual rain fall of the area is wet moist for most months of the year with relative dry season in end of December up to beginning of March.

Experimental materials: About 11 released tef varieties and one local that expected to perform better in the areas were used for this study. The varieties were selected based on average yield performance and agro ecological adaptation. The verities were obtained from Debrezeyt Agricultural Research center.

Experimental design: The experiment was laid out in RCBD with 3 replications and the plot size was 2×2 m. The spacing was 1 m between plots and 1.5 m between adjacent blocks. Each genotype was sown at seed rate of 25 kg ha^{-1} by row planting. A recommended fertilizer rate 100 kg ha^{-1} DAP and 53 kg ha^{-1} urea were applied. All other trial management activities were carried out as deemed necessary.

Data collection: The following quantitative data were recorded from field observation:

- Day from planting to heading
- Days to maturity
- Days to grain fill period
- Culm length (cm)
- Panicle length (cm)
- Plant height (cm)
- Number of primary branches/plant
- Grain yield/plot (kg)
- Biomass yield/plot (kg)
- Harvest index (%)

$$\text{Harvest index (HI)} = \frac{\text{Seed yield/plot (kg)}}{\text{Total biological yield/plot (kg)}} \times 100$$

Statistical analysis: The data were subjected to one way analysis of variance using SAS software v 9.1.3[9]. The significant difference among genotypes was tested by 'F' test at 1% and 5% levels of probability.

RESULTS AND DISCUSSION

The analysis of variance revealed that there were highly significant ($p<0.01$) difference among varieties for culm

length, primary panicle brunch, grain yield, biomass yield and harvest index and significant (5%) different in panicle length, plant height, days to heading, days to maturity and grain filling period at South Bench. These results were further supported by Chondie and Bekele[10], who reported considerable variation in the days to maturity, plant height and panicle length, days to heading and grain yield of different tef varieties when planted over years. Similarly, Kedir *et al.*[11] reported that significance differences between varieties for the characters like days to maturity, panicle length, plant height days to heading, days to maturity, grain yield. Grain yield of tested varieties at tested locations which was ranged from 496 kg ha^{-1} (magna) to 1955 kg ha^{-1} (kora) with mean value of 1340 kg ha^{-1} (Table 1). Kora was among the highest yielding cultivars followed Boset (1827 kg ha^{-1}) and Dukem (1750 kg ha^{-1}) however; statistically there was no significance difference. On the other hand, lowest grain yield was recorded by Magna (490 kg ha^{-1}) at South Bench. In agreement with the current study, Kedir *et al.*[11] reported that Boset, showed better performance for most of the studied characters including grain yield. Likewise, Assefa *et al.*[12] reported that the combined data analysis across locations and over the years indicated that candidate variety Kora (DZCr-438) performed better than the two checks and other test genotypes.

At Guraferda, the analysis of variance indicated that there were highly significant ($p<0.01$) difference among varieties in plant height, days to emergency, grain yield and biomass and significant ($p<0.05$) in culm length, panicle length, days to heading, days to maturity, primary panicle brunch and harvest index. Similar result was reported by Demelash[13] for days to heading, days to maturity, grain yield per and shoot biomass. Grain filling period is only character that show non significance. Grain yield of tested varieties ranged from 950 kg ha^{-1} (Degatef) to 1723 kg ha^{-1} (Quncho) with mean value of 1279 kg ha^{-1}. High grain yield was recorded by variety Quncho1723 kg ha^{-1} followed Gimbechu (1650 kg ha^{-1}) and Enatit (1630 kg ha^{-1}). However; there was no statically difference between them. Earlier researchers also reported that Quncho and Gimbichu for its short maturity period and its higher grain yield for Hosanna areas relatively[10]. Similarly, Hailekiros[14] reported that Quncho variety showed highest grain yield. Lowest grain yield was recorded by Degatef (950 kg ha^{-1}) (Table 2).

At Sheko, the analysis of variance indicated that there were highly significant ($p<0.01$) difference among varieties in culm length, plant height, days to emergency, days to heading, panicle length and Grain filling period and significantly different in days to maturity, primary panicle brunch, grain yield, biomass yield and harvest index. The result is in congruent with previous studies of Oljira *et al.*[15], who reported that highly significant difference in haricot bean. Similar result was reported by Oljira *et al.*[15], Nigus *et al.*[16] and Shiferaw *et al.*[17] for days to heading, plant height, panicle length, culm length, grain filling period, days to maturity, grain yield, above ground biomass and harvest index. A wide range of variability was recorded for grain yield among genotypes (Table 3). It's ranged from 790 kg ha^{-1} (local) to 1733 kg ha^{-1} (Dukem) with mean value of 1130 kg ha^{-1}. Dukem (1730 kg ha^{-1}) followed Quncho (1380 kg ha^{-1}) and Gimbechu (1380 kg ha^{-1}) were among the highest yielding cultivars at Sheko (Table 3). Lowest grain yield was recorded by local

Table 1: Mean and range values for different agronomic traits for 12 cultivars at South bench in 2015 and 2016

	CL	PL	PH	DE	DH	DM	GFP	PPB	GY (kg ha^{-1})	BM	HI
Mean	58.00	32.48	90.48	5.39	72.12	113.27	41.15	21.64	1340	2.99	19.20
Range											
Max	68.13	37.46	95.13	8.00	75.67	118.6	46.3	26.33	1955	5.10	33.23
Min	50.83	25.86	82.03	3.67	68.00	109.3	36.3	15.8	496	2.00	6.44
DZ-Cr-354	57.5^{bcd}	31.2^{bcd}	88.7^{abc}	5.0^{cd}	73.0^{ab}	114.0^{abc}	41.0^{bcde}	23.4^{ab}	1424^{abc}	3.4.0^{b}	16.4^{bc}
DZ-01-899	56.7^{bcde}	30.9^{cd}	87.6^{abc}	5.3^{bcd}	72.3^{abc}	112.6^{bc}	40.3^{bcde}	24.3 ^{ab}	1230^{bc}	3.3^{bc}	14.8^{cd}
DZ-01-196	61.8^{b}	32.4^{abc}	94.3^{a}	5.6^{bc}	73.0^{ab}	109.3^{c}	36.3^{e}	16.9^{cd}	490^{d}	3.1^{bcd}	6.4^{d}
DZ-01-2675	50.8^{e}	31.2^{bcd}	82.0^{c}	5.6^{bc}	72.3^{abc}	118.6^{a}	46.3^{a}	19.8^{bcd}	1252^{bc}	2.1^{cd}	23.5^{b}
DZ-Cr-438	68.1^{a}	25.8^{d}	94.0^{a}	5.0^{cd}	73.0^{ab}	110.0^{c}	37.0^{de}	26.3^{a}	1955^{a}	5.1^{a}	16.0^{bc}
Ho-Cr-136	60.4^{b}	32.6^{abc}	93.06^{a}	7.0^{ab}	69.0^{cd}	113.3^{bc}	44.3^{ab}	15.8^{d}	960^{cd}	2.0d	20.0^{bc}
DZ-Cr-387	58.06^{bcd}	37.0^{ab}	95.1^{a}	4.3^{cd}	73.3^{ab}	111.6^{c}	38.3^{cde}	25.5^{a}	1620^{ab}	2.8^{bcd}	23.0^{bc}
DZ-Cr-409	58.1^{bcd}	33.7^{abc}	91.9^{ab}	4.6^{cd}	68.0^{d}	111.6^{c}	43.6^{ab}	22.6^{ab}	1827^{a}	2.23^{cd}	33.2^{a}
DZ-01-1285	52.5^{de}	31.8^{abc}	84.3^{bc}	8.0^{a}	75.6^{a}	117.3^{ab}	41.6^{abcd}	16.4^{cd}	1220^{bc}	2.8^{bcd}	18.4^{bc}
1DZ-01-255	53.8^{cde}	37.4^{a}	91.2^{ab}	3.6	71.0^{bcd}	114.0^{abc}	43.0^{abc}	20.6^{bc}	1040^{c}	2.24^{cd}	18.6^{bc}
CV (%)	6.25	10.67	5.09	19.40	2.89	2.74	7.38	13.1	23.26	23.73	25.73

CL: Culm length, PL: Panicle length, PH: Plant height, DH: Days to heading, DM: Days to maturity, GFP: Grain filling period, PPB: Primary panicle brunch, GY: Grain yield, BMY: Biomass yield, HI: Harvest index. Mean within a column followed by the same letter(s) within a column are not significantly different from each other at 5% by DMRT, CV: Coefficient of variation

Table 2: Mean and range values for different agronomic traits for 12 cultivars at guraferda in 2015 and 2016

	CL	PL	PH	DE	DH	DM	GFP	PPB	GY (kg ha^{-1})	BM	HI
Mean	57.4	31.8	89.2	5.3	68.83	101.75	32.91	20.19	1279	2.76	19.23
Range											
Max	68.7	37.1	104.1	8.0	73.3	106.00	37.6	25.0	1723	3.80	26.4^{a}
Min	46.6	25.8	79.3	3.6	63.6	97.30	26.6	16.90	950	1.73	15.3
Local	51.5^{def}	30.5^{bcde}	82.0^{def}	5.6^{b}	73.3^{a}	106.0^{a}	32.6^{abc}	18.6^{bcd}	1220^{cd}	2.2^{cd}	22.1^{ab}
DZ-Cr-354	46.6^{f}	32.6^{abcd}	79.3^{f}	3.6^{e}	68.6^{bc}	103.6^{abc}	35.0^{ab}	22.1^{abc}	1630^{ab}	16.3^{ab}	19.7^{bc}
DZ-01-899	54.5^{def}	28.6^{de}	83.2^{def}	4.6^{cd}	68.6^{cb}	100.3^{cd}	31.6^{abc}	18.5^{cd}	1650^{a}	16.5^{a}	20.3^{bc}
DZ-01-196	59.6^{bcd}	30.8^{bcde}	90.4^{bcd}	5.6^{b}	68.3^{bc}	97.3^{d}	29.0^{bc}	18.3	1120^{cd}	11.2^{cd}	15.4^{c}
DZ-01-2675	50.0^{ef}	29.8^{cde}	79.8^{ef}	6.0^{b}	67.3^{bcd}	105.0^{ab}	37.6^{a}	16.9^{d}	950^{d}	1.94^{d}	19.5^{bc}
DZ-Cr-438	56.8^{cde}	25.8^{e}	82.6^{def}	4.3^{de}	69.6^{abc}	101.3^{bcd}	31.6^{abc}	25.0^{a}	1330^{bc}	3.4^{ab}	15.5^{c}
Ho-Cr-136	56.8^{cde}	31.9^{bcd}	88.7^{cde}	7.3^{a}	69.3^{ab}	104.3^{abc}	35.0^{ab}	19.2^{bcd}	1150^{cd}	2.08^{d}	22.1^{ab}
DZ-Cr-387	68.7^{a}	35.4^{ab}	104.1^{a}	5.3^{bc}	71.3^{ab}	98.0^{cd}	26.6^{c}	21.9^{abc}	1720^{a}	3.8^{a}	18.2^{bc}
DZ-Cr-409	58.1^{bcd}	34.7^{ab}	92.8^{bc}	4.6^{cd}	65.6^{cd}	97.6^{d}	32.0^{abc}	19.8^{bcd}	1180^{cd}	2.9^{b}	16.03^{bc}
DZ-01-1285	65.2^{ab}	31.6^{bcd}	96.8^{abc}	8.0^{a}	71.0^{ab}	103.0^{abc}	32.0^{abc}	17.2^{d}	1050^{cd}	1.73^{d}	26.4^{a}
1DZ-01-255	61.1^{bc}	37.1^{a}	98.2^{ab}	3.6^{e}	63.6^{d}	100.3^{cd}	36.6^{a}	21.6^{abc}	1220^{cd}	3.1^{ab}	15.30
CV (%)	6.55	9.38	6.21	10.71	3.61	2.59	13.05	12.47	14.15	14.7	18.69

CL: Culm length, PL: Panicle length, PH: Plant height, DH: Days to heading, DM: Days to maturity, GFP: Grain filling period, PPB: Primary panicle brunch, GY: Grain yield, BMY: Biomass yield, HI: Harvest index. Mean within a column followed by the same letter(s) within a column are not significantly different from each other at 5% by DMRT, CV: Coefficient of variation

Table 3: Mean and range values for different agronomic traits for 12 cultivars at sheko in 2015 and 2016

	CL	PL	PH	de	DH	DM	GFP	PPb	GY (kg ha^{-1})	BM	HI
Mean	62.5	32.12	94.63	4.72	68.52	113.13	44.61	21.74	12.79	2.75	16.82
Range											
Max	74.73	38.80	111.80	7.67	75.30	119.30	104.3	25.8	17.23	4.33	24.20
Min	51.60	25.80	84.30	3.67	56.00	104.30	34.00	18.2	9.50	1.63	10.58
Local	56.5^{efg}	30.5^{cde}	87.0^{ef}	4.00^{d}	70.00^{cde}	115.6^{ab}	45.6^{b}	18.2^{d}	12.2^{cd}	2.6^{bcd}	10.6^{c}
DZ-Cr-354	51.6^{g}	32.6^{bcd}	84.30^{f}	3.60^{d}	56.00^{g}	114.6^{abc}	58.6^{a}	23.1^{abc}	16.3^{ab}	16.3^{ab}	16.1^{bc}
DZ-01-899	59.5^{def}	28.6^{de}	88.2^{defd}	4.00^{d}	67.30^{e}	110.6^{bcd}	43.3^{b}	25.6^{a}	16.5^{a}	16.5^{a}	15.9^{bc}
DZ-01-196	64.6^{bcd}	30.8^{cde}	95.4^{bcde}	4.00^{d}	70.60^{cde}	113.00^{abc}	42.3	20.7^{abc}	11.2^{cd}	11.2^{cd}	21.5^{ab}
DZ-01-2675	55.0^{fg}	29.8^{cde}	84.8	5.00^{bc}	62.60^{f}	104.3^{d}	41.6^{b}	21.4^{abcd}	9.5^{d}	9.5^{d}	24.3^{a}
DZ-Cr-438	63.1^{cde}	25.8^{de}	87.6^{ef}	4.00^{d}	70.00^{cde}	114.3^{abc}	44.3^{b}	24.3^{ab}	13.3^{bc}	13.3^{bc}	12.7^{c}
Ho-Cr-136	63.1^{cde}	31.9^{bcd}	93.7^{cdef}	7.60^{a}	63.00^{f}	119.3^{a}	56.3^{a}	20.2^{bcd}	11.5^{cd}	11.5^{cd}	20.2^{ab}
DZ-Cr-387	74.7^{a}	37.0^{ab}	111.8^{a}	4.00^{d}	75.30^{a}	114.00^{abc}	38.6^{bc}	22.9^{abcd}	17.2^{a}	17.2^{a}	20.5^{ab}
DZ-Cr-409	63.1^{cd}	34.7^{abc}	97.8^{bcd}	4.60^{cd}	68.00^{de}	110.6^{bcd}	42.6^{b}	18.2^{d}	11.8^{cd}	11.8^{cd}	17.5^{abc}
DZ-01-1285	70.2^{ab}	31.6^{bcd}	101.8^{bc}	7.00^{ab}	71.30^{bcd}	113.6^{abc}	42.3^{b}	18.9^{cd}	10.5^{cd}	10.5^{cd}	15.00^{bc}
1DZ-01-255	66.1^{bc}	38.8^{a}	104.9^{ab}	4.00^{d}	75.00^{ab}	109.00^{cd}	34.0^{c}	21.3^{abcd}	12.2^{cd}	12.2^{cd}	12.4^{c}
DZ-Cr-974	64.8^{bcd}	33.00^{bcd}	97.8^{bcd}	3.60^{d}	73.00^{abc}	118.3^{a}	45.3^{b}	25.8^{a}	11.1^{cd}	11.1^{cd}	15.4^{bc}
CV (%)	6.0	10.38	6.11	20.16	3.22	3.36	9.86	12.94	23.13	3.24	24.07

CL: Culm length, PL: Panicle length, PH: Plant height, DH: Days to heading, DM: Days to maturity, GFP: Grain filling period, PPB: Primary panicle brunch, GY: Grain yield, BMY: Biomass yield, HI: Harvest index. Mean within a column followed by the same letter(s) within a column are not significantly different from each other at 5% by DMRT, CV: Coefficient of variation

variety (791 kg ha^{-1}). In agreement with the current finding, Chondie and Bekele[10] reported that higher grain yield and easily adaptability Quncho and Gimbichu variety for Hosanna areas.

CONCLUSION AND RECOMMENDATION

The tef adaptation trial was conducted at three locations representing mid-land agro-ecologies of Bench Maji zone, SNNPR 2015 and 16 cropping season to evaluate and select adaptable, high yielding, early maturing, diseases resistant varieties. Grain yield was an important character to be considered for variety selection to address the objective of the conducted activity. For this reason, three improved varieties i.e. kora, Boset and Dukem at South Bench; Quncho, Gimbechu and Enatit at Guraferda and alsoDukem, Quncho and Gimbechu at Sheko showed better performance for most of the studied characters including grain yield. Therefore, these three varieties were selected and recommended for the study area and similar ecologies of Bench Maji zone.

SIGNIFICANCE STATEMENT

This study identifies and recommends adaptable, high yielding, insect pest and diseases resistance variety of tef, yet tef can't produce area of Bench Maji. For Each woreda this study indentifies and recommends three variety of tef.

ACKNOWLEDGMENT

The authors would like to thank Mizan Tepi University for their support and Debrezeyt Agricultural research center for contribution of seed.

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