

Performance Evaluation of Tef Varieties for Yield and Yield Related Traits in Traditional and Non-traditional Growing Areas Under Irrigation Production in Ethiopia

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Abstract: Tef is a foremost staple cereal crop with substantial contribution in the GDP of Ethiopia. Tef grain is highly nutritious gluten-free as well as high quality forage. However, yield losses of tef due to erratic rainfall and drought are estimated to reach up to 77%. Lodging is also the major bottleneck limiting tef quality and yield losses estimated at 30% - 35 %. Hence, the purpose of this research was design to evaluate, and recommend best performing tef varieties under irrigation farming system in both traditional and non-traditional tef growing areas in Ethiopia. The field experiment comprised 35 released tef varieties using randomized complete block design with three replications in 2m² plot size were evaluated at six locations (eight environments). The result revealed highly significant ($p < 0.001$) varietal difference for grain yield at all locations under irrigation. For non-traditional tef growing areas (Somali region), there was highly significant ($p < 0.001$) varietal difference for all recorded traits except panicle length. This finding indicates that the lodging index in tef is reduced when it is cultivated under irrigation production. The variety by location interaction effect in Somali region showed that there were highly significant ($p < 0.001$) varietal difference for plant height, days to maturity and harvest index. However, there was no interaction significant varietal difference for grain yield, above ground shoot biomass, lodging index, panicle length and days to head in the three locations of Somali region. There was no single variety demonstrating steady superiority for grain yield across all tested environments. However, variety Gamechis was the best varieties at five tested environments. Performance of tef variety in non-traditional tef growing area (Somali region) is encouraging both for small holder farmers and large-scale investors to grow tef in the area. Thus, cultivated tef in this region is crucial to ensure food security in region as well as in the country. Moreover, growing tef in non-traditional regions has vital role to get additional quality feed source for their animals where it is a major problem in the region. In addition to tef yield increment using irrigation production but may also reduce variability in production through improved control of the crop environment. Therefore, variety Gamechis, Boset, Kora and Quncho should be used under irrigation production both in non-traditional and traditional tef growing areas where the experiment was conducted and other similar agro ecological areas.

Keywords: Tef Varieties, Irrigation, Traditional and Non-traditional Growing Areas, Grain Yield

1. Introduction

Tef (*Eragrostis tef* (Zucc) Trotter) cover more than three million hectares (ha) in Ethiopia, ranks first [6] and aids as a staple food for more than 73 million of the local population and potential export crop. Tef has better advantages than the other cereals in terms of husbandry, utilization and economic benefits [3]. Tef grain is gluten-free and contains all eight essential amino acids, as well as high contents of high fiber and mineral contents like Fe, Ca, Cu, Zn and Mg, fiber, and vitamins like vitamin B1, B2, B3, B6 and C, preferred foodstuff for diabetics owing to slow carbohydrates release and iron-deficiency anaemia due to the rich source of iron [14, 5]. Moreover, tef has high quality forage crop because of its high feed quality, crude protein content, fast growth rate, and its suitability for multiple harvests [12, 11]. Because it is in high demand and thus has a high market value, it is a cash crop; farmers gain more from growing tef than growing other staple food crops.

Currently, tef is produced by smallholder farmers who rely on natural rainfall. Under future climate, rainfall amount and distribution future will have significant impact on tef yield [2]. Rainfall fluctuations play a significant impact in determining the national economy of Ethiopia. As a result, one of the main hindrances to developing sustainable agriculture in Ethiopia is

erratic rainfall and drought. Intensity and distribution of the rainfall are very crucial for satisfactory growth and development of tef [7, 8]. If the intensity of rainfall much exceeds the rate of infiltration of the soil, the consequences are runoff and development of anaerobic conditions in the root zone of the crop. These conditions affect crop performance through nutrient deprivation and oxygen deficiency. Similarly, if its intensity is less to satisfy infiltration and evaporative demands, the crop is subjected to water deficiency which greatly affects its productivity. The amount of rainfall received at periodic interval also determines the final productivity of crops as crops response to moisture varies from stage to stage because of its dependence on erratic rainfall for crop production; Ethiopia is highly exposed to drought. Yield reduction of tef due to drought up to 77% has been reported to have occurred as a result of drought at the anthesis stage of tef [16]. Most part of the country is suffering from drought especially during grain filling period. Thus, food insecurity has remained the main problem in the country. Furthermore, in Ethiopia researchers have never released improved varieties for the irrigated tef production system. Hence, the aim of this research was to evaluate, and recommend best performing released tef varieties under irrigation farming system in both traditional and non-traditional tef growing areas in Ethiopia.

2. Materials and Methods

2.1. Plant Materials Used for the Study

Table 1. Thirty-five released tef varieties were used for field evaluation.

No	Variety	Year	Centre	Altitude (m.a.s.l.)	RF (mm)	DM (days)	Productivity t ha ⁻¹	
							On station	on farm
1	DZ-01-354 (Enatit)	1970	DZARC	1600-2400	300-700	85-130	2.4-3.2	1.7-2.2
2	DZ-01-99 (Asgori)	1970	DAZRC	1500-2400	300-700	80-130	2.4-3.0	1.7-2.2
3	DZ-01-787 (Walankomi)	1978	DZARC	1800-2500	400-700	90-130	2.4-3.0	1.7-2.2
4	DZ-01-196 (Magna)	1970	DZARC	1500-2400	200-700	80-113	1.8-2.2	1.4-1.6
5	DZ-Cr-44 (Menagasha)	1982	DZARC	1800-2400	400-700	125-140	2.4-3.0	1.7-2.2
6	DZ-Cr-82 (Melko)	1982	DZARC	1700-2000	300-700	112-119	2.4-2.8	1.8-2.2
7	DZ-Cr-255 (Gibe)	1993	DZARC	1700-2200	300-700	114-116	2-3.0	1.6-2.2
8	DZ-01-974 (Dukem)	1995	DZARC	1400-2400	150-700	76-138	2.4-3.4	2-2.5
9	DZ-Cr-358 (Ziqala)	1995	DZARC	1400-2400	150-700	75-137	2.1-3.6	2.1-3.6
10	DZ-01-1285 (koye)	2002	DZARC	1900-2200	300-700	104-118	2.4-3.6	1.8-2.5
11	DZ-Cr-387/RIL-355 (Quncho)	2006	DZARC	1500-2500	300-700	80-113	2.4-2.8	2.0-2.2
12	DZ-Cr-37 (Tseday)	1984	DZARC	500-700	300-700	82-90	1.8-2.8	1.4-1.9
13	DZ-01-1281 (Gerado)	2002	DZARC	1850-2500	1000-1200	132	2.0-2.2	1.6-2.0
14	DZ-01-1681 (kay tena)	2002	DZARC	1600-1900	300-500	84-93	2.0-2.2	1.6-2.0
15	DZ-Cr-438 (Kora)	2014	DZARC	1650-2400	500-800	110-117	2.5-2.8	1.8-2.2
16	DZ-Cr-385 RIL295 (Simada)	2009	DZARC	1500- 1900	300-700	88	1.8-2.0	1.3 -2.3
17	DZ-Cr-409/RIL50d (Boset)	2012	DZARC	1500-1750	500-900	75-86	1.9-2.8	1.6-2.0
18	DZ-01-899 (Gimbichu)	2005	DZARC	1450-1695	690-965	62-83	1.8.2.0	1.6-1.8
19	Ho-cr-136 (Amarach)	2006	DZARC	1600-1700	500-850	63-87	1.3	1.2
20	DZ-01-2053 (Holetta key)	1998	Holetta	1900-2700	700-800	124-140	3.4	2.5
21	DZ-01-1278 (Ambo toke)	1999	Holetta	2200-2300	700-800	125-140	3.6	2.7
22	DZ-Cr-387 RIL#127 (Gamechis)	2007	Melksa	1450-1695	690-965	62-83	1.3-2.0	1- 1.4
23	DZ-01-2054 (Gola)	2003	Sirinka	1450-1850	660-1025	68-100	1.6	1.1
24	DZ-01-146 (Genete)	2005	Sirinka	1450-1850	660-1025	78-85	2.2	1.6
25	Dz-01-1821 (Zobel)	2005	Sirinka	1450-1850	660-1025	78-85	2.1	1.5
26	Acc.205953 (Mechere)	2007	Sirinka	1450-1850	660-1025	79	2.1	1.8
27	SR-RIL-273 (Laketch)	2009	Sirinka	1450-1850	660-1025	90	2.2	1.3-1.8
28	Dz-01-1868 (Yilmana)	2005	Adet	2000-2600	>600	108	2.7	1.6
29	Dz-01-3186 (Etsub)	2008	Adet	1800-2600	1230	92-127	1.9-2.7	1.6-2.2

No	Variety	Year	Centre	Altitude (m.a.s.l.)	RF (mm)	DM (days)	Productivity t ha ⁻¹	
							On station	on farm
30	Dz-01-2423 (Dima)	2005	Adet	2000-2600	>600	105	2.5	1.7
31	Dz-01-1880 (Guduru)	2006	Bako	1850-2500	1000-1200	132	1.5-2.3	1.4-2.0
32	23-tafi-adi-72 (Kena)	2008	Bako	1850-2400	1000-1200	110-134	1.7-2.7	1.3-2.3
33	PGRC/E205396 (Ajora)	2004	Areka	1600-1900	900-1200	85-110	1.0-3.1	1.0-3.1
34	Dz-01-2675 (Degatef)	2005	Debre Zeit	2000-2500	1000-1200	118-137	1.8-2.8	1.6-2.0
35	21476A (Workiye)	2014	Sirinka	1450-1850	505-1025	85	2.2	1.6

2.2. Study Area and Seasons

Though the experiment was conducted at Worer, Jijiga, Gode on farm, Gode on station and Mehoni, Koga, Gonder and Debre Zeit during 2015/16- 2016/2017, data from Debre Zeit and worer were not included because of data heterogeneity and poor grain yield due to unexpected rainfall at harvesting stage (Debre Zeit).

Jijiga, Gode on farm, Gode on station are non-traditional tef growing areas (where tef was no growing before). The rest are traditional tef growing areas.

2.3. Experimental Design and Field Management

Randomized complete block design with three replications and spacing of 1 m between plots and 1.5 m between blocks were used. The treatments were sown on 2m x 1m (2 m²) plot area in accordance with the recommended seed rate 15 kg ha⁻¹ during the two consecutive off seasons (2015/16 and 2016/17). Irrigation was applied every three days interval for the first initial stage, five days interval at vegetative stage and eight days interval after heading to early maturity with flood irrigation method. In general, the field experiment was managed as per the research recommendation of agronomic practices of the respective test locations.

2.4. Data Collection

Data were collected on plot and individual plant basis for eight traits. Data taken on plot basis were; days of heading and maturity which were taken when each plot attained 50% heading (panicle emergency) and 90% physiological maturity respectively, and days were calculated beginning from the date of sowing. Lodging index was taken during 90% physiological maturity by simple observation. Above shoot biomass was taken by measuring the whole dried biomass in the plot, grain yield (g) of each experimental plot was measured on clean, dried seed and the measured plot grain yield value (g) has changed to kilogram per hectare for data analysis.

Plant height (cm), and panicle length (cm) were taken on the five individual samples of plants which were randomly taken from the central rows of each plot, and the averages of five sample plants were as used for analysis.

2.5. Data Analyses

Pooled analysis of variance (ANOVA) for each individual growing environments were done using the mean value of each measured traits. and eventually upon getting positive results from tests of homogeneity of variances using the method F-max [10], a combined analysis of variance was

made across the environments (locations) only for Somali region to know the differences between varieties across environments, among environments and their interaction. For the analysis of variance, general linear model procedure suitable for the study experimental design were used [9] using SAS software version 9.00 [13] and the average performance for different traits presented below (Table 3). Least Significant Difference (LSD) were used to separate the mean both at 1% and 5% probability level for traits revealed significant difference in the ANOVA table using SAS statistical software.

3. Results and Discussions

3.1. Grain Yield Performance of Irrigated Tef Varieties at Different Environments

In the present study grain yield in kg ha⁻¹ revealed to be highly significant ($p < 0.001$) different at eight environments under irrigation which is presented in Table 3.

At Jijiga Variety code 22 (DZ-cr-387 RIL#127 (Gamechis) and variety code 17 DZ-Cr-409/RIL50d (Boset) presented the uppermost grain yield 3588 and 3573 kg ha⁻¹, correspondingly.

Gode on-station, variety code 15 (DZ-Cr-438 (Kora) and variety code 22 (DZ-cr-387 RIL#127 (Gamechis) gave the highest grain yield 3984 and 3935 kg ha⁻¹, respectively.

Gode on-farm, Variet Code 22 (DZ-cr-387 RIL#127 (Gamechis) and variety code 8 (DZ-01-974 (Dukem) recorded the highest grain yield 4224 and 4218 kg ha⁻¹, respectively.

Mehoni, there was over flooding irrigation before emergency, however variety code 22 (DZ-cr-387 RIL#127 (Gamechis) and DZ-Cr-387/RIL-355 (Quncho) were the most outperforming varieties with 5823 and 5385 kg ha⁻¹, respectively.

Koga 2017, there were high over flooding irrigation before emergency which ultimately result poor yield performance and some of the varieties were not germinated, however variety code 22 (DZ-Cr-387 RIL#127 (Gamechis) and DZ-01-1821(Zobel) provided the highest yield 2362 and 2339 kg ha⁻¹, respectively.

Koga 2016, there were data discrepancy and some of the varieties were not germinated due to irrigation management problem which is over flooding before plant emergency.

Dembi 2017 variety code 8 (DZ-01-974 (Dukem) and Code 7 (DZ-Cr-255 (Gibe) recorded the highest grain yield 3893 and 3422 kg ha⁻¹, respectively. In general, from the two year data, Dukem and Gibe were the best performed varieties

though the seed color of these varieties are not very white.

There was no single variety revealing steady superiority for grain yield across environments. However, code 22 (DZ-Cr-387 RIL#127 (Gamechis) had better yield performance across five tested tef genotypes. It surprising that the response of tef varieties under rain feed and irrigation is totally different. In general, this result indicates that crop

performance relies on the varieties, the environment in which it grows under irrigation. Thus, it indicated that the varieties respond differently for irrigation across environments [19]. Therefore, using the right variety at the right location under irrigation production plays a pivotal role for increasing production and productivity of tef and ultimately to ensure food security in the country.

Table 2. Yield performance and mean square of 35 released tef varieties at eight environments under irrigation.

ENTRY	Jijiga	Godeonstation	Gode onfarm	Mehoni	Koga-17	Koga-16	Dembi-16	Dembi-18
V1	3096	3659	3933	2935	1110	1552	1826	2895
V2	3165	3502	3718	3820	1940	2252	2157	2212
V3	2632	3489	3793	-	1916	598	2127	3128
4	2356	3556	3955	3725	1976	817	1813	2084
5	3205	3571	3744	3263	1994	1877	1754	1999
6	2888	3400	3893	284	0	-	1830	1762
7	2878	3196	3754	3567	1608	2919	2565	3422
8	3146	3788	4218	4885	1715	1781	2266	3893
9	2995	3560	3981	2607	0	-	1710	1743
10	3336	3153	3756	506	0	-	1929	1995
11	3212	3884	4143	5385	1976	2149	2006	2322
12	2666	3670	3964	4435	1689	764	1517	1594
13	2938	3283	3576	787	0	-	1809	3255
14	3018	3114	3544	2259	2094	1435	2105	2046
15	3372	3984	4182	4505	1573	1228	2225	2745
16	2940	3518	3915	4662	1396	951	2018	2125
17	3573	3795	4167	5825	2283	1970	2009	3230
18	3273	3130	3677	3992	1457	1663	2595	2682
19	2928	3319	3906	-	0	-	2136	2314
20	3145	3234	3821	2058	0	-	2168	2051
21	3238	3103	3728	3348	2063	2174	2412	2324
22	3588	3935	4224	4673	2362	2320	2381	2409
23	3400	3330	3915	5058	0	-	2491	3247
24	3070	3118	3728	4168	2038	1228	2359	2708
25	3307	3178	3901	5275	2339	1903	2075	2346
26	2916	3118	3829	3078	2107	1925	2384	2110
27	2798	3340	3839	4857	2119	2565	2410	2607
28	3163	3233	3673	4953	1029	1518	1687	2236
29	3406	3354	3799	4418	2119	2249	2173	3067
30	2474	3286	3842	4068	2287	2370	1452	2505
31	2648	3352	3815	3517	2015	1910	1738	1804
32	2713	3129	3901	3527	1240	718	1906	1752
33	2587	3335	3737	4327	1624	2036	2058	2456
34	3038	3102	3914	2134	1088	2542	2142	2642
35	3149	3098	3859	3732	1940	2551	2249	2710
Mean	3036	3395	3867	3446	1460	1428	2065	2462
CV	13	5	5	27	-	-	16	14
LSD	625	287	313	1512	1068	1421	666	638
R ²	62	77	54	82	77	63	56	80
Variety	269633**	205797***	84734**	756169***	197224***	2530523***	237839**	911205***

Results with dash is missing plots due to germination problem (high amount of flooded irrigation).

3.2. Interaction Effect on the Mean Performance of Tef Varieties Yield Related Traits in Non-traditional Tef Growing Areas

The performances of evaluated tef varieties in this study were unbelievable and encouraged to cultivate tef in Somali region.

The result from three locations, tef varieties displayed highly significant ($P < 0.001$) difference for all recorded traits except panicle length. The observed variances for all the traits recorded could be because of dissimilarity in the

genetic makeup of the studied tef varieties. Similar result with the current finding was reported by different scholars on substantial amount of variability in different tef genotypes studied [17, 20]. The location also showed highly significant ($P < 0.001$) difference for all tested tef varieties.

Days to 50% heading ranged from 46 days (Tseday) to 53 days (Guduru) with the overall mean of 50 days (Table). Tseday, Simada and Amarach which are early maturing varieties demonstrated significant fewer days than the rest of the varieties studied.

Mean performance of days to maturity demonstrated that

there were varieties which had few days maturity 90 days variety Simada to 91 days variety Tseday and Boset (Table 3). The current finding indicates that these differences possibly accredited to the agronomic parameters and to the climate adaptability of different tef varieties to the local condition [1]. Days to maturity has a significant function in the cropping system. Early maturing crops are timely handled, evacuate the land early for the next crops and escape from insect pest attack. Pervious study by [18] also declared that early maturity has been revealed to be a vital trait under stress conditions because early maturing tef can escape from drought stress.

Plant height: it is one of a vital growth parameter of any crop since it regulates or alters yield contributing characteristics and ultimately shapes the grain yield [4]. It is a multifaceted trait and is the end product of several genetically controlled factors mostly controlled by the genetic make-up of the genotypes. The variance in plant height could be attributed to the varietal characteristics of the crops planted. The mean performance of the plant height is ranged from 88 cm (Simada) to 108 cm (Kora). The change in plant height among the varieties might be linked to genetic differences, which may lead to the variable performances in growth and development and might be due to varietal effect and plant canopy which determine main stem to different locations.

Panicle length: average mean panicle length of the varieties ranged from 34 cm (Simada) to 42 cm (Kora and Quncho). The panicle length is directly related to the grain yield. This result in relation to panicle length is in concurrence to those of [17, 20] who found panicle length were genetically influenced by breeding material for development of tef cultivars developed in different environmental conditions.

Lodging index: the average lodging index ranged from 17% (kora) to 49 (Simada) %. Surprisingly from this study lodging is not directly related to plant height and panicle length. The highest lodging percentage was recorded in the shorter plant height variety Simada. This indicates that the cause of tef lodging might be due to weak stem strength

instead of plant height. In general, this finding indicates that the lodging index in tef is reduced when it is cultivated under irrigation production. This may be due to avoiding of rain fall pressure [15].

Above ground biomass: the average mean above ground biomass of the evaluated varieties ranged 11105 kg ha⁻¹ to 15318 kg ha⁻¹. The observed variances for all the traits recorded could be because of dissimilarity in the genetic makeup of the studied tef varieties. Similar result with the current finding was reported by different scholars on substantial amount of variability in different tef genotypes studied [17, 20].

Harvest index: it is vital yield traits in different grain crops including tef. The high harvest index showed more grain yield over biological yield and vice versa. A significant difference was showed among the varieties across the environments for the parameters recorded in the present study, it ranges from 21 (variety Dima, Guduru, Mechere, Zobel) to 26 (variety Simada, Tseday, Koye).

The range of the grain yield was from 3201 kg ha⁻¹ (Variety Dima) to 3916 kg ha⁻¹ (Variety Gamechis), respectively. The mean grain yield was 3433 kg ha⁻¹. Variety Gamechis, Kora, Bost, Quncho and Dukem were the outmost performance among the evaluated varieties in grain yield (Table 3). The reason getting highest grain yield from these tested varieties are might be due to absence of rain fall pressure which results lodging and because of timely supply and distribution of adequate amount of water [15]. The result calls up investors and smallholder farmers to start producing tef using irrigation in Somali region which makes them profitable and good opportunity to ensure food security in the area and in the country (Table 3).

Above ground biomass: The range of the above ground biomass was from 13698 (variety Simada) to 17728 (variety Kora) kg ha⁻¹. Apart from the grain yield, it is also very important for the region to get tef straws for feeding for their animals since there is scarcity of feeding during the dry season in the region.

Table 3. Mean square and performance of released tef varieties for yield and yield related traits combined across three locations under irrigation in non-traditional tef growing areas (Somali Region) in 2016/17.

No	Varieties	GYKG	ABMKG	LI	PL	PH	HI	DM	DH
1	DZ-01-354 (Enatit)	3562	15327	41	38	98	24	96	49
2	DZ-01-99 (Asgori)	3462	15136	40	37	99	24	94	51
3	DZ-01-787 (walankomi)	3305	15321	39	36	99	23	96	51
4	DZ-01-196 (magna)	3289	15185	34	39	99	22	96	50
5	DZ-Cr-44 (menagasha)	3507	15494	39	38	100	23	95	50
6	DZ-Cr-82 (melko)	3394	14241	38	39	99	24	95	51
7	DZ-Cr-255 (gibe)	3276	14414	44	35	96	24	94	50
8	DZ-01-974 (Dukem)	3717	17222	28	40	105	22	95	52
9	DZ-Cr-358 (ziqala)	3512	14883	33	38	100	24	95	50
10	DZ-01-1285 (koye)	3415	13809	40	36	98	26	94	50
11	DZ-Cr-387/RIL-355 (Quncho)	3746	16444	27	42	105	23	94	49
12	DZ-Cr-37 (Tseday)	3433	13914	46	36	91	26	91	46
13	DZ-01-1281 (gerado)	3265	14827	41	36	94	23	95	50
14	DZ-01-1681 (kayt-ena)	3225	15241	39	36	97	22	94	51
15	Dz-Cr-438 (Kora)	3846	17728	17	42	108	22	96	52
16	Dz-Cr-385 RIL295 (simada)	3458	13698	49	34	88	26	90	47
17	DZ-Cr-409/RIL50d (Boset)	3845	15778	36	37	97	24	91	49
18	DZ-01-899 (gimbichu)	3360	13784	36	36	95	25	95	52

No	Varieties	GYKG	ABMKG	LI	PL	PH	HI	DM	DH
19	Ho-cr-136 (Amarach)	3384	14179	46	34	92	25	93	47
20	Dz-01-2053 (holeta key)	3400	14265	41	36	96	25	95	50
21	Dz-01-1278 (ambo toke)	3356	15407	39	38	92	23	96	51
22	Dz-cr-387 RIL#127 (Gamechis)	3916	17037	26	39	98	23	96	51
23	Dz-01-2054 (Gola)	3548	14398	37	37	100	25	96	51
24	Dz-01-146 (genete)	3305	14975	41	38	98	23	97	50
25	Dz-01-1821 (zobel)	3462	16438	28	36	99	21	95	51
26	Acc.205953 (Mechere)	3288	15562	41	36	95	21	96	51
27	SR-RIL-273 (Laketch)	3326	14728	22	38	100	23	95	52
28	Dz-01-1868 (Yilmana)	3356	14698	39	36	97	23	96	51
29	Dz-01-3186 (Etsub)	3520	14661	40	36	98	25	95	51
30	Dz-01—2423 (Dima)	3201	15802	37	36	96	21	95	50
31	Dz-01-1880 (Guduru)	3271	16000	20	38	100	21	96	53
32	23-tafi-adi-72 (Kena)	3248	14302	41	36	95	23	96	51
33	PGRC/E205396 (Ajora)	3220	14772	40	36	96	23	95	51
34	Dz-01-2675 (Degatef)	3351	16179	37	35	98	22	95	49
35	21476A (Workiye)	3369	15315	42	39	100	23	95	50
	Grand Total	3433	15176	37	37	98	23	95	50
	CV	9	14	29	17	5	8	2	4
	LSD (%)	291	2068	10	3	5	4	2	2
	R ²	74	67	82	54	71	75	85	91
	Varieties	312207**	8873030**	486**	19ns	136**	31**	18**	18**
	Locations	18246154**	505228498**	36755**	817**	545**	1092**	2072**	4335**
	Replications	834004**	15034675*	6059**	123**	242**	150**	16*	57**
	Varieties x Locations	12399 ^{ns}	4951732 ^{ns}	63 ^{ns}	21 ^{ns}	90**	22**	7**	5 ^{ns}
	Error	97876	4951732	115	1d	24	8	4	5

3.3. Significance of Statement

This study discovered the importance of evaluating different tef varieties under irrigation, since climate change is one of the challenges threatening tef production. This study can be beneficial for tef producers to improve the production and productivity as well as to exploit the potential of the crop. Moreover, it will help the tef scientists to discover the critical areas of tef growing areas under irrigation that many previous scholars were not able to discover. Thus a new theory on genetic variability under irrigation production system may be arrived at tef research.

4. Conclusion and Recommendation

The study demonstrated for the first time the feasibility of tef production under irrigated condition both for traditional and non-traditional tef growing areas in Ethiopia.

Variety Gamechis, Bost, Kora, Quncho and Dukem were the outmost performance among the evaluated varieties in grain yield indicating significant tef varietal response under irrigation production. Apart from varietal difference response for irrigation, the reason getting highest grain yield from these tested varieties are might be due to absence of rain fall pressure which results lodging and because of optimum intensity and distribution of adequate amount of water. From the result of this study, there was no single variety exhibiting consistent superiority for grain yield across environments. However, code 22 (DZ-Cr-387 RIL#127 (Gamechis) had better yield performance across five tested tef genotypes. Consequently, it would be advisable to use variety Gamechis, Boset and Korea under irrigation condition.

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