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 content, fast growth rate, and its suitability for multiple harvests, 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

| No | Variety | Year | Centre | Altitude (m.a.s.l) | RF (mm) | DM (days) | Productivity t ha\(^{-1}\) |
|----|---------|------|--------|------------------|--------|-----------|-----------------|
| 1  | DZ-01-354 (Enatit) | 1970 | DZARC | 1600-2400 | 300-700 | 85-130 | 2.4-3.2 |
| 2  | DZ-01-99 (Asgori) | 1970 | DZARC | 1500-2400 | 300-700 | 80-130 | 2.4-3.0 |
| 3  | DZ-01-787 (Walankomi) | 1978 | DZARC | 1800-2500 | 400-700 | 90-130 | 2.4-3.0 |
| 4  | DZ-01-196 (Magna) | 1970 | DZARC | 1500-2400 | 200-700 | 80-130 | 1.8-2.2 |
| 5  | DZ-Cr-44 (Menagasha) | 1982 | DZARC | 1800-2400 | 400-700 | 125-140 | 2.4-3.0 |
| 6  | DZ-Cr-82 (Melkko) | 1982 | DZARC | 1700-2000 | 300-700 | 112-119 | 2.4-2.8 |
| 7  | DZ-Cr-255 (Gibe) | 1993 | DZARC | 1700-2200 | 300-700 | 114-116 | 2.3-0 |
| 8  | DZ-01-974 (Dukem) | 1995 | DZARC | 1400-2400 | 150-700 | 76-138 | 2.4-3.4 |
| 9  | DZ-Cr-358 (Ziqla) | 1995 | DZARC | 1400-2400 | 150-700 | 75-137 | 2.1-3.6 |
| 10 | DZ-01-1285 (koye) | 2002 | DZARC | 1900-2200 | 300-700 | 104-118 | 2.4-3.6 |
| 11 | DZ-Cr-387/RIL-355 (Quencho) | 2006 | DZARC | 1500-2500 | 300-700 | 80-113 | 2.4-2.8 |
| 12 | DZ-Cr-37 | 1984 | DZARC | 500-700 | 300-700 | 82-90 | 1.8-2.8 |
| 13 | DZ-01-1281 (Gerado) | 2002 | DZARC | 1850-2500 | 1000-1200 | 132 | 2.0-2.2 |
| 14 | DZ-01-1681 (kay tena) | 2002 | DZARC | 1600-1900 | 300-500 | 84-93 | 2.0-2.2 |
| 15 | DZ-Cr-438 (Kora) | 2014 | DZARC | 1650-2400 | 500-800 | 110-117 | 2.5-2.8 |
| 16 | DZ-Cr-385 RIL295 (Simada) | 2009 | DZARC | 1500-1900 | 300-700 | 88 | 1.8-2.0 |
| 17 | DZ-01-409/RIL50d (Boset) | 2012 | DZARC | 1500-1750 | 500-900 | 75-86 | 1.9-2.8 |
| 18 | DZ-01-899 (Gimbichi) | 2005 | DZARC | 1450-1695 | 690-965 | 62-83 | 1.8-2.0 |
| 19 | Ho-cr-136 (Amarach) | 2006 | DZARC | 1600-1700 | 500-850 | 63-87 | 1.3 |
| 20 | DZ-01-2053 (Holetta key) | 1998 | Holetta | 1900-2700 | 700-800 | 124-140 | 3.4 |
| 21 | DZ-01-1278 (Ambo toke) | 1999 | Holetta | 2200-2300 | 700-800 | 125-140 | 3.6 |
| 22 | DZ-Cr-387 RIL#127 (Gamechis) | 2007 | Melksa | 1450-1695 | 690-965 | 62-83 | 1.3-2.0 |
| 23 | DZ-01-2054 (Gola) | 2003 | Sirinka | 1450-1850 | 660-1025 | 68-100 | 1.6 |
| 24 | DZ-01-146 (Genete) | 2005 | Sirinka | 1450-1850 | 660-1025 | 78-85 | 2.2 |
| 25 | Dz-01-1821 (Zobel) | 2005 | Sirinka | 1450-1850 | 660-1025 | 78-85 | 2.1 |
| 26 | Acc.209593 (Mechere) | 2007 | Sirinka | 1450-1850 | 660-1025 | 79 | 2.1 |
| 27 | SR-RIL-273 (Laketich) | 2009 | Sirinka | 1450-1850 | 660-1025 | 90 | 2.2 |
| 28 | Dz-01-1868 (Yilmana) | 2005 | Adet | 2000-2600 | 700-800 | 108 | 2.7 |
| 29 | Dz-01-3186 (Etsub) | 2008 | Adet | 1800-2600 | 1230 | 92-127 | 1.9-2.7 |

On station  
on farm
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 consecutives 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 which were taken when each plot attained 50% heading (panicle emergency) and 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, Variety 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 (Quenoch) 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 38 93 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 farm 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 | Meholi | 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        | 3893   | 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      | 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   | 62     | 287           | 313         | 1512   | 1068    | 1421    | 666      | 636      |
| R²    | 62     | 77            | 54          | 82     | 77      | 63      | 56       | 80       |
| Variety | 26963** | 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 Amarah 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 Tseaday 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 matrity 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 makeup 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, Mecherere, Zobel) to 26 (variety Simada, Tseaday, 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 (izqala) | 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 (Tseaday)  | 3433 | 15184 | 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 |
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 Dukern 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.

References

[1] Aemiro B., Caterina A, Ermmas A, Yosufe G, Carol F, Mario E., Mattew D., 2020. Current and projected eco-geographical adaptation and phenotypic diversity of tef (Eragrostis tef) across its cultivation range. *Agriculture, ecosystem, & Environment*. Vol 300, 2020 107020, ISSN 0167-8890. Http://doi.org/10.1016/j.agee.2020.107020.

[2] Araya A., Atkilt G. Tse Dale D., Lucia G., Haity H., Amaan Z. 2015. Assessing the impact of climate change on tef (eragrostis tef) productivity in Debre Zeit area, Ethiopia. *International Journal of agricultural Science Research*. Vol 4 (93), pp. 039-048, 2015.

[3] Assefa, K., Yu, J. K., Zeid, M., Belay, G., Tefera, H., & Sorrells, M. E. (2011). Breeding tef [Eragrostis tef (Zucc.) Trotter]. Conventional and molecular approaches. *Plant Breeding*, 130 (1), 1–9. https://doi.org/10.1111/j.1439-0523.2010.01782.x

[4] Bayable M. Tsuneekaw A., Haregeweyn N., Alemayhu G., Tsuji W., Tsuho M., Adgo E., Tassew A., Ishii T., asargew F., Yield potential and variability of tef (eragrostis tef (Zucc.) Trotter) geremplasm under intensive and conventional management conditions. *Agronomy* 2021, 11, 220 /Http://doi.org/10.3390/agronomy11020220.

[5] Baye, K. (2014). Tef: *Nutrient Composition and Health Benefit*. Center for food science and nutrition, College of Natural Science. Addis Ababa University.

[6] Central Statistics agency (CSA) Sample Survey 2019/2020. Volume 1 Report on area and production of major Crops Ethiopia, Ababa Addis, 587 Bulletin.

[7] Deressa, T. T., & Hassan, R. M. (2009). Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures. *Journal of African Economics*, 18 (4), 529–554. https://doi.org/10.1093/jae/ejp002
Yazachew Genet et al.: Performance Evaluation of Tef Varieties for Yield and Yield Related Traits in Traditional and Non-traditional Growing Areas Under Irrigation Production in Ethiopia

[8] Felix M. (2018) the impact of climate change on tef production in southeast Tigray, Ethiopia. Journal of Agricultural Economics and rural development. Vol 4 (1), pp. 389-396, ISSN 2167-0477.

[9] Gomez, K. A., and A. A. Gomez. (1984). Statistical Procedures for Agricultural Research. 2nd ed., John Wiley and Sons Inc., New York, USA.

[10] Hartley HO (1950). The maximum F–ratio as a short cut test for heterogeneity of variances. Biometrika 37: 308-312.

[11] Matthew Davidson, J. Evaluating teff Grass as Summer Forage; College of Agriculture Manhattan: Kansas, NY, USA, 2018.

[12] Miller, D. Teff Grass: Crop Overview and Forage Production Guide; Cal/West Seed Company: Woodland, CA, USA, 2010.

[13] SAS Institute (2002). SAS/STAT guide for personal computers, version 9.00 edition. SAS Institute Inc., Cary, NC.

[14] Saturni L., Ferretti G. and Bacchetti T. (2010). The gluten-free diet: safety and nutritional quality. Nutri. 2: 16-34 1748–1749. https://doi.org/10.1056/NEJMct051492

[15] Shiran B., Onn R., Valerie O., Assaf C., Nitsen G., Yarden G., Yeshoshua S. (202). Lessis more: lower sowing rate of irrigated tef (Eragrostis tef) alters plant morphology and reduce lodging. Agronomy, 10, 570; doi:10.3390/agronomy10040570.

[16] Takele, A. (2001). Canopy temperatures and excised leaf water loss of tef [Eragrostis tef (Zucc.) Trotter] cultivars under water deficit conditions at anthesis. Acta Agronomica Hungarica, 49 (2), 109–117. https://doi.org/10.1556/AAgr.49.2001.2.1

[17] Tsion Fikre, Yazachew Genet, Worku Kebede, Kidist Tolossa, Solomon Chanyalew, Mengistu Demissie, Kebebew Assefa, Atinkut Fentahun, Esuyawkal Demis, Tadiyos Bayisa, Zerihun Tadele. 2020. Yield and Agronomic Performance of Selected Semi-dwarf Tef (Eragrostis tef (Zucc.) Trotter) Genotypes under Irrigation Farming System in Ethiopia. American Journal of Plant Biology. Vol. 5, No. 4, 2020, pp. 112-121. doi: 10.11648/j.aplb.20200504.16.

[18] Worku Kebede, Yazachew Genet, Tsion Fikre, Kidist Tolosa, Solomon Chanyalew, Mengistu Demissie, Kebebew Assefa, Kidu G/Meskel, Atinkut Fantahun and Zerihun Tadele. 2020. Tef (Eragrostis tef) variety development for moisture stress areas of Ethiopia. Journal of Innovative Agriculture: 7 (4): 1-6, 2020. DOI: 10.37446/jinagri/7.4.2020.1-6.

[19] Yazachew G, Solomon Ch, Tsion F, Worku K, Kidist T, Mengistu D, Kebebew A and Habte J. 2021. Genotype by Environment Interaction and grain yield stability analysis of advance tef genotypes for high potential tef growing areas of Ethiopia. J Adv plant Sci 3: 204.

[20] Yazachew Genet, Tsion Fikre, Worku Kebede, Solomon Chanyalew, Kidist Tolosa, Kebebew Assefa. 2020. Performance of Selected Tef Genotype for High Potential Areas of Ethiopia. Ecology and Evolutionary Biology. Vol. 5, No. 3, 2020, pp. 35-42. doi: 10.11648/j.eeb.20200503.11.