

Adaptation of Tef {Eragrostistef(Zucc) Trotter} Varieties for Early Maturing Types in Tigray

Chekole Nigus¹, Yonas G/Mariam¹, Muez Mehari² & Haftamu H/kiross¹

¹ Tigari Agricultural Research Institute, Axum Agricultural Research center, Axum, Ethiopia

² Tigari Agricultural Research Institute, Alamata Agricultural Research center, Ethiopia

Correspondence: Chekole Nigus, Tigari Agricultural Research Institute, Axum Agricultural Research center, P. O. Box. 230, Axum, Ethiopia. E-mail: chekolenigus@gmail.com

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Abstract

Tef is the most important and wider adaptable cereal crop in Ethiopia. The most limiting tef productions are low yielding cultivars, biotic such as pest and diseases and abiotic such as drought, fertility depletion and inappropriate agronomic practice and difficulty nature of tef for mechanization. The objective of the study was to evaluate the adaptability of early maturing tef varieties. Tef varieties were evaluated for their earliness and adaptability at three locations and over two years. The trial included 8 varieties and one local check with the design of RCBD in three replications. The analysis of variance showed that there was significant difference ($P < 0.001$) between genotypes and locations for the days to heading, days to maturity, plant height, panicle length, grain yield and ($P < 0.05$) for biomass yield. However, it does not provide evidence for interaction between the varieties and locations on all traits except for days to maturity. Simada was early maturing and well performing, following Boset. Therefore, cultivation of both varieties enhances the production of tef in the study areas and similar agro-ecologies. Allocation of varieties to their niche might increase the productivity of tef. In general, evaluation tef varieties in the right place and development of target variety for earliness and yield performance increase production in the region as well as the nation. Further work needed breeding to develop drought tolerant and higher yielding.

Keywords: Adaptation, erratic rainfall, Early maturing and Tef

1. Introduction

Tef is the most important and wider adaptable cereal crop in Ethiopia. Tef is grown by more than 6.8 million households (CAS, 2018) with growing season rainfall of 450-550 mm (Ketema, 1993). It grows in various agro climatic condition from sea level to 3000meter above sea level and different types of edaphic factors thus from light sandy to heavy clay soil in variable fertility(Kebebew,2003). Tef has an advantage over the other cereal by generating and fulfilling nutritional needs (Assefa et al., 2015) and it is healthy food due to the grain is free of gluten (SpaenijDekking *et al.*, 2005). The major features of the crop are resilience to drought and waterlogging problems, serves as a low-risk crop to replace long-maturing crops such as maize and sorghum, and no serious threats of pest and disease (Assefa et al., 2015). As result, the research institutes in Ethiopian needed to increase the productivity of tef per unit area.

There are different types of tef production constraints in the nation. The most limiting tef productions are low yielding cultivars, biotic stress such as pest and diseases and abiotic stress drought (Assefa et al., 2011), fertility depletion and inappropriate agronomic practice (tef needs well prepared land for planting) and difficulty nature of tef for mechanization. The most yield-limiting factor is drought and it causes to reduce the yield 29 % (Mizan,2017), 40 % (Mulu, 1993) and 77% (Abuhay, 2001). Even though, the production areas is the higher coverage, but the productivity is very low in nationwide and as well as in the Tigray region, 17.50qt/ha and 16qt/ha (CAS, 2019), respectively. The constraint being lower yielding cultivars are selection and development of tef variety is not appropriate niche and inadequate enhancement of yield. Therefore, identifying the right bottleneck of tef production leads to provide a solution.

The wider adaptability of tef under different agro ecology is the reason why tef selective crop in nation and the region. Different authors reported that there is a statistically significance difference in phenological and yield and yield related traits of tef varieties/genotypes (Seyfu, 1993; Molla et al.,2012; Aliyi et al., 2016; Abebe and Wondwosen, 2017; Bakala et al., 2018). These authors determined the yield depends on the moisture availability for better yielding tef varieties. The most farmers selection criteria is higher yielding, early maturing and white

seed color(Molla et al.,2012). These works were evaluated different maturing tef varieties under different rainfall and humidity condition. We evaluated early maturing tef varieties under light and moisture stressed areas of the region.

Selection of tef varieties with wider adaptable through early maturity and higher yielding in biomass and yield is the criteria in stressed areas. Adaptation is the survival value of an organism for its habitat (Wilsie, 1962). The adaptable for various factors might be expressed with different mechanism; these might be physiological by earliness and rolling their leaves escaped from deficit of moisture. Tef required days to physiological maturity from 60-140 days Assefa et al. (2001) this range is categorized in to three sets the first set is early set it ranges less than 80days and the intermediate also 80 to 95 days while the third group is late set more than 95 days(Tiruneh et al., 2000). As result, the broader genetic variability in maturity evaluation of early released tef varieties under moisture stressed areas leads to increase the production. Then, evaluation of the statistically significance difference for early maturing tef variety is important in advancing the yield.

Furthermore, providing improved tef variety for tef growing farmer's needs selection and evaluation of released tef varieties for adaptability. Farmers have a limitation in cultivating improved tef varieties, but also it grown under inappropriate niches. Even though the current production influenced by different factors and yielding 17.5qt/ha. However, the potential yield of tef is estimated more than 50 qt/ha as recorded per experimental plots (Tefera and Ketama, 2000). The purpose of the study was to evaluate tef varieties under moisture stress areas facing with early and late drought problems. Therefore, an evaluation of early maturing tef varieties for their adaptability can serve as an assessment of a mechanism to escape drought.

The main contribution of this paper is to provide a best performing early maturing tef varieties and thereby to increase the production of tef in the region. The objective of the study was to evaluate the adaptability of early maturing tef varieties in the study area.

2. Methodology

The experiment was conducted at Axum and Alamata Agricultural Research center during the 2017/18 and 2018/19 cropping season. Experiments venues were such that at the station of Ahiferom(dibdbo) with altitude of 2021masl, latitude 14°16'57.12'' and longitude 39°04'6.78'' while the soil texture is loam. Whereas, the second substation was adwa (mayteum) having an altitude of 1887masl, latitude of 14°9'4.64'' longitude, 38°50'57.24'' and loam soil texture. The third substation was Alamata(Kara-Adisho) altitude of 1550masl, latitude 12°40'48'', longitude 39°41'06'' the soil texture is loam.

There was a failure at Ahiferom in the first year 2017/18 the data were only from Adwa and Alamata, while for the second season data were collected from all sites. The materials were including one local check and 8 varieties to evaluate their yield performance and adaptability. The experiment was laid out as RCBD design with three replication and plot size of 2m x 2m = 4m² net harvestable plot size 3.2 m², 0.2m between rows, 0.5m between plots and 1m between replication spaced. Blended fertilizer was applied per the recommendation of the specific locations with rate of 100 kg/ha and while the urea was applied 100 kg/ha for all locations with split application. The first phase at early two weeks later after germination the second phase also applied near to heading of the crop. Whereas, all recommended agronomic management practice was applied.

The following data were collected:-day to heading, days to maturity, plant height, panicle length and biomass yield and grain yield. Days to heading and Days to maturity were measured from date of planting to 50% heading and 90% of physiological maturity respectively. Plant height measured from the ground to tip of the plant and panicle length was also from the base of the panicle to the tip of it. Whereas, the biomass yield and grain yield also weighed from the net harvestable plot area 3.2m² by hand threshing and converted to hectare.

The data was subjected to analysis of variance by SAS software of version 9.1.3 (SAS, 2004) for days to maturity and grain yield and while the remained traits were analyzed by R software (Pinheiro, and Bate, 2000). The normality and homogeneity of the data was tested by shapiro.test(Patrick Royston, 1982) and levenes.Test(Wilcox, 1989) respectively by R software.

Table 1. List of tef pedigree and common name varieties and release of year

S.no	Pedigree	Varieties	Year of released
1	(DZ-01-186 XDZ-01-566)T-4	Tseday	1984
2	DZ-01-196 X DZ-Cr-37	Boset	2012

3	DZ-01-2785 X E. Pilosa(305)1998	Simada	2009
4	Ho-Cr-136	Amarach	2006
5	DZ-01-146	Genet	2005
6	Acc. 205953	Macharie	2007
7	(DZ-Cr-387 RIL273)	Lakech	2009
8	(DZ-Cr-387 RIL127)	Gemechus	2007
9	Farmers cultivar	Local early	

3. Results and Discussion

The analysis of variance shown that the varieties were statistically significant differed for all traits. This indicates that there is variance in earliness for heading and maturity, difference ($P < 0.01$) and agronomic traits that is plant height and panicle length as well as higher and lower performance for biomass and grain yield of the tested tef varieties ($P < 0.05$) Table 3. Therefore, the presence of the statistically significance difference leads for the selection tef variety having an advantage of early maturing and higher yielding in the moisture limiting areas of the region.

In areas facing with moisture stress, cultivation of early heading and maturing tef varieties are important. In this research the shorter days to heading and days to maturity is Simada. Tef heading less than 39 days were grouped under the early heading category (Truneh et al., 2000). Confirming Tiruneh et al., reported Simada is the best variety for the production of tef in the study area. While, the longest days to heading and maturity is Lakech. Tef varieties headed and matured more than 44 days to heading and 90 days maturity are grouped in the late set (Truneh et al., 2000) which are not well adaptable for the study area. This causes to mature by forcing due to the early or late drought existing. In such condition, the grain filling is becoming influenced to be poor seed size and grain. The presence of variability between tef varieties helps for the choice early maturing and wider adaptable tef variety for the tested locations.

Determining the correlation of agronomic traits for the grain yield of tef variety is an important ways to select tef varieties. The study shows that there was significance difference between the varieties in agronomic traits. Macharie and Genet measured a longer plant height and panicle length respectively. The longer plant height did not have a direct correlation to a longer panicle length. Even the yield also not associated with longer plant height and panicle length (Table. 3). However, the shorter plant height and panicle length was recorded on Simada. Moreover, the shorter length on plant height and panicle has a direct relationship to be weight the higher grain yield (Table 3). In contrast, to the potential tef variety, evaluation, which is the longer panicle length, has the higher yield, but the shorter panicle length recorded the higher yield in this research. The finding noted that the combination of earlier days to maturity and shorter plant height is a good trait for selection of tef variety for moisture stressed areas. The report of Mzan et al., (2016) confirming with present finding in earliness has positively correlated with grain yield however, disagreed with this result longer plant height panicle length has lower yielding.

In small scale farming system higher in biomass and grain yield of tef, varieties are required. The evaluated tef varieties were statistically significance difference with local check in biomass and grain yield. Boset was the higher biomass whereas; the lower biomass was obtained from Simada. Farmers, which are practicing the mixing farming system highly needs both biological yield and grain yield of tef variety. Thus, tef straw is the favorable feed for livestock's in this farming system. The higher yielding tef variety from the evaluated for their adaptability was Simada following by Boset. Simada shows statistically significance difference in grain yield with local check and the higher yield of the tested tef varieties. The yield advantage of Simada over the local check was 18.80%. This might be due to presence of drought adaptation mechanism which is drought escaping, the variety matured before the drought occurred (Zerihun, 2016). Therefore, cultivation of Simada and Boset under the tested areas enhance the yield in both providing the food for human and feed for animals.

Understanding the influence of varieties, location and their interaction between location and varieties on tef grain yield and adaptability is so vital. Tef varieties shows that a statistically significance difference on performance of the yield. This might be due to the phenologically variance in days to heading and maturity. The earlier the variety was the higher yielding in the tested locations. Except the days to maturity, not all traits had shown statistically

significance difference variety by locations interaction (VLI). Worku, (2018) proved out that days to maturity had a genotype by location interaction that the other traits. Moreover, locations were shown significantly differ for all measured traits. Even though there is difference in locations the variety by location, interaction did not demonstrate statistically significant difference, thus the average mean performance would be selected for the tested areas and similar agro-ecologies. The absence of variety by location interaction in grain yield indicated that varieties did not a differently response at different locations (Eberhart and Russel, 1966) and it has wider adaptability capacity in yield. So it makes easy to give a general recommendation of cultivars without loss of maximum yield (Cruz and Castodi, 1991). Therefore, varieties were selected by their average mean yield of location and season. As a result, of the present finding early maturing and well performing in biomass and grain yield of tef varieties were *Simada and Boset*.

Moreover, location difference implies that the genotypes were exposed to diversified growth condition to evaluate their performance and stability. Kassa et al. (2006) reported that there is a presence of variability between tef genotypes and location tested. The significance interaction of varieties and location on days to maturity revealed that it might be due to the variability of rainfall over the tested locations and seasons. This difference of rainfall forced fluctuation of the maturity of varieties on the different environments (Table. 3). Then, selection early heading and maturing with combined of higher biomass and grain yield enhance the production of tef in moisture stress areas.

In addition to this, the response of tef varieties per different locations varies in phenologically and yield and yield related traits (Table.2). The minimum yield of nine varieties over the tested location was record from *Lakech* (1084kg/ha) at Ahiferom. The reason why this variety was low yield might be the days to heading of that variety was very late than the others. As result, in moisture limiting and fertility depleted areas late heading varieties are faced a problem of maturing/grain filling in the right time and then become lower yielding. Whereas, the maximum yield also obtained at Alamata(2242.77kg/ha) from *Simada*. Whereas, *Boset* was expressed the performance on biomass and grain yield at Adwa while, *Buni*(local check) was earlier in maturity at Alamata (Table 2).

Table 1. The Combined mean performance of day to maturity and grain yield at three locations in two growing seasons (Ahiferom, Alamata and Adwa and 2017/18 and 2018)

S.no	Varieties	DH	DM	Ph	Pl	Biom	G Y(kg/ha)
1	Tseday	44.78f	84.733c	94.73de	35.84de	7083.33bc	1687.5cde
2	Boset	50.44cd	84.60c	103.47bc	36.64cde	8333.33a	1945.8ab
3	Simada	38.56g	81.66e	89.18e	34.8e	6875c	2074.4a
4	Amarach	47.44e	83.80cd	100.33cd	35.89de	7083.33bc	1822.9abcd
5	Genet	52.11bc	89.53b	108.49ab	44.067a	7083.33bc	1433.2e
6	Macharie	51.33c	88.60b	111.267a	43.64a	6875c	1621.3de
7	Lakech	56.87a	91.40a	109.02ab	39.6b	8055.56ab	1880.5abc
8	Gemechus	53.89b	88.20b	105.93abc	39.156bc	7638.89abc	1737.2bcd
9	Local early	49de	82.60de	104.02bc	38.64bcd	7291.67bc	1746.2bcd
	Grand mean	49.29	86.125	102.9	38.7	7369	1772.092
	CV%	4.56832	2.84342	5.805	7.7704	14.4362	19.80623
	R-square	0.8725	0.9503	0.497973	0.417	0.6615	0.74806
	Location	*	***	***	**	**	***
	Varieties	2.1****	1.7796***	5.65***	2.84***	1006.27*	255.05***
	Location X Varieties	Ns	***	Ns	Ns	Ns	ns

DH(days)=days to heading, PH(cm)=plant height, PL(cm)=panicle length, Biom(kg/ha)=biomass yield, DM(days)=days to maturity and GY(kg/ha)=grain yield, ns=non significance difference, * and*** signfi difference at P<-0.05 and P<-0.001 value

Table 2. The combined mean performance of days to heading (days), days to maturity (days), plant height (cm), panicle length (cm), biomass (kg/ha) and grain yield (kg/ha) for Adwa, Ahiferom and Alamata in 2017/18 and 2018/19. NB:-for days heading, plant height, panicle length and biomass did not include from Alamata for both year and Ahiferom also missed from 2017/18 for traits

s.no	Varieties	Adwa	Ahiferom	Adwa	Ahiferom	Adwa	Ahiferom	Adwa	Ahiferom	Adwa	Ahiferom	Alamata	Adwa	Ahiferom	Alamata
		DH	DH	PH	PH	PL	PL	Biom	Biom	DM	DM	DM	GY	GY	GY
1	Tseday	44.83	44.67	95.33	93.53	36.67	34.2	6354.17	8541.67	82.83	79	89.5	1744.58	1285.52	1831.38
2	Boset	51	49.33	105.1	100.13	36.5	36.93	7916.67	9166.67	86	81	85	2208.59	1224.06	2043.92
3	Simada	39.5	36.67	91.97	83.6	35.9	32.6	6250	8125	78.67	79	86	2016.3	1853.65	2242.77
4	Amarach	47.83	46.67	102.43	96.13	36.2	35.27	6979.17	7291.67	83.33	80.33	86	2097.45	1300.94	1809.25
5	Genet	51.5	53.33	111.37	102.73	44.03	44.13	6979.17	7291.67	90.33	85.33	90.83	1751.25	911.98	1375.67
6	Macharie	53.17	47.67	113.4	107	45.5	39.93	6458.33	7708.33	89.83	84.33	89.5	1927.4	1202.08	1524.73
7	Lakech	56.75	57	112.2	102.67	41.63	35.53	7395.83	9375	90.67	89.67	93	1848.7	1084.58	2118.52
8	Gemechus	53.83	54	109.8	98.2	40.4	36.67	6666.67	9583.33	87.83	84	91	1798.65	1263.44	1668.17
9	Local early	49.83	47.33	105.27	101.53	38.27	39.4	6562.5	8750	85	80	81.5	1816.35	1127.81	1877.04

4. Summary and Conclusions

Cultivation of early maturing and wider adaptable tef varieties are helpful to minimize a yield gap due to the presence of erratic rainfall in the study area. Allocation of variety at their right niche and application of appropriate agronomic practice might increase the productivity of tef. We recommend that from the present research finding *Simada* and *Boset* with appropriate agronomic practice for the tested and other similar agro-ecologies. Further work needed breeding to develop drought tolerant and higher yielding.

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