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Performance evaluation and adaptation trial of Tef genotypes for moisture stress areas of Borana, Southern Oromia

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Abstract

Tef is one of the most important staple food crop in Ethiopia cultivated throughout the country. The field experiment was conducted at Yabello pastoral and dry land agricultural research center main site for three consecutive years. The experimental materials were brought from Debre-Zeit Agricultural Research center and planted with one local check in randomized complete block design (RCBD).The result of analysis revealed significant differences among genotypes in grain yield and biomass for all year under study. Tsedey was performed than other genotypes in 2011 cropping season in which low rainfall was recorded for the study area. Magna was performing well in study area relative to other genotypes in all cropping seasons except 2011 cropping season.

Keywords: Adaptation, grain yield, local check, moisture stress, variety.

Introduction

Tef (*Eragrostis tef* (Zucc.) Trotter) ($2n=4x=40$) is classified under *poaceae* family and *Eragrostis* genus. Tef is an annual cereal crop most widely grown over broad environmental conditions. Its owes its center of origin and diversity in Ethiopia and is widely cultivated throughout the country as a staple food crop[1]. The harvested caryopsis is chiefly used for preparing "injera" (a flat, circular and very soft bread), porridge, and sometimes alcoholic drinks. The bread made of tef flour, "injera", is the mainstay of the Ethiopian diet[2,3]. The nutrient construction of tef grain has high potential to be used in foods and beverages worldwide[4]. Tef annually occupies over 29% of the entire field and contributes approximately 19.33% of the gross grain output of all cereals in Ethiopia[5]. The production area of tef is increasing in extraordinary scale due to increased market demand, higher nutritional value, low incidence of damage by insects, better adaptation to drought and high value of straw[6].

The performance of one genotypediffer significantly from environment to environment[2,7]. Tef performs in different environments differently. Genetically, tef is malleable to a wide range of environmental conditions and even under unfavorable environmental condition. It can be grown at altitudes ranging from near sea level to 3000mas, but it performs well between 1100 and 2950 masl[8]. Despite its adaptability to different environmental conditions, the average national yield (1.5tone per hectare) is below the potential yield of tef[9]. In moisture stress areas of southern Oromia, the yield of tef is by far below the average national yield, which may be due to lack of improved varieties, non-adoption of improved technologies, disease and pests are some of the most serious production constraints. Currently different varieties of tef have been released from the regional and Ethiopian Agricultural Research Institutes[10]. Even though some varieties of tef have been released in Ethiopia, most of them were not evaluated around moisture stress areas of southern Oromia. So the following experiment is objected to evaluate and recommend best performed tef genotypes with better performance and adaptability for the tef growers of moisture stress areas of Southern Oromia.

Materials and methods

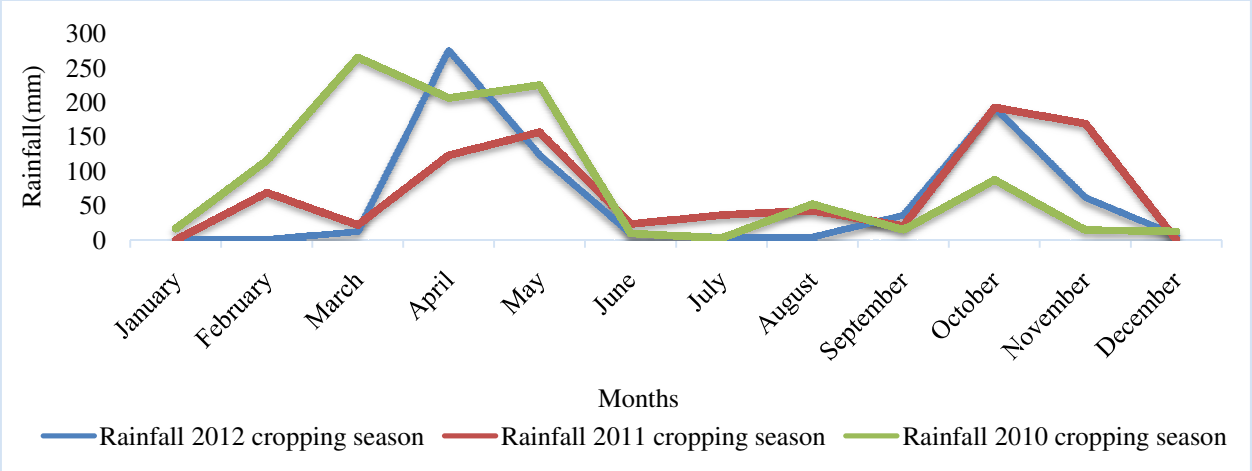
Description of study area: The experiment was done at yabello pastoral and dry land agricultural research center on station for three consecutive main cropping seasons from 2010 and 2012. Yabello is found 563km from Addis Ababa to southern direction. Yabello is situated at 04°52'49" and 038°08'55" latitude and longitude, respectively, at an altitude of 1635 masl. The soil of study area is characterized by well-drained sandy loam (46% sand, 36% silt and 18% clay), with a pH of 7.03. It has 0.026% total nitrogen, 15.36 ppm Phosphorus and 20.4 meq of/100gm soil CEC.

The total annual rainfall in 2010, 2011 and 2012 was 1019.1mm, 851.6mm and 719.0 mm respectively (Figure -1). The average temperature in 2010, 2011 and 2012 was 21.5°C, 19.3°C and 20.6°C respectively (Figure-2). The most commonly cultivated crops in its surrounding area has been maize (*Zea mays* L.), haricot bean (*Phaseolus vulgaris* L.), tef (*Eragrostis tef* (Zucc.) Trotter) and wheat (*Triticum aestivum*). Maize and haricot bean were the predominant crops and staple food crops in Borana.

Experimental design and materials: Nine improved tef varieties were brought from Debre zeit Agricultural Research Center (Table-1). A total of ten varieties including local check were put into trial in RCBD with three replications at Yabello pastoral and dryland agricultural research center main site from 2010 to 2012 cropping seasons. Each variety was planted in plot area of $12m^2$ 3m*4m of land in hand broadcast method. All agronomic practices were equally performed for all varieties as per recommendation to ensure normal plant growth and development.

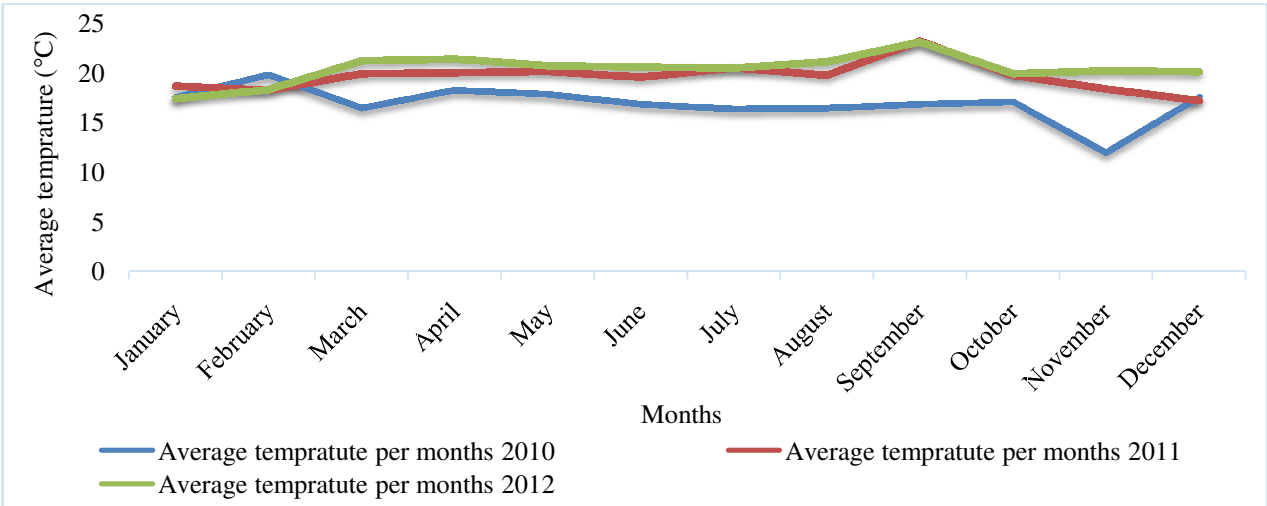
Data collection: i. Days to heading: the number of days from 50% of the plots showing emergence of seedlings up to the emergence of the tips of the panicles from the flag leaf sheath in 50% of the plot stands, ii. Days to maturity: the number of days from emergence up to 50% of the plants in the plot reaching phonological maturity stage (as evidenced by an eyeball judgment of the plant stands when the color is changed from green to color of straw, iii. Plant height (cm): measured as the distance from the base of the stem of the main tiller to the tip of the panicle when physiological maturity attained, iv. Panicle length (cm): the length from the node where the first panicle branch starts up to the tip of the main panicle at maturity, v. Number of fertile tillers per plant: the number of panicle-bearing (fertile) tillers produced per plant, vi. Total biomass (g): the weight of all the harvestable area including tillers harvested at the level of the ground. vii. Grain yield (g): the weight of grain yield for all the harvestable area of plot, viii. Harvest Index (HI): the value computed as the ratio of grain yield to the total (grain plus straw) biomass.

Data analysis: All data were subjected to analysis of variance (ANOVA) as suggested by Kwanchai A.G. et.al.[12] using SAS software (Version 9.0). Mean separations were carried out using least significant difference (LSD) at ($p<0.05$).



Source: Yabello Pastoral and Dryland Agricultural Research Center meteorology station (unpublished data)

Figure-1: Rainfall distribution of Yabello from 2010 to 2012



Source: Yabello Pastoral and Dryland Agricultural Research Center meteorology station (unpublished data)

Figure-2: Average temperature of Yabello from 2010 to 2012.

Table-1: Lists and descriptions of experimental materials[11].

Varieties	Year of release	Area of adaptation		Maturity date	Yield (t/ha)		Seed color
		Altitude (masl)	Rainfall (mm)		On research site	On farmers field	
Manga	1978	1800-2500	600-1200	80-113	18-22	14-16	Pale white
Tsedey	1984	1800-2700	500-1200	82-90	18-28	14-19	White
Gerado	2002	1450-1850	600-900	73-95	22	10-17	White
Key-tena	2002	1600-1900	300-500	84-93	25	16-19	Darkbrown
Ajora-1	2004	1600-2200		85-110	18	11	
Genete	2005	-	-	-	-	-	White
Zobel	2005	-	-	-	-	-	White
Gemechis	2007	-	-	-	-	-	-
Simada	2009	Low to mid	300-700	88	16	10	white

Results and discussion

Analysis of variance showed a significant difference among tef varieties at ($p<0.05$), for days to maturity, biomass and grain yield for all cropping seasons (Table-2). Fentie M. et al.[13] and Chondie Y.G. et al[14] were reported considerable variation in the days to maturity, plant height, spike length and grain yield of different Tef varieties when planted over years.

In days to heading, significant difference was observed in 2011 and 2012 cropping seasons (Table-2). Early flowering was recorded for Tsedey (25.33 days) in both seasons while local check (45days) was flowered later than all varieties. Kwanchai A.G. et. al.[12], Chondie Y.G. et.al[14] and Plaza S. et al.[15] also reported significant differences among the tested varieties for days to heading.

Days to maturity: Significant difference was observed among genotypes in all cropping seasons in days to maturity. Tsedey (79.67days) was matured earlier than all other varieties under study while local check (95.67) was late matured than all other varieties. In line with the current finding, Plaza S. et al.[15] observed significant difference among genotypes in days to maturity.

Productive tillers: Analysis of variance showed significant difference among varieties in productive tillers in 2010 and 2011 cropping seasons. Maximum numbers of productive tillers were recorded for Magna (4.00) followed by Tsedey (3.67) while the minimum numbers of productive tillers were observed for local check (1.00). A similar result was reported by Aliyi K. et al.[16].

Panicle length: Significant differences among varieties were observed only in the 2012 cropping season. The longest spike length was recorded for Magna (44.67cm) while the lowest spike length was recorded for Key-tena (20.23cm) (table 2). Chondie Y.G. et al.[14] and Aliyi K. et al.[16] reported significant panicle length among different tef varieties.

Plant height: Analysis of variance showed a significant difference among tef varieties under study in 2010 and 2011 cropping seasons. The longest variety was Magna (99.80cm) followed by local check (99.20cm) while the shortest variety was Tsedey (52.13cm) (Table-2). The longest variety is susceptible to lodging while the shortest variety is resistant to lodging. Chondie Y.G. et al.[14] and Aliyi K. et al.[16] reported significant plant height among different tef varieties. In contrast to current finding, Kwanchai A.G. et al.[12] reported non-significant difference among tef varieties over years in plant height.

Biomass: Analysis of variance showed significant difference among varieties under study overall years (Table-2). The highest biomass was recorded for Magna (9.67t/ha) followed by local check (8.50t/ha). The lowest biomass was recorded for Simada (2.63t/ha).

Grain yield: Significant differences were observed for tef varieties under study in grain yield ($p<0.001$). The highest grain yield was recorded for Magna (2.03t/ha) followed by Local (check) and Tsedey (1.79t/ha) in 2010 cropping season. In the 2010 cropping season there was relatively high rainfall distribution. In 2011 and 2012 cropping seasons, there was lower rainfall distribution in the study area, in these seasons Tsedey yield higher grain yield (1.34t/ha) and (1.57t/ha) 2011 and 2012 cropping seasons respectively. The lowest grain yield was recorded for Key-tena (0.57t/ha) across all locations. Fentie M. et al.[13], Chondie Y.G. et al.[14] and Aliyi K. et al.[16] reported significant grain yield among different tef varieties.

Harvest Index: Significant differences were observed for in harvest index ($p<0.05$) in both 2011 and 2012 cropping seasons (Table-2). The harvest index of tef is very low compared to other cereal crops, implying that the total grain yield is very low compared to biomass or straw yield. The highest harvest index was recorded for Tsedey (23%) while the lowest harvest index was recorded for Key-tena and Zobel (16%) (Table-2) in 2010 cropping season. In 2011 cropping season the highest harvest index was recorded for Tsedey and Ajord-1 (0.27). In 2012 cropping season the highest harvest index was recorded for Key-tena (39%). Generally, the total harvest index calculated for 2012 cropping season was greater than that of 2010 and 2011 cropping seasons. This should be due to the difference of rainfall distribution among seasons.

Table-2: Mean performance of Phenological, grain yield and grain yield related traits of tef varieties evaluated at Yabello in 2010, 2011 and 2012 cropping seasons

Varieties	Dh (days)	Dm (days)	PT (no)	PL (cm)	PH (cm)	Bm (t/ha)	Yld (t/ha)	HI (%)
2010 cropping season								
Gerado	43.67b	91.00a	3.00a-c	35.80b	91.13ab	6.33bc	1.54bc	20ab
Gemechis	44b	90.67a	2.67b-d	35.80b	93.40ab	5.58bc	1.40c	20ab
Ajora-1	41.00b	95.00a	2.67b-d	36.20b	95.60ab	6.00bc	1.55bc	21ab
Local (check)	50a	95.67a	3.00a-c	36.13b	99.20a	8.50ab	1.79ab	18ab
Genete	43.67b	95.33a	1.67d	38.13b	95.80ab	7.83ab	1.50bc	17b
Zobel	43.33b	91.67a	2.00cd	36.67b	86.47ab	8.42ab	1.64bc	16b
Manga	43.33b	94.67a	4.00a	44.67a	99.80a	9.67a	2.03a	21ab
Tsedey	42.33b	79.00b	3.67ab	37.13b	97.33ab	7.75ab	1.79ab	23a
Key-tena	42.33b	95.00a	2.67b-d	36.87b	97.13ab	4.50c	0.89d	16b
Simada	40.67b	94.33a	3.00a-c	32.07b	82.60b	5.90bc	1.77ab	23a
LSD	5.51ns	8.78*	1.28*	6.48ns	15.78*	2.96*	0.34***	6ns
CV	18.23	8.95	9.68	10.22	9.80	24.50	10.2	17.13
2011 cropping season								
Gerado	34.33ab	83.67c	2.00bc	20.27a	52.53d	4.03bc	1.15b-d	22b
Gemechis	31.67b	79.00d	1.67b-d	21.27a	59.80bc	3.93bc	1.05d	21bc
Ajora-1	35.67a	83.00c	2.33ab	23.20a	58.40c	3.13de	1.13cd	27a
Local (check)	35.00a	95.33a	1.00d	23.60a	63.27ab	5.07a	0.76ef	13d
Genete	31.67b	90.00b	3.00a	22.40a	56.23cd	4.33b	1.28ab	20bc
Zobel	35.00a	82.33c	2.00bc	20.73a	5767c	2.60e	0.68fg	21bc
Manga	33.67ab	85.00c	2.33ab	26.07a	64.40a	5.17a	1.26a-c	23b
Tsedey	25.33c	84.33e	1.33cd	23.93a	52.13d	3.53cd	1.34a	27a
Key-tena	33.00ab	78.00d	2.33ab	20.23a	60.20a-c	4.27b	0.57g	12d
Simada	34.00ab	83.33c	2.33ab	20.93a	57.67c	3.70b-d	0.83e	18c

Varieties	Dh (days)	Dm (days)	PT (no)	PL (cm)	PH (cm)	Bm (t/ha)	Yld (t/ha)	HI (%)
LSD	3.30***	2.74***	0.80**	6.47ns	4.28***	***	0.15***	3***
CV	5.84	2.18	22.99	16.93	5.17	2.18	8.80	8.92
2012 cropping season								
Gerado	35.00b	79.67d	1.67ab	27.73de	63.80ab	3.08c	1.30cd	34ab
Gemechis	36.67b	82.67c	1.67ab	25.07ef	60.80a	3.07c	1.47ab	32a-c
Ajora-1	35.67b	79.98d	1.33b	31.93a-c	66.67ab	2.75c	1.38bc	35a
Local (check)	45.00a	90.67b	2.00ab	22.33f	68.07a	3.70c	0.94e	20de
Genete	35.00b	85.00c	2.33a	30.07cd	63.47ab	3.78bc	1.36bc	23b-e
Zobel	36.67b	88.33b	1.67ab	30.00cd	68.73a	4.92ab	1.22cd	21c-e
Manga	36.00b	94.00a	2.33a	34.00a	66.60ab	5.75a	1.33b-d	18e
Tsedey	35.00b	79.67d	1.67ab	31.00bc	81.80a	2.83c	1.57a	36a
Key-tena	35.00b	79.97d	2.33a	32.2a	66.60ab	2.92c	1.31b-d	39a
Simada	37.00b	88.67b	1.33b	33.07ab	55.67b	2.62c	1.17d	31a-d
LSD	2.54***	2.78***	0.98ns	2.98***	11.52ns	1.18**	0.17***	12**
CV	4.04	2.17	25.45	5.83	14.56	14.48	7.47	23.67

Means with the same letter are not significantly different, ***=significant at (P<0.001), **=significant at (p<0.01), *=significant at (p<0.05) and ns=non-significant, Dh=days to heading, Dm=days to maturity, PT=number of productive tillers, PL=pedicel length, PH=plant height, Bm=biomass, Yld=grain yield, HI=harvest index, LSD=least significant difference, CV=coefficient of variance.

Conclusion

Analysis of variance showed significant different for all year in biomass and grain yield. From the result different teff varieties interact to the study area differently. Based on days to maturity Tsedey (79.67days) was earlier than other varieties but, relatively higher grain yield. Local check (95.67days) was late matured than all other varieties but relatively low yielder. The performance of magna was good under well rainfall distribution while Tsedey performed better in low rainfall distribution season. The result of the study revealed, recommendation of varieties is depending on rainfall distribution of study area. Based on rainfall forecast of national metrological agency of Ethiopia Tsedey is recommended for low rainfall distribution seasons (moisture stress) while Manga recommended for seasons relatively good rainfall distribution seasons.

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