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Participatory Evaluation and Selection of Recently Released *tef* [*Eragrostis tef (Zucc.)* Trotter] Varieties in Awi Zone, Western Ethiopia

Yaregal Damtie[1], Worku Kebede[2] and Taye Haile[1]*

[1]*Ethiopian Institute of Agricultural Research, Pawe Research Center, Ethiopia*

[2]*Ethiopian Institute of Agricultural Research, Debre-Zeit Agricultural Research Center, Ethiopia*

Abstract

Tef is honored and the main dietary food for health existence and food security in Ethiopia. It is adaptable to a wide range of environmental conditions; however its production and productivity varied across the environment. Therefore this experiment was conducted in the agro pastoral areas of Jawi District at Worqi Meda kebele in the 2020 main season at the agro pastorals field with the objectives to evaluate and recommend high yielding improved *tef* varieties, assess the agro pastoral selection measures for *tef* and select varieties to build agro-pastoralists' knowledge and skill of production and management of improved *tef* technologies through the target areas. It was comprised 13 varieties including local check in RCBD with 3 replications. The analysis of variance revealed significant differences between treatments except days to seedling emergency and total biomass. The highest mean grain yield was recorded for DZ-Cr-438 (RIL91A) (1056.7 kg ha^{-1}) followed by Areka-1 (945.0 kg ha^{-1}) while the lowest was local check (467.1 kg ha^{-1}). The agro-pastoralists' selection measures were days to maturity, biological and economical yield, seed color, lodging tolerance and field performance. Based on their selection criteria, agro-pastoralists preferred Dagiem and Areka-1 for grain yield, field performance and lodging tolerance while Dagiem for bio mass yield, Neguse, Ebba and Dagiem also for earliness. Hence, Dagiem and Areka-1 varieties were mainly preferred by the agro-pastoralists and also recommended to be further demonstrated and promoted through the agro pastoral areas to enhance their adoption of *tef* and increase its production.

Keywords

Genetic advance, Genotypic, Phenotypic, *tef* and yield

Introduction

Tef [*Eragrostis Tef (Zucc.)* Trotter, 2n = 4x = 40] is self-pollinated annually grown belongs under the *Poaceae* family and the genus of Eragrostis which is an imperative crop with its origin and center of diversity in Ethiopia [1]. It is the second most important among cereal crops in terms of production volume next to maize and the leading for production area coverage in Ethiopia [2]. Genetically, *tef* is adaptable to a wide range of environmental conditions however its production and productivity varied with the altitude range [3]. The performance of one genotype drastically varied from environment to environment [4,5]. *Tef* is a C_4 plant that has high chlorophyll a/b ratios and exploits CO_2 proficiently for the period of photosynthesis which is adapted 1100 to 2950 m.a.s.l in Ethiopia [6].

Tef has a very traditional value for injera making and has the highest privilege engaging gusts in most parts of Ethiopia. It is also used for the preparation of local food porridge and alcoholic drink in most rural communities of the country [7]. *Tef* is not only honored crop, but also the main dietary food for healthy existence and food security in most areas of Ethiopia [8]. The dietary value of *tef* grain is like to the conventional cereals and believed to have an excellent amino acid composition, lysine levels privileged than wheat and barley, while somewhat less than rice and oats. It is gluten free or contains very minute gluten and superior in several minerals mainly iron, now a days this makes popular in the health food in some developed countries.

Tef is highly produced in Amhara, Oromia, Tigray Regions

***Corresponding author:** Yaregal Damtie, Ethiopian Institute of Agricultural Research, Pawe Research Center, Ethiopia, PO Box No 25, Ethiopia, Tel: +251-9-13-34-49-12

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and Southern Nations and Nationalities with average grain yield of 1.79, 1.78, 1.54 and 1.49 t ha^{-1} respectively [9]. This report also indicated that in Amhara Region it is highly produced in diverse areas have cultural and economic values. In Awi zone *tef* is prominently valued by farmers and consumers for human food consumptions mainly injera making in addition to barley, peas, and potatoes along with its straw which is very indispensable for animal feed. The *tef* straw is not used only for animal fodder but also for house construction in mud like adhesive, so it is multipurpose crop. In this area it is the 4th mostly produced among cereals next to maize, finger millet and wheat with an average grain yield of 1.6 t ha^{-1}. Henceforward the production of *tef* varied from place to place at this zone mainly at Jawe District.

The living culture of the society in Jawi is agro pastoralist and *tef* is not common product in this area reasonably ignored crop due to several motives. The first motives of the society are cash crop dependent mainly sesame and soybean. From cereal crops sorghum is a very common while maize is rarely produced. The second reason is the attitude and understanding of farmers for *tef* production is very low. The third main problem is the research gap by itself and absence of adapted improved *tef* variety and technology promotion with the active farmers' participation stated as the major constrains for *tef* in the low land rather focusing in the mid and highland areas of evaluation and interventions. Subsequently, there is no accurate accreditation of agro pastoralist production on *tef* and *tef* partialities through agro pastoral did not addressed in Jawi, Ethiopia. These enforced us to evaluate the performance of released *tef* varieties and assess the agro pastoral selection perspective to improve *tef*. Therefore the objectives of this study were:

- To evaluate and recommend high yielding improved *tef* varieties through the target areas
- To assess the agro-pastoral selection measures for improved *tef* and select varieties through agro-pastoral participation
- To build agro-pastoralists' knowledge and skill of production and management of improved *tef* technologies

Materials and Methods

Description of the study area

This experiment was conducted at Jawi District in Worqi Meda Kebele at farmers' training center (FTC) in the 2020 main season. Jawi is one of the Districts in the Amhara Region of Ethiopia. It is enclosed on the West by the Benishangul-Gumuz Region, on the North by North Gondar Zone, East by West Gojjam Zone, and Southeast by Dangila. Worqi Meda is geographically located latitude 11°21′30"N and longitude 36°39′3″E with an altitude of 1308 masl. This area has unimodal with high rainfall pattern and the duration of main rainfall season starts in May and ends at the end of October. The soil type in the study area was Nitosol.

Experimental materials and design

The experiment comprised 13 released *tef* varieties including local check. The varieties were collected from Debre Zeit Agricultural Research Center (Table 1). Randomized complete block design (RCBD) with 3 replications was used. Each variety was planted using 20 cm inter row spacing and assigned at 4 m^2 plot size (2m × 2m) plot length and width for each.

Data collected

Days to 50% of seed emergency: The number of days take the seed to be emerged and cover 50% of the plot area, days to heading: The number of days from 50% of the plots showing

Table 1: Tef Varieties Used for Evaluation at Jawi (Worqi Meda) in the 2020 main cropping season.

Sr.No.	Pedigree Name	Genotype (Variety Name)	Maintainer	Owner
1.	DZ-Cr-438 (RIL91A)	Dagiem	DZ-ARC National *tef*	EIAR
2.	DZ-Cr-429	Neguse	DZ-ARC National *tef*	EIAR
3.	DZ-Cr-457	Tesfa	DZ-ARC National *tef*	EIAR
4.	DZ-Cr-442	Felagot	DZ-ARC National *tef*	EIAR
5.	DZ-Cr-419	Hiberande	DZ-ARC National *tef*	EIAR
6.	DZ-Cr-438 (RIL7	Abola	DZ-ARC National *tef*	EIAR
7.	Areka-1	Areka-1	DZ-ARC National *tef*	EIAR
8.	DZ-Cr-458 (RIL-18)	Ebba	DZ-ARC National *tef*	EIAR
9.	DZ-Cr-453(RIL-120B)	Bora	DZ-ARC National *tef*	EIAR
10.	DZ-Cr-429 (RII29)	Washara	DZ-ARC National *tef*	EIAR
11.	DZ-01-256-	Jitu	DZ-ARC National *tef*	EIAR
12.	DZ-Cr-428	Mena	DZ-ARC National *tef*	EIAR
13.	Local check	Local check	DZ-ARC National *tef*	EIAR

Source: DZ-Agricultural Research Center.

seedling emergence up to 50% of the plants in the plot flower, days to maturity: The number of days from 50% of the plots showing seedling emergence till to 50% of the plants in the plot success phonological maturity time evidenced via eye-ball decision of the plant take as the color is changed from green to color of white straw, plant height (cm) measured the length from the base of the stem of the main tiller to the tip of the panicle at the maturity stage, panicle length (cm) this was also measured from the node where the first panicle starts to branch till to the apex of the main panicle at maturity phase, total biomass (g) the weight of all the harvestable plot area including tillers harvested at the level of the ground then converted to kg ha^{-1} and grain yield (g) this was also weighed the grain yield for all the harvestable area of each plot and converted kg ha^{-1} in the analysis.

Results and Discussion

Agronomic and yield Performance of *Tef*

The collected data were summarized and subjected to the analysis of variance (ANOVA) via using SAS Software (Version 9.4). The mean separation was done using least Significant Difference (LSD) at 5% level of significance.

The analysis of variance showed a significant variation among evaluated *tef* varieties at ($p < 0.05$), for days to heading (DH) and grain yield (GYLD), and highly significant difference ($p < 0.01$) for days to maturity (DN), plant height (PH) and panicle length (PL) at the main cropping seasons (Table 2). Fentie, et al. [10], Yasin and Agedew [11] and Bakala, et al. [5] also reported considerable variation in the days to maturity, plant height, panicle length and grain yield of different *tef* varieties at the planted season.

Plant height: is a vital character to be considered during advancing lodging tolerant crops. It is the cumulative of Culm Length (CL) and Panicle Length (PL). The analysis of variance explained highly significant difference among varieties in the study of 2020 main cropping season. The longest variety was DZ-01-256- (Jitu) (132.3 cm) followed by DZ-Cr-438 (RIL91A) (Dagiem) (121.5 cm) whereas the shortest was the local check (103.5 cm) (Table 2). This investigation stated that the longest variety is liable to lodging leading low grain yield. Even though DZ-Cr-438 (RIL91A) (Dagiem) revealed the second largest in plant height, it was not lodged and provided better grain yield (1056.7 kg ha^{-1}). Hence this investigation also shown that DZ-01-256-(Jitu) is susceptible to lodging and provide low mean grain yield (594.2 kg ha^{-1}). This result agreed with previously reported by Plaza, et al. (2013) as Culm length and panicle length has a substantial role for developing lodging tolerant. On the contrary the shortest variety (local check) granted the lowest mean grain yield (467.1 kg ha^{-1}) due to the cumulative effect of genetic constituents of inheritable traits, shoofly and lodging problem. Panicle length: the result also revealed highly significant differences among varieties. The highest panicle length was recorded for DZ-Cr-453(RIL-120B) (Bora) (55.9 cm) while the shortest panicle length was recorded for DZ-Cr-442 (Felagot) (35.8 cm) (Table 2). Similar results were reported with this investigation by Aliyi, et al. [12]; Yasin and Agedew [11] and Bakala et al. [5] reported the presence of significant variation in plant height and panicle length among *tef* varieties. Comparing the mean grain yield of all varieties with DZ-Cr-438 (RIL91A) (Dagiem)**,** it was the first and showed highly significant difference among all varieties except DZ-Cr-429 (Neguse), Areka-1 and DZ-Cr-429 (RIl29) (Washara). Areka-1 and DZ-Cr-429 (Neguse) varieties were the second and third highest mean grain yield (945.0 and 878.8 kg ha-

Table 2: Combined mean yield and agronomic traits for tested tef varieties at Jawe District (Worqi medakebele) in the 2020 main season.

Verities	DSE	DH	DM	PH	PL	TBM	GYLD
DZ-Cr-438 (RIL91A) (Dagiem)	7.0a	50.7a-c	89.3c	121.5a-c	46.6a-d	7333.0a	1056.7a
DZ-Cr-429 (Neguse)	5.0a	46.3	89.3c	103.9c	42.1c-e	6167.0a	878.8a-c
DZ-Cr-457(Tesfa)	5.0a	49.3b-e	89.7c	104.1c	38.5de	5167.0a	657.9b-d
DZ-Cr-442 (Felagot)	7.0a	47.0de	89.0c	104.0c	35.8e	6167.0a	585.0cd
DZ-Cr-419 (Hiberande)	5.3a	50.3a-c	90.3a-c	120.7a-c	49.4a-c	7000.0a	705.0b-d
DZ-Cr-438 (RIL7)(Abola)	6.0a	52.7a	89.0c	114.1a-c	49.9a-c	5167.0a	558.8cd
Areka-1	6.0a	48.0c-e	90.0bc	102.9c	41.4c-e	5833.0a	945.0ab
DZ-Cr-458 (RIL-18) (Ebba)	7.0a	48.3c-e	89.0c	108.4bc	43.2b-e	5000.0a	700.0b-d
DZ-Cr-453(RIL-120B)(Bora)	5.3a	51.7ab	90.7a-c	126.2ab	55.9a	7000.0a	590.0cd
DZ-Cr-429 (RIl29) (Washara)	6.0a	50.0a-d	90.7a-c	118.8a-c	52.1ab	6167.0a	842.1a-c
DZ-01-256-(Jitu)	7.0a	49.7a-d	91.7ab	132.3a	52.4ab	6667.0a	594.2cd
DZ-Cr-428(Mena)	7.3a	49.0b-e	90.3a-c	116.5a-c	44.7b-e	7000.0a	776.3a-d
Local check	5.3a	48.7b-e	92.0a	103.5c	41.1c-e	5833.0a	467.1d
Mean	6.1	49.4	90.1	113.6	45.6	6192.3	719.7
CV (%)	22.1	4.0	1.1	8.5	7.9	23.5	27.2
LSD (0.05)	2.3	3.3	1.7	16.3	6.1	2449.1	330.5

NB: DH: Days to Heading; DSE: Days to Seed Emergency; PH: Plant Height (cm); PL: Panicle Length (cm); TBM: Total Biomass (kg ha^{-1}) and GYLD: Grain Yield (kg ha^{-1}).

^{1}) respectively while the lowest grain yield was recorded for local check (467.1 kg ha^{-1}). Fentie, et al. [10], Aliyi, et al. [12], Yasin and Agedew [11] and Bakala, et al. [5] also reported the existence of significant variation in the mean grain yield among different *tef* varieties Generally this yield result indicates that agro-pastoral areas of Awi Zone (Jawi District) have the probability of potential for *tef* production.

Agro-Pastoral preference on *Tef* varieties and evaluation methods

Even though agro-pastoralists have comprehensive indigenous knowledge and experience accrued over several years on their farming of oil crops and other cereals, they are not well familiar for *tef*. They didn't have any control treatment for comparison and arithmetical tools to examination the assumption they well identified their eco-friendly condition, crop, harvesting system, cropping calendar and have well standard experiences over their agricultural system. *Tef* has numerous odd structures which kind it a favorite crop among agro-pastoralists. Culturally and nutritionally *tef* is desired by farmers. Currently the production of sesame become decline due to various biotic stress and the need of other alternative crop like *tef* become the most ideal and staple food in the agro pastoralist in general and the claim for *tef* production. This study is also similar with reported by Kebede, et al. [13].

Farmers' selection measures were biomass yield, grain yield, seed color, maturity period (early to medium) and field performance. Based on their selection criteria agro pastoralists were preferred first DZ-Cr-438 (RIL91A) (Dagiem) among the verified *tef* varieties due to its high biomass and grain yield, seed color, early and lodging character tolerant. Secondly and similar selection criteria Areka-1 was favored by farmers due to its seed color, grain yield, field performance, high market sound. In general seed color, lodging tolerant, field performance, maturity date, biological yield and market value were the main agro pastoralist selection measures set in the main production season in the participatory varietal selection of *tef*. High Biomass and grain yield verities were the most preferred by agro-pastoralists due to its straw used for livestock fodder and the grain also used for household consumption and market value. DZ-Cr-438 (RIL91A) (Dagiem) and Areka-1 varieties were comparably good in the biomass and grain yield preferred by agro pastoralists in the study area as shown in the table (Table 3).

The agro-pastoralist was invited and visited the *tef* trial field at the two growth stages. Since the trial was conducted on the agro pastoralist field, this make easy for visiting and evaluating. The first simple observation was done before panicle initiation (at vegetative growth stage) while the second evolution and selection criteria was done near maturity stage (Figure 1). At this stage first they were round and observe the performance of all *tef* varieties and then started selection based on their evaluation measurement. Among the agro pastoral selection criteria set in the two growth stages, most selection criteria like lodging tolerance, total biological yield, grain yield and over all filed performance were coincide with the participatory varietal selection of *tef*.

Conclusion and Recommendation

Thirteen (13) varieties including local check were evaluated in the 2020 main cropping season at Jawi District (Worqi Meda Kebele) with the participation of agro pastoralists. All the above *tef* varieties were evaluated on the field at different phenological growth and agronomic traits like plant height, panicle length, lodging tolerance, biological and grain yield considered by the researchers as evaluation

Table 3: Varietal selection criteria and the average scores given by the agro pastoralists.

Variety	Agro pastoralist selection criteria						Total score	Average	Rank
	Earliness	Seed colour	Biomass yield	Grain yield	Field performance	Lodging tolerance			
Dagiem	4.5	4.5	5	5	5	5	29	4.8	1
Areka-1	4	4.5	4	5	5	5	27.5	4.6	2
Washara	4	4.5	4.5	4.5	4.5	4.5	26.5	4.4	3
Mena	4	4	4.5	4.5	4.5	4.5	26	4.3	4
Neguse	4.5	4	4	4	4.5	4	25	4.2	5
Ebba	4.5	4.5	3.5	4	4.5	3.5	24.5	4.1	6
Hiberande	4	4	4	3.5	3.5	3.5	22.5	3.8	7
Tesfa	4.5	4.5	3	3	3.5	3.5	22	3.7	8
Bora	4	4	3	3	3	3	20	3.3	9
Felagot	4.5	4	2.5	2.5	2.5	3	19	3.2	10
Jitu	3	4	3	2.5	2.5	2.5	17.5	2.9	11
Abola	4.5	4	2	2	2.5	2	17	2.8	12
Local check	2.5	3	2.5	2.5	2.5	2.5	15.5	2.6	13

NB: number of participant (n = 30) and the performance scale given for varietal selection was 1-5 scale (5 = excellent, 4 = very good, 3 = good, 2 = poor, 1= very poor).

Figure 1: Farmers' participation and selection measures in the *tef* trial field in 2020 main season.

measure. The result has shown substantial variations among the varieties. The highest mean grain yield was recorded for Dagiem (1056.7 kg ha^{-1}) followed by Areka-1 and Neguse varieties (945.0 and 878.8 kg ha^{-1}) second and third highest mean grain yield respectively while the lowest was recorded for local check (467.1 kg ha^{-1}). In plant height the longest variety was Jitu (132.3 cm) which was susceptible for lodging followed by DZ-Cr-438 Dagiem (121.5 cm) which was lodging tolerant whereas the shortest was the local check (103.5 cm). Agro-pastoralists' reaction valuation about the adaptability and performance of *tef* were evaluated. Agro-pastoralists' selection measures for *tef* varieties were number of days for maturity, seed colour, biological and grain yield, lodging tolerance and field performance. Based on their selection measure, agro pastoralists selected Dagiem and Areka-1 grain yield, field performance and lodging tolerance while Dagiem for bio mass yield, Neguse, Ebba and Dagiem also for earliness. Hence, the two varieties (Dagiem and Areka-1) were mainly preferred by the agro-pastoralists in the study area and also recommended to be further demonstrated and promoted through the agro-pastoral areas to enhance their adoption of *tef* and increase its production.

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