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Pre-Extension Demonstration of Newly Released Tef (*Eragrostis tef*) Technologies for Selected High Potential Districts of Oromia Region, Ethiopia

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Abstract: Tef (Eragrostis tef) is one of a crucial cereal crop for smallholder farmers in Ethiopia, providing essential food and nutrition security. Nonetheless, the productivity of tef grain is relatively low (1.94 tha^{-1}), resulting from the limited access to improved varieties by farmers and low adoption of recommended management practices. Hence, this activity was conducted to demonstrate and create awareness of improved tef varieties along with their management practices in six selected potential districts namely, Adea, Lume and Gimbichu districts of East Shewa zone, Gelan and Akaki Kality districts of Sheger city administration and Becho districts of South West Shewa zone of Oromia region. Bishoftu, the newly released variety, was demonstrated along with the standard checks (Eba and Dagim) varieties and the farmers practice during the 2022/23 main planting season. Yield data was collected and analyzed using descriptive statistics, while farmers' preference and feedback were evaluated using direct ranking and narration methods, respectively. The highest grain yield (25.5 qha^{-1}) was obtained from Bishoftu variety at Akaki kality district while the lowest mean grain yield (20.3 qha^{-1}) was recorded from Eba variety at Adea district of East Shewa zones of Oromia region. A mean grain yield increment of 0.2% to 21.6% was recorded from Bishoftu variety over the standard check Eba variety in all the demonstration sites. Similarly, Bishoftu variety was selected first followed by Dagim and Eba varieties in Adea, Gimbichu and Lume districts while Dagim variety was selected first followed by Bishoftu and Eba variety in the Gelan district of Sheger city administration of Oromia region. Therefore, the selected varieties should be scaled up in the target areas and other similar agro-ecological areas by involving all the concerned stakeholders such as the government sectors, non-governmental organizations and other private sectors at different levels.

Keywords: *Eragrostis tef,* Grain Yield, Pre-extension, Preference Ranking, *Tef* Variety

1. Introduction

Tef (*Eragrostis tef*) is the most important cereal crops of Ethiopia, covering approximately 29.3% of the total acreage and contributing to 19.3% of the overall grain production of all cereals. It is cultivated by more than 6.6 million smallholder farmer households and serves as the main staple food grain for over 50 million people in Ethiopia. [1].

Tef is indigenous to Ethiopia and has been cultivated for thousands of years in the Ethiopian highlands [2] and it has been an ingrained in the country's culinary tradition of making *injera (*a sour fermented pancake-like flatbread with a slightly spongy texture, traditionally made of tef flour) [3]. It is highly nutritious and contains high level of protein, fiber, and minerals such as iron and calcium [4, 5]. It is also a gluten free, making it an important food source for peoples with gluten intolerance [6-8]. Besides, it is also an important cash crop for smallholder farmers in Ethiopia, as it fetches the highest price of all cereals due to high local demand [9, 10]. Tef's straw, the main byproduct of its grain production, is an important component for livestock diet and considered the most valuable resource by the farming communities of

Ethiopia [11-13].

Despite the crucial significance of tef in the national food security, nutrition and income generation of smallholder farmers of Ethiopia, its productivity is relatively lower than other cereal crops. The national average grain yield of tef is about 1.9 tons per ha compared to 3.1, 4.2 and 2.5 tha^{-1} for wheat, maize and barely respectively Ethiopia [1, 14]. Besides, there is a significant yield gap between the on-station research grain yield potential which reaches 2.8 tha^{-1} [15] and the national average of farmers practice of 1.9 tha^{-1} [1]. The primary reasons for the low productivity of tef is mainly due to low access to technology/innovations such as improved varieties and agronomic management practices by farmers [3, 16].

Since the tef improvement was started in 1956/57 [11] up to the year 2021, over 54 improved tef varieties were released in Ethiopia by the National Agricultural Research System (NARS), which includes the Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Research Institutes (RARI) [17]. Efforts have also been made to transfer and promote these varieties to farmers in different areas of the country where tef is intensively grown using a variety of extension approaches such as, the pre-extension demonstration and popularization approaches [3].

Despite the progress in generating and transferring tef technologies, the adoption rate of these technologies remained low [3, 18], primarily because of limited location-specific recommendations, inadequate capacity to multiply source technologies and uncoordinated demand creation demonstration activities. In 2020, the Debre Zeit *tef* research program released a new variety known as Bishoftu variety for high potential areas, with a yield potential of 2.4-3.2 tha^{-1} at research station and 2.0-2.8 tha^{-1} at on farm station [3]. Thus, it is important to demonstrate this variety with its associated management practices for the farmers in the selected districts of Oromia region. The objectives of this study is to evaluate the yield performance of improved tef varieties along with their improved management practices under farmers' circumstances and to develop awareness and confidence of farmers and development agents on improved tef technologies in the study area.

2. Material and Methods

2.1. Description of the Study Areas

The study was conducted in purposively selected districts of East Shewa zone, Sheger City administration and South West Shewa zone of Oromia regional state during the 2022/23 main cropping season. Accordingly, the study districts were Adea, Lume and Gimbichu districts of East Shewa zone, Gelan and Akaki Kality district of Sheger city administration and Becho districts of South West Shewa zone of Oromia region. Selection of the districts was based on potentiality for teff production. These areas are generally characterized by a mixed crop-livestock farming system. Farmers predominantly cultivate staple crops, such as, tef, sorghum, maize, wheat, barley, potato, and fababean.

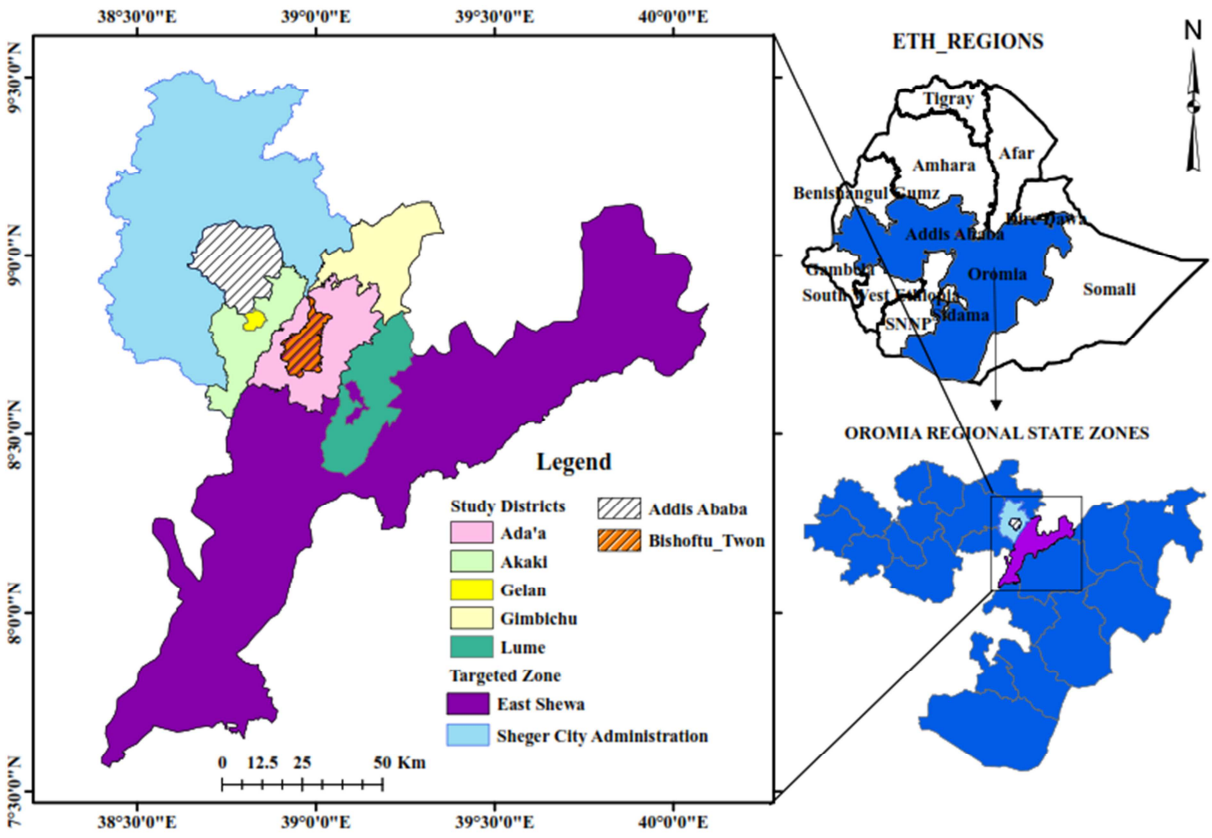

Figure 1. *Map of the study area.*

2.2. Site and Farmers' Selection

From each district, one representative *kebele* was selected based on the potential for tef production and accessibility for supervision in collaboration with development agents (DAs) and agricultural experts. Accordingly, a total of 6 *Kebeles* were selected as a demonstration sites of the varieties. From each *kebele*, 5 host farmers (30 farmers) were selected and directly involved for the activity. The selection of farmers was conducted based on the availability of suitable and sufficient land (0.125 ha per variety per head) to accomplish the trials, vicinity to roadsides, and willingness and interests of participation of farmers in the demonstration activity. Farmers were selected jointly by teams of researchers in collaboration with district agricultural development offices' experts assisted by kebele-based agricultural extension agents.

2.3. Implementation Design

2.3.1. Planting Materials and Inputs Used

Bishoftu, the newly released variety along with their full production packages was demonstrated with the standard checks (Eba and Dagim) varieties. The recommended amount of seed of the selected variety was delivered to the host farmers free of cost. Seed was broadcasted at the recommended rate of 15-20 $kgha^{-1}$and a fertilizer rate of 100 $kgha^{-1}$ Urea and NPS was applied respectively. All other agronomic practices, including ploughing, weeding, and plot management were applied based on the research recommendation.

Table 1. *Description of tef varieties used in the demonstration.*

Variety	Year of release	Altitude (masl)	Rainfall (mm)	Seed color	Days to mature	Grain yield (tha^{-1})	
						On station	On farm
Bishoftu	2020	1700-2500	700-1200	Very white	94-110	2.4-3.2	2.0-2.8
Eba	2019	1700-2500	700-1200	Very white	95-110	2.3-3.2	2.0-2.6
Dagim	2016	1700-2400	700-800	Very white	116-144	2.4-3.2	2.0-2.5

Source: (MoA, 2021)

2.3.2. Capacity Building Trainings

Training is key in technology transfer activities in general and for the pre-extension demonstration activity in particular as it enables the DAs and farmers introduce the new technologies and practices and show them how to implement it [19]. Thus, training was given for farmers, agricultural experts, and DAs on planting methods, input application, and general agronomic practices. Fields were managed by participant farmers as per the recommendations for all demonstration plots with close supervision of researchers and DAs while a continuous follow-up was undertaken in the course of the implementation of the activity.

2.3.3. Field Days and Experience Sharing Events

Field days and field visits are important extension methods for creating wider awareness and facilitating farmer to farmer information and knowledge sharing [20]. Hence, field days were undertaken at maturity stages to evaluate the performance of the varieties and create awareness on the availability and importance of the technology demonstrated for different users. In addition, Participatory technology evaluation and selection were employed and the performance of the demonstrated varieties were evaluated by a group of farmers against their own selection criteria such as growth, responsiveness to different pest and diseases, response to lodgings, and yield.

2.4. Data Collection and Analysis

Both quantitative and qualitative types of data were collected through direct field observations and focused group discussions (FGD). The quantitative types of data such as the grain yield of the varieties, numbers of farmers become aware of the availability and importance of the technology were collected via a structured checklist. While qualitative types of data such as farmers' preferences and feedback on the technology demonstrated was gathered through FGD.

Simple descriptive statistical test, such as percentage and mean were employed to analyze the quantitative types of data whereas, pair wise ranking was used to compare and rank the different traits of the varieties demonstrated. The qualitative types of data, such as farmers' perception, and feedback on the technology by users and other stakeholders was analyzed through narration. Furthermore, the technology gap and extension gap analysis were used as suggested [21].

$$\text{Technology gap } (qha^{-1}) = \text{Potential yield } (qha^{-1}) - \text{Demonstration yield } (qha^{-1})$$

$$\text{Extension gap } (qha^{-1}) = \text{Demonstration yield } (qha^{-1}) - \text{Farmers practice yield } (qha^{-1})$$

3. Results and Discussions

3.1. Grain Yield Performance of the Technology

The study assessed the grain yield performance of the recently released Bishoftu variety in comparison with standard checks (Eba and Dagim) and farmers' practices in all districts. The findings revealed that the highest grain yield (25.5 qha^{-1}) was obtained from the Bishoftu variety in the Akaki kality district of Sheger City administration in the Oromia region. In contrast, the lowest average yield (20.3 qha^{-1}) was recorded from Eba variety in the Adea district of

East Shewa zones of Oromia region (Table 2).

Moreover, the study examined the grain yield advantages of the demonstrated varieties across the test locations. The results showed that Bishoftu variety had a mean grain yield increment of 0.2% to 21.6% compared to the Eba variety in all demonstration sites This indicates that Bishoftu had a relative yield advantage over the Eba variety. However, as compared to Dagim, a standard check variety, a mean grain yield increment ranging from -4.0% to 4.2% was observed (Table 2). Based on this study, Bishoftu performed well in Becho districts of South West Shewa zone, and Gimbichu, Adea and Lume districts of East Shewa zones. However, Bishoftu variety showed lower yield advantage in Gelan and Akaki Kality districts of Sheger City Administration and Lume districts of East Shewa zone of Oromia regions, as compared to the Dagim variety.

In general, the results of this study concluded that the Bishoftu variety showed a positive and significant yield advantage over the standard check Eba variety in all the locations. However, concerning the standard check Dagim variety, it presented a lower yield advantage in Gelan and Akaki Kality districts of Sheger City Administration and Lume districts of East Shewa zone of Oromia region. Additionally, the new variety was compared with farmers' practices, revealing that Bishoftu had 4.4-18.5% yield advantages over local practices in Becho, Lume, Adea, Gelan, Gimbichu, and Akakai Kality districts (Table 2).

Table 2. *The grain yield performance of the technology demonstrated.*

Variety/standard checks/yield advantages	Yield (qha^{-1}) vs districts					
	Adea	**Gelan**	**Gimbichu**	**Lume**	**Akaki kality**	**Becho**
Bishoftu	24.6	24.0	25.4	24.1	24.5	22.8
Eba	20.3	22.2	22.2	22.7	21.9	22.3
Dagim	23.7	25.0	24.4	24.6	25.5	22.7
Farmers practice (Zonal average)	21.5	20.7	21.5	21.5	20.7	21.8
Yield advantage (%) of Bishoftu over Eba	21.6	7.9	14.4	6.3	12.1	2.0
Yield advantage (%) of Bishoftu over Dagim	4.2	-4	4.1	-2.2	-3.9	0.5
Yield advantage (%) of Bishoftu over farmers practice	14.6	15.8	18.2	12.0	18.5	4.4
Technology yield gap	0.9	1.1	1.6	0.4	1.6	-1.1
Extension yield gap	1.6	2.2	0.9	2.1	1.7	3.3

Source: (Own field data, 2022)

Note: The zonal average yield of 2022 from CSA was used as farmers practice in the respective districts of the demonstration sites.

$$\text{Yield advantage (\%)} = \frac{\text{Yield of new variety (qha-1)} - \text{Yield of standard check (qha-1)}}{\text{Yield of standard check (qha-1))}} * 100$$

3.2. Extension and Technology Yield Gap

The extension yield gap varied from 0.9 to 3.3 qha^{-1}, with the highest (3.3 qha^{-1}) in the Becho district of South West Shewa Zone, and the lowest (0.9 qha^{-1}) in the Gimbichu district of the East Shewa Zone, Oromia Region (Table 2). The reason behind the gap could be attributed to the inadequate transfer of improved varieties and lack of effective extension services to facilitate technology transfer. These findings underline the existence of a significant extension yield gap in tef, highlighting the necessity of educating farmers about various techniques for adopting improved tef production technologies, thus reducing the yield gap.

Similarly, the technology gap, or the differences between potential yield and yield of newly released variety (Bishoftu), ranged from -1.1 to 1.6 qha^{-1} in the Becho district of South West Shewa Zone, Gimbichu and Akaki Kality districts of East Shewa and Sheger City administration of the Oromia region, respectively (Table 2). and the Ada'a districts of East Shewa zone, respectively. Although the technology gap is smaller than the extension gap, the study revealed that there is still potential to increase the productivity of tef by utilizing available technologies and associated management practices in the study areas.

3.3. Preference Ranking of the Demonstrated Technologies

Farmers are the ultimate decision makers to accept or reject a certain technology or management practices. Therefore, it is vital to include farmers' viewpoint and knowledge while evaluating and selecting the most promising tef varieties for their respective locations, in addition to the yield per plot area [22]. Thus, participatory variety evaluation was also carried out at maturity stage of the crop by a group of farmers comprising of 5-8 in each location in assessing the performance of the varieties. The group was established by considering different crieterias such as experience in tef farming, gender, and others. Hence, based on this, farmers identified ten different evaluation crieterias, including panicle length, tillering capacity, moisture tolerant, lodging resistant, plant height, seed size, seed color, palatability of straw for cattle, rust resistant and early maturity. Out of these crieterias, panicle length, tillering capacity, lodging resistant, seed size and color and straw palatability were common across the demonstration districts.

During the farmers' varietal preference ranking exercises, they were asked to rank the three demonstrated varieties according to their own ranking criteria. Bishoftu variety was identified as the most preferred variety, followed by Dagim and Eba variety across all five locations, namely Adea, Gimbich, and Lume districts of East Shewa zone and Becho

districts of South West Shewa Zone of Oromia region. However, in the Gelan district of Sheger City administration of Oromia region, farmers preferred and ranked the Dagim variety first, followed by Bishoftu and Eba variety (Table 3).

Table 3. *Rank of the varieties based on farmers' selection criteria in each district.*

Varietal Selection Criteria (Traits)	Districts VS Varieties demonstrated								
	Adea			Gelan			Gimbichu		
	Bishoftu	Eba	Dagim	Bishoftu	Eba	Dagim	Bishoftu	Eba	Dagim
Large panicle length	2	1	3	2	3	1	2	3	1
Large tillering capacity	2	3	1	2	3	1	1	2	3
Moisture tolerant	2	3	1	2	3	1	NS	NS	NS
Lodging resistant	1	3	2	NS	NS	NS	3	2	1
Medium plant height	1	3	2	NS	NS	NS	1	3	2
Large seed size	2	3	1	2	3	1	NS	NS	NS
White seed color	2	1	3	2	1	3	NS	NS	NS
Palatable straw	2	1	3	2	1	3	NS	NS	NS
Resistant to Rust	1	1	1	NS	NS	NS	1	1	1
Early maturity	1	2	3	NS	NS	NS	1	2	3
Total acceptability score	16	21	20	12	14	10	9	13	11
Rank	1	3	2	2	3	1	1	3	2

Table 3. *Continued.*

Varietal Selection Criteria (Traits)	Districts VS Varieties demonstrated								
	Lume			Akaki kality			Becho		
	Bishoftu	Eba	Dagim	Bishoftu	Eba	Dagim	Bishoftu	Eba	Dagim
Large panicle length	2	1	3	2	3	1	2	1	3
Large tillering capacity	2	3	1	1	2	3	2	3	1
Moisture tolerant	2	3	1	2	3	1	NS	NS	NS
Lodging resistant	1	3	2	2	3	1	2	3	1
Medium plant height	1	3	2	1	3	2	1	3	2
Large seed size	2	3	1	2	3	1	2	3	1
White seed color	2	1	3	2	1	3	1	2	3
Palatable straw	2	1	3	2	1	3	2	1	3
Resistant to Rust	1	1	1	1	1	1	1	1	1
Early maturity	NS	NS	NS	1	2	3	NS	NS	NS
Total acceptability score	15	19	17	16	22	19	13	17	15
Rank	1	3	2	1	3	2	1	3	2

Source: (own field data, 2022/23)
NS denotes not suggested criteria in the specific districts

The combined analysis results of the mean grain yield (qha^{-1}) and farmers varietal preference ranking also showed that Bishoftu variety was selected first followed by Dagim and Eba varieties in Adea, Gimbich and Lume districts of East Shewa zone and Becho districts of South West Shewa Zone while Dagim variety was selected first followed by Bishoftu and Eba variety in the Gelan district of Sheger City administration of Oromia region (Table 4).

Table 4. *Farmers varietal preference ranking (FPR) and grain yield performance (GYP) of tef technologies in each district.*

Variety	Districts vs FPR and GYP (qha^{-1}) of varieties demonstrated											
	Adea		Gelan		Gimbichu		Lume		Akaki kality		Becho	
	FPR	GYP	FPR	GYP	FPR	GYP	FPR	GYP	FPR	GYP	FPR	GYP
Bishoftu	1	24.6	2	24.0	1	25.4	1	24.1	1	24.5	1	22.8
Eba	3	20.3	3	22.2	3	22.2	3	22.7	3	21.9	3	22.3
Dagim	2	23.7	1	25.0	2	24.4	2	24.6	2	25.5	2	22.7

Source: (Own field data, 2022/23)
FPR denotes that Farmers preference ranking and GYP denotes that grain yield performance

4. Conclusions and Recommendations

Based on the combined analysis results of the mean grain yield (qha^{-1}) and farmers varietal preference ranking, Bishoftu variety was best performed in Adea, Gimbichu and Lume districts of East Shewa zone and Becho districts of South West Shewa Zone while Dagim variety was performed better than Bishoftu in the Gelan district of Sheger City administration of Oromia region. Therefore, the selected varieties should be scaled up in the target areas and other unaddressed areas with similar agroecology by participating all the concerned stakeholders like the government sectors, non-governmental organizations and other private sectors at different levels.

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Conflicts of Interest

The authors declare no conflicts of interest.

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