

Pre-Extension Demonstration of Newly Released Tef (*Eragrostis Tef*) Technologies in Selected Moisture Deficit Areas of North and East Shewa Zones of the Amhara and Oromia Regional States, Ethiopia

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Abstract: Tef (*Eragrostis Tef*) is one of the most important cereal crops in Ethiopia and holds significant importance for food security, nutrition, and income generation for smallholder farmers. However, its production faces various challenges, including low yields, which is caused by limited access to improved varieties and lack of knowledge on best agronomic practices. The study was aimed at enhancing the adoption of new tef technologies by raising farmers' awareness towards better management practices in the study area. The newly released Boni variety along with the standard checks (Bora and Boset) was demonstrated during the 2022 main cropping season. Yield data was collected and analyzed using descriptive statistics. The farmers preference and feedback were evaluated using direct ranking and narration respectively. The finding showed that the highest grain yield (2.22 tha^{-1}) was obtained from Bora variety in the Minjar Shenkora district of North Shewa zone, Amhara regional state. Conversely, the lowest average yield (1.84 tha^{-1}) was recorded from Boni variety in the Bora district of East Shewa zone, Oromia regional state. The yield increment of Boni over Bora ranges from -4.2% to 1.0% across the districts. Furthermore, comparing Boni to the Boset variety, Boni consistently demonstrated higher yields, with yield advantages ranging from -1.1% in the Bora district to 7.2% in the Boset district. In contrast, the yield advantage of Boni over farmers' practices varies across districts, ranging from -14.4% in Bora district to 5.9% in Minjar Shenkora district. Similarly, Boni variety was selected first, followed by Bora and Boset varieties in Boset and Bora districts, while Bora variety was selected first followed by Boni and Boset variety in the Liben Chiquala and Minjar Shenkora districts. Therefore, it is recommended to promote the selected varieties in the specific target areas as well as other similar agro-ecological areas by involving all the concerned stakeholders at different levels.

Keywords: *Eragrostis Tef*, Grain Yield, Moisture Deficit, Preference Ranking, Tef, Variety

1. Introduction

Tef (*Eragrostis Tef*) is the most important cereal crop in Ethiopia, accounting for about 29.3% of the total acreage and 19.3% of the gross grain production of all cereals. It is grown by over 6.6 million smallholder households, and constitutes the major staple food grain for over 50 million Ethiopian

people [1].

Tef is indigenous to Ethiopia and has been cultivated for thousands of years in the Ethiopian highlands [2] and it has been 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 levels of protein, fiber,

and minerals such as iron and calcium [4, 5]. It is also gluten free, making it an important food source for people with gluten intolerance [4, 6, 7]. 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 [8–13]. In addition, tef straw is the main byproduct of its grain production and it is an important feed source for livestock and considered the most valuable resource by the Ethiopian farming communities [8, 12–15].

It is annual versatile crop that grows in a wide variety of agro-ecological conditions. Since it produces a reasonable yield when grown in areas that experience drought, waterlogging, and poor soil, it is considered a low-risk crop. Despite the crucial significance of tef in the national food security, nutrition, and income generation of smallholder farmers in Ethiopia, its productivity is relatively low than other cereal crops. The national average grain yield of Tef is about 1.91tha^{-1} compared to 3.11, 4.2, and 2.5 tons per hectare for wheat, maize, and barely, respectively [1]. The numerous yield variables in tef includes the absence of cultivars tolerant to lodging and drought [18], even with very small seed size. Yield misfortunes are assessed to achieve up to 40% during extreme moisture stress [19]. Furthermore, yield reductions of up to 77% have been reported as a result of drought at the anthesis stage of tef [20].

In response to these challenges, up to the year 2021, the Tef improvement program of Debre Zeit Agricultural Research Center (DZARC) has developed and released over 54 improved Tef varieties in Ethiopia, of which, 15 varieties are for moisture deficit stress areas [19, 20]. Similarly, a number of recommended tef production technologies, mainly improved varieties along with optimum management practices, have been disseminated to smallholder farmers in major tef growing areas of the country using a variety of extension approaches such as, the pre-extension demonstration and popularization [23].

Despite the efforts made so far in generating and transferring agricultural technologies, the rate of adoption of these technologies remained low primarily because of limited access to improved seeds, lack of awareness, and weak seed system [17, 18]. To address these problems, in the year 2021, DZARC tef breeders has developed a new variety Boni for moisture deficit areas aimed at improving the productivity and yield stability of tef in drought prone areas of Ethiopia. Thus, it is important to demonstrate and create awareness of the newly released variety and its associated management practices for the farmers in the selected districts of Amhara and Oromia Regional states.

2. Material and Methods

2.1. Description of the Study Areas

This study was carried out in purposively selected districts of North Shewa and East Shewa zones of Amhara and Oromia Regional states during the 2022 main cropping season. Four districts were purposively selected for the

demonstration. Thus, Minjar Shenkora district was selected from North Shewa zone of Amhara regional state while Bora, Liben-Chiquala, and Boset districts were selected from East Shewa zones of Oromia regional state. The districts were selected based on the prevalence of moisture deficit and the potential for tef production.

Menjar Shenkora ("Menjar and Shenkora") is one of the districts in the Amhara Regional state of Ethiopia. It is situated at the southern end of the North Shewa zone and shares borders with the Oromia Regional state to the east, south, and west. It is bordered by Hagere Mariamna Kesem to the northwest and by Berehet district to the northeast. The district is located 106 km away from Addis Ababa, the capital city of Ethiopia. The study area encompasses a geographical location extending from $8^{\circ}42'46''$ N to $9^{\circ}7'37''$ N latitude and from $39^{\circ}12'57''$ E to $39^{\circ}46'53''$ E longitude.

Liben-Chiquala district is located 80 km east of Addis Ababa in the East Shewa zone of the Oromia regional state. The district has 18 kebeles with a total population of 93,367 (45,783 females) or 15,153 households. The district has a total cultivated area of 48,125 hectares with main crops such as Tef, maize, and wheat.

Bora district is located in the east Shewa zone of Oromia Regional state. Bora district in the East Shewa zone of the Oromia Region. It is located at a latitude and longitude of 8.30°N 38.95°E , with an elevation of 1,611 meters. The district is surrounded by the districts of Lomme, Lake Koka, and Dodota to the east, Dugda to the west, Liben to the north, and Zeway Dugeda and Lake Zeway to the south. The capital town of Alemtina is located 160 kilometres away from Addis Ababa and 105 kilometres away from Awassa. The district is mostly known for the production of vegetable crops, wheat, maize, and tef [25].

Boset district is located in the east Shewa zone of Oromia Regional state, Ethiopia. The district is located in the Great Rift Valley (GRV) and is bordered on the south by the Sire and Dodota, on the west by Adama district, on the east by Merti, on the north by the Amhara region, and on the northeast by Fentale; southeast by Jeju districts. The total land coverage is 124, 160 hectares and the altitude ranges from 1200–1800 meters above sea level. 89% of Boset district belongs to the tropical /hot agro-climatic zone, and the remaining smaller section (about 11%) is sub-tropical moderate hot. The major soils of Boset, andosols, though have low water retention capacity, are quite productive, especially during periods of sufficient rains.

2.2. Site and Farmer Selection

One representative kebele was selected from each district in consultation with DAs and experts based on the agro-climatic conditions, the potential for tef production, and the accessibility for road. Accordingly, a total of four Kebeles were selected for the demonstration sites. In addition to site selection, host farmer selection was made for better scalability of the technologies. From each kebele, five host farmers (20 farmers) was carefully selected and directly involved for the demonstration. The selection of farmers was

conducted based on the availability of suitable and sufficient land (0.125 per variety per head) for the demonstration purpose, proximity to roadsides, and the willingness to manage and adopt new technologies. The farmers were

selected jointly by teams of researchers in collaboration with district agricultural development offices experts assisted by kebele-based agricultural extension agents.

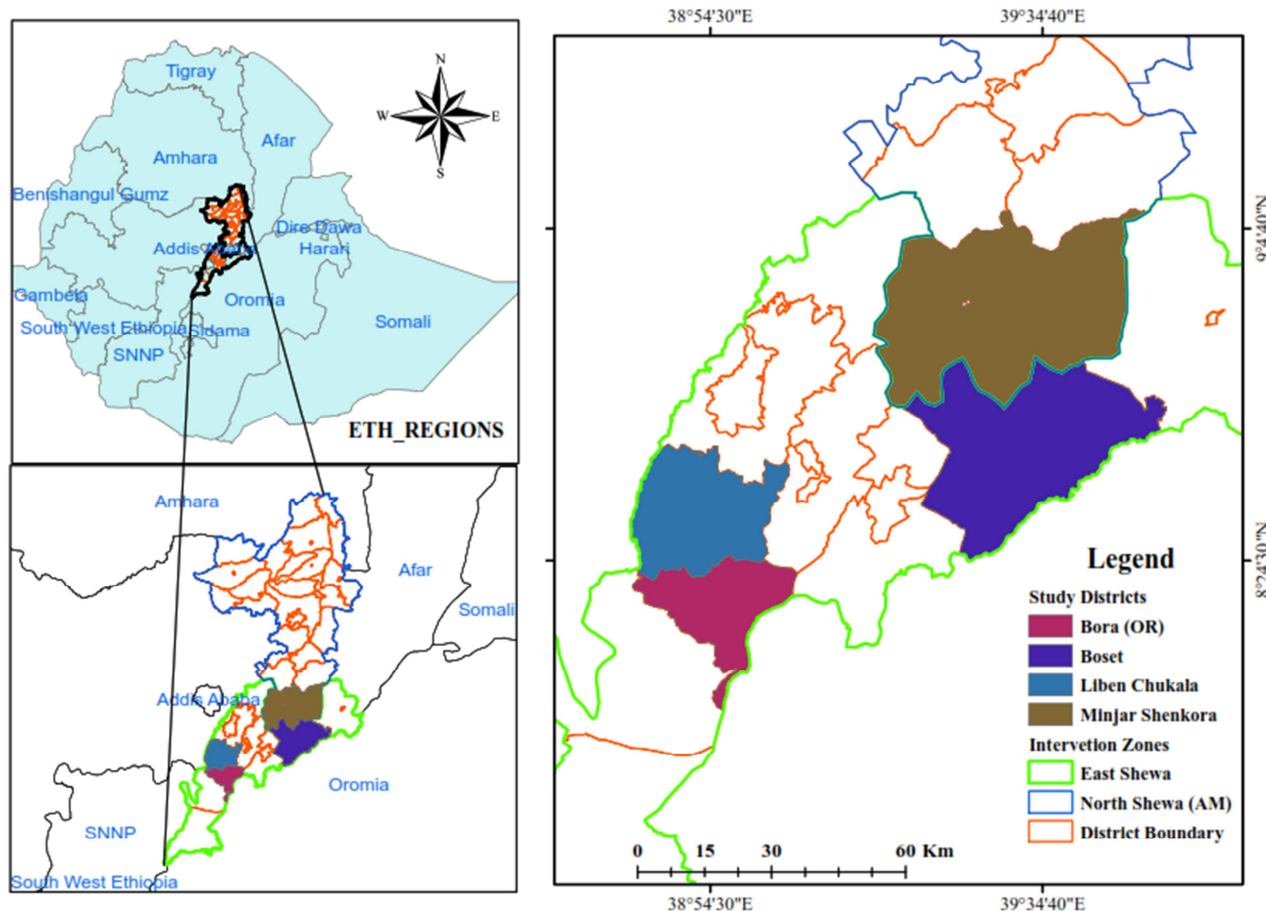


Figure 1. Map of the study area.

2.3. Implementation Design

For this activity, Boni, the newly released variety along with their full production packages was demonstrated with the standard checks (Bora and Boset) varieties. These varieties were selected based on their high yield potential and the relative advantage of early maturity natures. Each variety was planted in plots of 0.125 hectares side by side and

replicated in 20 farmers' land, resulting in a total of 60 demonstration plots. Seed was broadcasted at the recommended rate of 15 kg/ha and a fertilizer rate of 100kg/ha Urea and NPS were applied respectively. Standard agronomic practices were followed throughout the cropping season, including weeding, fertilizer application, pest, and disease management.

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 (t/ha)	
						On station	On farm
Boni	2021	750-1500	500-700	Very white	62-88	2.0-3.0	1.8-2.6
Bora	2019	750-1500	500-700	Very white	74-85	2.0-2.8	1.8-2.4
Boset	2012	750-1500	500-700	Very white	75-86	1.9-2.8	1.8-2.2

Source: (MoA, 2021)

2.4. Input Supply and Field Management

For successful introduction and demonstration of the new tef technologies, emphasis was given to enhance the

knowledge and skills of farmers, agricultural experts, and development agents. Thus, before the implementation of the activity, training was given for the host farmers, agricultural experts, and extension agents to provide comprehensive

understanding of the tef production and management practices. The training program was tailored to the specific needs and capacity of target farmers in the respective districts. The recommended amount of seed of the selected variety was delivered to the host farmers free of cost. Fields were managed by host farmers as per the recommendations for all demonstration plots with guidance and regular monitoring by development agents and researchers throughout the growing seasons.

2.5. Field Days and Experience Sharing Events

Field days and experience-sharing events have broader implications beyond the individual farmers and their immediate communities. These events provide an opportunity for farmers to network and exchange knowledge with experts and researchers in the field. By showcasing the success of the new technologies, field days can inspire other farmers to adopt similar practices, leading to widespread adoption and the potential transformation of the improved agricultural practices in larger areas. Field days were conducted at maturity stages to evaluate the performance of the varieties and create awareness about the availability and importance of the technologies.

In addition, participatory technology evaluation and selection were employed and the performance of the demonstrated varieties was evaluated by a group of farmers against their own selection criteria, such as growth, responsiveness to different pests and diseases, response to lodgings, and yield. This participatory approach allowed for a

comprehensive assessment of the demonstrated varieties, taking into account the specific needs and preferences of the farmers. The feedback collected from the farmers' evaluation played a crucial role in determining which varieties were most suitable for their local conditions and farming practices.

2.6. 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 who became 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 statistics such as percentage and mean were used to analyze the quantitative types of data, whereas pair wise ranking was used to compare and rank the different traits of the demonstrated varieties. 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 by [26]. The technology gap analysis helped identify areas where the current technology fell short, while the extension gap analysis highlighted potential gaps in knowledge or outreach that could be addressed.

$$\text{Technology gap (tha}^{-1}\text{)} = \text{Potential Yield (tha}^{-1}\text{)} - \text{Demonstration Yield (tha}^{-1}\text{)}$$

$$\text{Extension gap (tha}^{-1}\text{)} = \text{Demonstration Yield (tha}^{-1}\text{)} - \text{Farmers Practice Yield (tha}^{-1}\text{)}$$

3. Results and Discussions

3.1. Grain Yield Performance of the Technology

The study assessed the grain yield performance of the recently released Boni tef variety in comparison with standard checks (Bora and Boset) and farmers' practices in all districts. The finding revealed that the highest grain yield (2.22 tha⁻¹) was obtained from the Bora variety in the Minjar Shenkora district of the North Shewa zone of Amhara regional state. In contrast, the lowest average yield (1.84 tha⁻¹) was recorded from the Boni variety in the Bora district of the East Shewa zone of Oromia regional state.

Moreover, the study examined the grain yield advantages of the demonstrated varieties across the test locations. In terms of yield advantages, the Boni variety outperforms the Bora variety in two districts, the Boset and Liben Chiquala districts. The percentage yield increment of Boni over Bora ranges from -4.2% to 1.0% across the districts. When comparing Boni to the Boset variety, Boni consistently demonstrates higher yields, with percentage advantages ranging from -1.1% in the Bora district to 7.2% in the Boset

district. In contrast, the yield advantage of Boni over farmers' practices varies across districts, ranging from -14.4% in Bora district to 5.9% in Minjar Shenkora district (Table 2).

The results of this study indicated that the Boni variety had a positive yield advantage over the standard check Bora variety in the Boset and Liben Chiquala districts, while the standard check Bora variety outperformed the new variety Boni in the Minjar Shenkora and Bora districts. However, compared with the standard check Boset variety, it presented a higher yield in all districts except the Bora district (Table 2). The finding suggests that Boni has the potential to significantly improve yields compared to both Bora and Boset in most districts. However, it is important to note that there are some districts where Boni may not provide much of a yield advantage, such as the Bora and Minjar Shenkora districts, where the percentage yield increment is negative. These findings suggest that the performance of the Boni variety may vary depending on the specific district. Additionally, further pre-extension demonstration research could be conducted to determine the yield performance difference between Boni and Bora varieties in different districts.

Table 2. Summary of the grain yield performance of the technology demonstrated.

Variety/standard checks/yield advantages	Yield (tha^{-1}) vs districts			
	Minjar Shenkora	Boset	Liben Chiquala	Bora
Boni	2.14	2.09	2.02	1.84
Bora	2.22	2.07	1.99	1.92
Boset	2.01	1.95	1.91	1.86
Farmers practice (Zonal average)	2.02	2.15	2.15	2.15
Yield advantage (%) of Boni over Bora	-3.6	1.0	1.5	-4.2
Yield advantage (%) of Boni over Boset	6.5	7.2	5.2	-1.1
Yield advantage (%) of Boni over farmers practice	5.9	-2.8	-6.5	-14.4
Technology yield gap of variety Boni	0.86	0.91	0.98	1.16
Extension yield gap variety Boni	0.12	-0.06	-0.14	-0.31

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.

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

In addition to the yield advantages, table 2 presents the technology yield gap and the extension yield gap. The technology yield gap measures the difference between the actual yield and the potential yield achievable with the demonstrated technology. Conversely, the extension yield gap represents the difference in yield between the technology demonstrated and the yield achieved through extension efforts. These gaps provide valuable insights into the potential for further improvement in yield through technological advancements and extension efforts.

The extension yield gap varied from -0.31 to 0.12 tha^{-1} , with the highest (0.12 tha^{-1}) in the Minjar Shenkora district of the North Shewa zone of the Amhara regional state, and the lowest (-0.31 tha^{-1}) in the Bora district of the East Shewa zone, Oromia Regional state (Table 2). The reason behind the gap could be attributed to the use of the zonal productivity of the CSA data (uses the aggregate productivity of both the high potential and low potential areas) as the yield of farmers' practices to compute the extension yield gap in the respective districts.

Similarly, the technology gap, or the differences between the potential of a newly released variety (Boni) yield and its demonstrated yield, ranged from -1.16 (Bora district) to 0.86 tha^{-1} (in the Minjar Shenkora district) of Amhara regional

state respectively (Table 2), suggesting that there is room for improvement in achieving optimal yields with better management practices.

3.2. Preference Ranking of the Demonstrated Technologies

Farmers are the ultimate decision makers about whether to accept or reject a certain technology or management practice. Therefore, including farmers' viewpoints and knowledge in the evaluation and selection process of tef varieties ensures that the chosen varieties align with their specific needs and preferences. Thus, participatory variety evaluation was also carried out at the maturity stage of the crop by a group of farmers comprising 5-8 in each location to assess the performance of the varieties. The group was established by considering different criteria such as experience in tef farming, gender, and others. Based on this, farmers identified ten different evaluation criteria, including panicle length, tillering capacity, moisture tolerance, lodging resistance, plant height, seed size, seed color, palatability of straw for cattle, rust resistance and early maturity. Out of these criteria's, panicle length, tillering capacity, drought resistance, seed size, color, and straw palatability were common across the demonstration districts.

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

Varietal Selection Criteria (Traits)	Districts VS Varieties demonstrated											
	Minjar Shenkora			Boset			Liben Chiquala			Bora		
	Boni	Bora	Boset	Boni	Bora	Boset	Boni	Bora	Boset	Boni	Bora	Boset
Large panicle length	2	1	2	2	1	3	2	1	3	2	1	3
Large tillering capacity	1	1	1	2	1	3	2	1	3	2	1	3
Drought tolerant	3	2	1	1	1	1	1	1	1	1	2	2
Large seed size	3	1	2	2	1	2	2	1	3	2	1	3
White seed color	2	3	1	1	1	1	1	1	1	1	1	2
Palatable straw	2	3	1	1	3	2	1	2	1	1	2	3
Early maturity	1	3	2	1	3	2	1	1	1	1	2	1
Resistant to cold weather	1	2	2	NS	NS	NS	NS	NS	NS	NS	NS	NS
Total acceptability score	15	16	12	10	11	14	10	8	13	10	10	17
Rank	2	3	1	1	2	3	2	1	3	1	1	2

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

During the farmers' varietal preference ranking exercises, they were asked to rank the three demonstrated varieties

according to their own ranking criteria. Boni variety was identified as the most preferred variety, followed by Bora and

Boset varieties in the Bora and Boset districts of the East Shewa zone, while Bora variety was selected first in the Liben Chiquala district followed by, Boni and Boset varieties. Similarly, in the Minjar Shenkora district of the North Shewa zone farmers preferred and ranked the Boset variety first, followed by, Boni and Bora variety (Table 3).

The farmers' varietal preference ranking also showed that Boni variety was selected first in Boset and Bora districts of

East Shewa zone; while Bora variety was selected first in Liben Chiquala and Bora districts. Boset variety was preferred first in Minjar Shenkora district of North Shewa zone (Table 4). After the combined analysis of the mean grain yield with farmers variety preference revealed that both varieties Boni and Bora were better in two districts. The Boni variety can be used in specific districts as an alternative variety to Bora variety (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 (tha^{-1}) of varieties demonstrated							
	Minjar Shenkora		Boset		Liben Chiquala		Bora	
	FPR	GYP	FPR	GYP	FPR	GYP	FPR	GYP
Boni	2	2.14	1	2.09	2	2.01	1	1.84
Bora	3	2.22	2	2.07	1	1.99	1	1.92
Boset	1	2.01	3	1.95	3	1.91	2	1.86

Source: (Own field data, 2022, 23)

FPR denotes that Farmers preference ranking and GYP denotes that grain yield performance

4. Conclusions and Recommendations

According to the combined analysis of average grain yield and farmers' preference rankings, the Boni variety showed the best performance in the Boset and Liben Chiquala districts of the East Shewa zone. On the other hand, in the Minjar Shenkora and Bora districts, Bora variety performed better and was preferred by farmers compared to the Boni variety. As a result, it is recommended to promote the selected varieties in the specific target areas and other unaddressed areas with similar agro-ecology by involving all the concerned stakeholders, such as the government sectors, non-governmental organizations, and other private sectors at different levels.

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