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# Demonstrating Improved Tef (*Eragrostis tef*) Varieties Through a Cluster-based Approach: Yield Performance and Farmer Perceptions in Central Ethiopia

**Getachw Dessalegn Shiferaw**

Central Ethiopia Agricultural Research Institute, Worabe Agricultural Research Center, Worabe, PO Box 21, Ethiopia.

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**Corresponding author:** Getachw Dessalegn Shiferaw, Central Ethiopia Agricultural Research Institute, Worabe Agricultural Research Center, Worabe, PO Box 21, Ethiopia.



## Abstract

Despite the existence of improved tef varieties, their adoption by smallholder farmers in Ethiopia remains low. This study evaluated the performance of and farmer preferences for two improved tef varieties. This raises the need to conduct further cluster-based large-scale demonstrations of improved varieties. A cluster-based demonstration was conducted in five districts, namely Abeshige, Sodo, Worabe town administration, Misrak Azernet, and Saja Zuria districts. Training for the participant farmers and different stakeholders was provided at each demonstration site. The varieties applied were "boset and dagim", which are currently productive and high-yielding. The technology packages were applied according to scientific recommendations. The field day was organized at Misrak Azernet district, Yerim kebele demonstration site, to involve key stakeholders and enhance better linkage among relevant actors. The average grain of the improved tef varieties in Misrak Azeernet, Worabe town administration, Sodo, and Saja Zuriya districts were 2060, 1800, 2180, 1790, and 2280 kg/ha, respectively. At three of the five sites, yields exceeded the national average of 1,914 kg/ha. Farmers rated 'Dagim' highly for grain yield and marketability (4.9/5), while 'Boset' was preferred for early maturity (4.8/5). A field day engaged 168 stakeholders. The cluster approach effectively demonstrated the potential of improved varieties. Concerned bodies are expected to disseminate those varieties further in order to produce quality seed and address potential areas.

## Keywords

Cluster; extension demonstration; preference; technology

## 1. Introduction

In developing countries like Ethiopia, the agriculture sector is the most important sector of the economy, which occupies an important place in the overall economic policy of the country's agricultural development, leading to industrialization. It serves as a source of income and employment for the majority of the country's population. Currently, agriculture contributes more than 35.8% of the country's GDP, almost 90% of exports, and 72.7% of employment [1]. Nevertheless, the current state of production, productivity, and efficiency in the sector falls significantly short of the global average. Primarily, farmers possessing similar resources yield varying outputs per hectare due to inefficiencies in management inputs; limited adoption of modern agricultural technologies; outdated farming practices; inadequate complementary services such as extension, credit, marketing, and infrastructure; as well as

biased agricultural policies prevalent in developing countries like Ethiopia [2]. According to [3], cereals are the major food crops in terms of area coverage and volume of production, accounting for 95% of agricultural production in Ethiopia, and contributed 87.48 percent of grain production. Among them, Teff *(Eragrostis tef)* is one of the most important and dominant staple cereal crops in Ethiopia [4]. Most Ethiopian farmers are motivated to cultivate tef because of its relative advantages over other cereals in the use of both grain and straw. Culturally, tef grain is used for human consumption, which is called Enjera, the most popular food of most Ethiopians.

Tef has both cultural and economic value for Ethiopian farmers. Currently, it is among the cash crops, attracting an export market because of its nutritional value, and it is believed to be gluten-free [5]. Combined with its low vulnerability to pests and diseases, it is considered a low-risk crop. It is a daily staple food for approximately 57.20 million people in Ethiopia, accounting for more than 64% of the total population of the country [6].

Currently, Ethiopia cultivates approximately 3.02 million hectares. This makes Tef the first among cereals in the country in area coverage. However, out of the total cereal grain produced, tef accounts for 17.71% (5.8million tons), and the average national yield of tef is only 1.91 tons $ha^{-1}$ in 2021/22 2021-22 the cropping season, which is very low compared with tef yield produced at research station 2.53 to 3.2 tons $ha^{-1}$ and its yield potential [7]. In recent years, different adaptation and demonstration activities have been conducted at different locations and agroecologies. The Worabe Agricultural Research Center has conducted different activities related to adaptation and demonstration research endeavors. However, the dissemination of improved varieties that are preferred by farmers is very minimal. This raises the need to conduct further cluster-based large-scale demonstrations of improved varieties. Thus, undertaking participatory demonstration, promotion, and popularization of improved tef technologies with the participation of farmers and other stakeholders is important to familiarize the farming communities with improved varieties. Although some improved varieties have been introduced to farmers in the area, farmers have not fully adopted the recommended agronomic practices, and productivity was below its potential, even though there are potential agroecologies in the area. Therefore, this study was undertaken with the following objectives: (1) to demonstrate the yield potential of the improved tef varieties 'Boset' and 'Dagim' under a cluster-based farming system; (2) to assess farmer perceptions of these varieties using a participatory approach; and (3) to facilitate stakeholder linkages and technology diffusion through field days.

## 2. Materials and Methods

### 2.1 Study Area Description

The Misrak Azernet Berbere Woreda (district) and Worabe Town Administration are key administrative and agricultural units within the Siltie Zone. These areas are characterized by a diverse topography and a climate suitable for various cereal and perennial crops. The altitude in the Misrak Azernet district and surrounding Worabe areas varies significantly, contributing to a diverse set of microclimates. The elevation of the Misrak Azernet Berbere district ranges from approximately 2,001 to 3,500 meters above sea level (masl) [8]. Worabe Town is located at an elevation of at an elevation of approximately 2,113 meters. The mean annual rainfall in Misrak Azernet is recorded between 1,001 mm and 1,200 mm [8]. The mean annual temperature is approximately 17.5°C, typically fluctuating between 12.6°C and 20°C [9]. The soils in the Siltie Zone, particularly in Misrak Azernet, are influenced by the region's volcanic history and high-altitude erosion processes. The area primarily consists of Nitosols (red basaltic soils) and Vertisols (black cotton soils) in the lower undulating plains. In the highlands of Misrak Azernet, the soil texture is often classified as clay to clay loam, which provides good water-holding capacity but can be susceptible to erosion on steep slopes [10].

The Abeshige district is primarily defined by its lower elevation relative to the eastern Gurage highlands. The altitude typically ranges from 1,050 to 1,883 meters above sea level (masl) [11]. The district follows a bimodal rainfall distribution common to the region, heavily influenced by the ITCZ (Inter-Tropical Convergence Zone). The mean annual rainfall is approximately 1,200 mm to 1,500 mm, with peaks typically occurring in July (monthly mean of ~222 mm) [11]; [12]. The mean monthly temperature is around 21.5°C, with a general range between 18°C and 25°C depending on the specific elevation [13]. Research at Wolkite University sites within the district shows surface silt and sand contents varying between 12-26% and 8-30%, respectively [11]. The soils are generally acidic to slightly acidic, with surface pH values ranging from 4.5 to 5.6.

The Deri Saja Zuria District is a prominent administrative and agricultural unit within the Yem Zone of the Central Ethiopia Regional State. The district surrounds the town of Saja, which serves as the administrative seat for both the district and the Yem Zone. The district spans a wide altitudinal gradient, generally ranging from 920 to 2,939 meters above sea level (masl) [14]. The mean annual rainfall is high, ranging from 900 mm to 2,200 mm. The

highest rainfall intensity typically occurs between July and August. The mean annual temperature fluctuates between 12°C and 30°C, largely dependent on the specific altitudinal belt [15]. The soils in the Yem Zone are primarily of volcanic origin and are generally fertile, though susceptible to erosion on the steeper slopes typical of the Deri Saja landscape. Research indicates that the soils are typically slightly acidic to strongly acidic (pH 5.2-6.6) [16].

### 2.2 Experimental Design and Treatments

The demonstration was laid out as a participatory varietal selection (PVS) trial without replication, with each farmer's field considered a replication site. For comparison, each host farmer maintained an adjacent plot of their preferred local tef variety, managed according to their traditional practices."

### 2.3 Crop Management and Inputs

The varieties applied were "*Boset and Dagim",* which are recognized for their high productivity and yield potential. The technology package, i.e., Seed 20 kg/ha, NPS 100 kg/ha, Urea 100 kg/ha, and other necessary chemicals such as 2-4D, was applied according to scientific recommendations. Before sowing, farmers prepared their land appropriately. Specify the sowing date, fertilizer application timing (e.g., "Full dose of NPS was applied at sowing; Urea was split-applied, half at tillering and half at booting stage"), and the rate and timing of the 2,4-D application.

### 2.4 Data Collection

Grain yield was determined by harvesting three randomly placed 1m² quadrats per demonstration plot. Grain weight was adjusted to 12.5% moisture content and then extrapolated to kg/ha. Farmer perceptions were collected during a structured feedback session using a 5-point Likert scale (1 = very poor, 5 = very good) on pre-defined traits.

### 2.5 Data Analysis

Yield data were analyzed using descriptive statistics (mean, standard deviation). To compare the performance of the improved varieties against the national average, a one-sample t-test was performed. Likert scale data were summarized using median scores and frequencies.

### 2.6 Site and Farmer Selection

Representative districts were selected from each zone. Abeshige and Sodo districts from Gurage zone, Worabe town administration, and Misrak Azernet districts from Silte zone, and Saja Zuria district from Yem zone were selected purposively on the basis of EFSRP beneficiary districts. From those districts, one representative kebele was also selected purposively as a demonstration site of the varieties on the basis of its accessibility and potential. From each kebele, 20 to 24 ha of clustered land were selected.

Farmers were selected on the basis of the availability of farm land, initiatives to implement activities, good field management, and willingness to explain the technologies to others, which were criteria used to select the hosting farmers. Participant farmers shared knowledge and skills with other farmers at the end of the demonstration. Agricultural offices at the zonal and district levels participated in the implementation and follow-up activities. In all cluster sites, 125 farmers were selected and benefited.

**Table 1. Number of beneficiaries/farmers from each Keble**

| District/Woreda | Kebele | Male | Female | Total | Area in ha |
|---|---|---|---|---|---|
| Misrak azeernet | Yerim | 31 | 5 | 36 | 20 |
| Worabe adminst | Fuge | 40 | 3 | 43 | 24 |
| Sodo | Negesa | 13 | 2 | 15 | 20 |
| Abeshge | Ambelte | 8 | 3 | 11 | 20 |
| Saja zuria | Deri tegu | 18 | 2 | 20 | 23 |
| Sub total | | 110 | 15 | 125 | 207 |

### 2.7 Training and Land Preparation

We communicated with the woreda, keble extension agents, and farmers to make the activities convenient and smooth. Before implementing the activity, training sessions were organized for participating farmers and stakeholders at each demonstration site. All the stakeholders from the selected kebeles were involved in the training through collaboration with the District Agriculture Office. Moreover, Kebeles Development Agents and District-level experts participated in the training. 64, 85, 34, 28, and 123 participants were trained at the Misrak Azernet, Worabe town Administration, Sodo, Abeshige, and Saja Zuria districts, respectively. At all five demonstration sites, a total of 334 stakeholders participated in training. The training focused on the performance of the provided teff varieties, their productivity, and on teff agronomic practices from land preparation to post-harvest handling. The main aim of training was to create awareness among farmers, development agents, district-level experts, and participant farmers on cluster-based tef production technology. Women farmers were empowered to participate actively and achieve the gender cross-cutting issue of the project.

**Table 2. Number of participants during training at each of the demonstration sites**

| District | Number of participants | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farmers | | | Kebele Das | | | Researchers | | | Woreda agri exps | | | |
| | M | F | T | M | F | T | M | F | T | M | F | T | |
| Ms/Azernet | 46 | 12 | 58 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 64 |
| Worabe T. A | 53 | 25 | 78 | 2 | 0 | 2 | 3 | 0 | 3 | 2 | 0 | 2 | 85 |
| Sodo | 18 | 7 | 25 | 2 | 0 | 2 | 4 | 0 | 4 | 3 | 0 | 3 | 34 |
| Abeshge | 14 | 3 | 17 | 2 | 1 | 3 | 4 | 0 | 4 | 3 | 1 | 4 | 28 |
| Saja Zuriya | 79 | 35 | 114 | 2 | 0 | 2 | 4 | 0 | 4 | 3 | 0 | 3 | 123 |
| Sub total | 210 | 82 | 292 | 10 | 1 | 11 | 17 | 0 | 17 | 13 | 1 | 14 | 334 |

## 3. Results

Accordingly, the average grain yield of the improved *tef* in Misrak Azeernet, Worabe town Administration, Sodo, and Saja Zuriya districts was 2063.6, 1835, 2182.5, 1790, and 2280 kg/ha, respectively (Figure 1). The highest mean yield was recorded for 'Dagim' in Saja Zuria (2,280 ± 494 kg/ha, n=10), while the lowest was in Worabe town (1,790 ± 342 kg/ha, n=10).

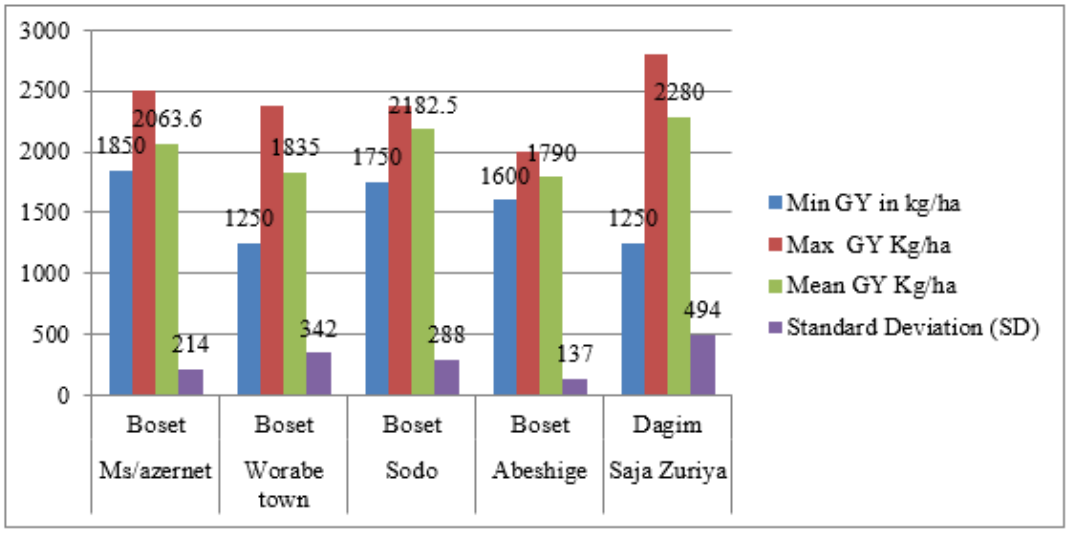


**Figure 1. Yield performance of teff in each district (Misrakazernet, Worabe Town, Sodo, and Saja zuria districts).**

**Table 3. Yield performance of teff at each district**

| District | Variety | Min GY in kg/ha | Max GY Kg/ha | Mean GY Kg/ha | Standard Deviation (SD) | NO of sampled farmers |
|---|---|---|---|---|---|---|
| Ms/azernet | Boset | 1850 | 2500 | 2063.6 | 214 | 10 |
| Worabe town | Boset | 1250 | 2375 | 1835 | 342 | 10 |
| Sodo | Boset | 1750 | 2375 | 2182.5 | 288 | 10 |
| Abeshige | Boset | 1600 | 2000 | 1790 | 137 | 10 |
| Saja Zuriya | Dagim | 1250 | 2800 | 2280 | 494 | 10 |

## 3.1 Farmers' Perceptions

Farmers have a wide range of knowledge, but they lack statistical tools to test the hypothesis and a control treatment for comparison. 20 Participants tended to believe what they perceived at each demonstration site. Likert scales are rating scales with a number of "anchors" that can be numerically or verbally displayed to allow measurements of a given item or question. a five-point Likert scale ranging from very poor to very good: very poor, poor, medium, good, and very good. Farmers were asked to give a rank from 1-5 on each attribute of the technology, where 1= very poor, 2= poor, 3= medium, 4= good, and 5= very good. Farmers rated 'Dagim' highly for market demand (median = 5) and grain yield (median = 5), while 'Boset' was particularly preferred for its early maturity (median = 5). (Table 4). According to the overall average score, both varieties had good perceptions of disease tolerance, spike length, spike count, plant height, seed size, early maturation, adaptability, crop stand, and marketability.

**Table 4. Farmers' perceptions of improved teff (Boset variety and Dagm variety) attributes at each cluster site**

| | | Misrak azernet and Saja zuria district (N=20) | |
|---|---|---|---|
| No | Criteria | Median (boset variety) | Median (dagim variety |
| 1 | Early maturity | 5 | 4 |
| 2 | Disease resistance | 4 | 4 |
| 3 | panicle length | 4 | 4 |
| 4 | plant height | 4 | 4 |
| 5 | Seed color | 5 | 4 |
| 6 | Lodging resistance | 3 | 3 |
| 7 | Straw-biomass yield | 4 | 4 |
| 8 | Seed emergence potential | 4 | 3 |
| 9 | Market demand | 5 | 5 |
| 10 | Grain yield | 5 | 5 |

## 3.2 Field day

The field day was organized at Misrakazernet district, Yerim kebele demonstration site, to involve key stakeholders and enhance better linkage among relevant actors. Thus, to demonstrate the technology, it was arranged and all concerned stakeholders were invited to the site. It was organized on October 12, 2023. It was organized by inviting different stakeholders, such as Southern Agricultural Research Institute (SARI) management and ATTC coordinator, FSRP coordinator, SARI Human Resource management and finance expert, regional agricultural experts, Worabe ARC management and ATTC researchers, and other work process researchers, Silte Zone and Woreda Level managers, Silte Zone and Misrak Azernet Woreda officials, kebele DAs, and Silte Communication Agency. Accordingly, 125 males, 43 females, and a total of 168 participants from different disciplines and sectors participated. In total, more than 67 individuals participated in the field day event, 35 of whom were female farmers (Table 5). The field day program included a visit to the fields, in-depth discussions about the activities, and reflections from farmers and

stakeholders regarding the performance of the "Boset" variety. A discussion session and result communication forum were also organized. Farmers' perceptions were further assessed. Furthermore, the participants actively discussed and established plans regarding the seed exchange system, seed collection, and marketing.

**Table 5. Field day participants in the Misrak azernet district, Yerim kebele tef cluster site**

| No | Participants | Male | Female | Total |
|---|---|---|---|---|
| 1 | SARI management and ATTC coordinator, FSRP coordinator | 8 | - | 8 |
| 2 | Regional agricultural experts | 2 | - | 2 |
| 3 | SARI drivers | 2 | | 2 |
| 4 | Worabe ARC management and ATTC Researchers and other work process researchers | 18 | 3 | 21 |
| 5 | Worabe ARC Finance experts | 3 | - | 3 |
| 6 | Worabe ARC drivers | 3 | | 3 |
| 7 | Silte Zone and Woreda level managers (Mesirak azernet and Worabe town administration) | 10 | 3 | 13 |
| 8 | DAs from ms. Azernet woreda into kebeles | 6 | 2 | 8 |
| 9 | Zone and Woreda drivers | 4 | - | 4 |
| 10 | Silte zone Communication | 2 | | 2 |
| 11 | Number of participant farmers | 67 | 35 | 92 |
| | Gross Total | 125 | 43 | 168 |

**Figure 2. Tef field days with different stakeholders: a) Yem zone, Saja Zuria district, b) silte zone, Mistak azernet district.**

## 3.3 Lessons Learned

Researchers transfer scientific knowledge about the full packages of the technology, and again, farmers share their indigenous knowledge with researchers. On the basis of the data collected from farmers through interviews, they reported that clustering of small farms (involving a large number of farmers and relatively larger land areas) provides small landholding farmers an opportunity to obtain good profits for their produce. Strong integration among stakeholders (follow-up from Districts and Zonal experts, centers, researchers, and institute leaders), the timely availability of sufficient input is a better platform for technology transfer, and the cluster was effective. They also reported that the demonstration provided better opportunities to use full packages, i.e., fertilizer, seed rates, and chemical applications, to obtain better yields, which helps farmers obtain better knowledge of the crop and opens doors to farmers to work together and share ideas and skills that they inquire from researchers and extension. They

also reported that the demonstration helped them to share seeds from neighboring farmers (farmer–to–farmer seed sharing) in FRG, and helps farmers to share ideas with each other to work, weed, and apply chemicals on time.

## 4. Discussion

The recorded tef yields across the five study sites demonstrate a productive performance that generally exceeds the current national standards, while still highlighting a significant gap when compared to the crop's biological potential. Yield variability in tef was due to differences in soil fertility status, rainfall distribution, and management practices. The variation between 1,790 and 2,280 kg/ha across the sites underscores the impact of site-specific factors. To bridge the gap toward the potentials cited by [4], future interventions should focus on site-specific fertilizer recommendations and the adoption of lodging-resistant technologies. These results indicate that Misrak Azernet, Sodo, Abeshige, and Saja district demonstration sites have higher yield than the national average teff yield data (1914 kg/ha) [7]. These results were associated with effective clustering approaches, with the best field management and variety selection. In contrast, the yields recorded in Worabe Town and Abeshige were lower than the national average yield. This might be due to lower soil fertility and poor field management, such as timely weeding. The highest grain yield in the Yem zone, Saja Zuria district, indicated that the "Dagim" variety performed better than the *Boset* variety. The highest yielding site (2,280 kg/ha) performed 19.4% higher than the national average, suggesting that the specific agro-ecological conditions or management practices at these sites are superior to the typical smallholder traditional system.

The Tef Cluster Approach is significantly more effective at closing the "Yield Gap II" (Research vs. Farm) because it treats smallholder farming as a coordinated business entity rather than a survival activity. To reach the potential yields of 2.5–3.4 t/ha cited by [4], the transition from individual "trial-and-error" to cluster-based "standardized-precision" is essential.

## 5. Conclusion

Both improved tef varieties performed well in almost all the farmers' fields. The yields recorded at the three cluster sites were greater than the national average yield (1914 kg/ha) (CSA, 2022). This was attributed to the yield potential of the varieties for the areas and the best field management practices. The evaluation of tef varieties across the study sites reveals a significant intersection between biological productivity and farmer socio-economic priorities. The improved varieties demonstrated robust performance, with peak yields reaching 2,280 kg/ha. This significantly outperforms the CSA national average of 1,910 kg/ha, proving that with stabilized inputs, these varieties can narrow the "Yield Gap II" identified in research by [4]. Beyond raw tonnage, farmers showed a strong preference for varieties that exhibit lodging resistance, early maturity (to escape terminal drought), and high straw yield, which is critical for livestock feed in the mixed farming systems of the Gurage and Yem zones. 'Dagim' was favored for its grain quality and yield stability, while 'Boset' was highly valued in lower-altitude areas for its drought tolerance.

## 6. Recommendations

To bridge the gap between current farm productivity and the research potential of tef, the following policymakers and agricultural extension services:

- Strengthen the Cluster Farming Model: Shift from individual farmer support to Tef Cluster Farming (TCF) to enable mechanized row-planting and synchronized chemical applications, which are proven to reduce lodging and labor costs.
- Decentralized Seed Distribution: Establish localized seed multiplication centers within the Gurage and Yem zones to ensure farmers have timely access to "Dagim" and "Boset" seeds, reducing the dependency on distant marketing unions.
- Integrated Lodging Management: Extension services should prioritize training on reduced seed rates and the use of growth regulators or lodging-resistant varieties to protect the high-yield gains achieved in fertile clusters.

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No funds have been received for this experiment.

## Data Availability

The required data collected for analysis are included in the manuscript. The corresponding author is ready to clarify the data and provide the necessary data set as per the request.

## Declarations/Consent for publication

I agreed on the data in the manuscript and submitted our final manuscript to this journal for possible publication.

## Competing interest

The author declares no competing interests**.**

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