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Pre-Extension Demonstration of Improved Tef (Eragrostis tef (Zucc.) Varieties in verti soil of Silte Zone, Central Ethiopia Regional State, Ethiopia

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Abstract: A pre-extension demonstration of improved tef varieties was conducted at Dalocha and wulbareg districts were selected in Silte Zone. From each district, two representative Kebeles and two farmer training centers were selected purposefully based on their accessibility and potentiality. After farmers had been selected, informative training was given in all kebeles. Tef sowing was done in collaboration with respective researchers and stakeholders based on recommended agronomic practices. In the Dalocha district, the average grain yield of Areka-1 and Standard Check varieties across the two locations was 2006.75 kg ha and 1447.67 kg ha, respectively. In the Wulbareg district, the average grain yield of Cross-37 and local check varieties across locations was 1969. Kg ha- and 1514.3 kg ha^{-1}, respectively. In the Dalocha district, the improved Areka-1 variety was selected, and in the Wulbareg district, the improved Cross-37 variety was selected by all its attributes, including yield, followed by the standard check variety. In terms of profitability, using Cross-37 and Areka-1 varieties can make it more profitable than standard varieties of both districts. Based on these facts, the Areka-1 tef variety is recommended for further large-scale demonstration in the Dalocha district, and cross-37 variety is recommended for further large-scale demonstration in the Wulbareg district and in their other similar agroecology.

Keywords: Areka-1, Cross-37, Demonstration, Tef, Variety.

Research Paper

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1. BACKGROUND AND JUSTIFICATION

Tef (Eragrostis tef) is a self-pollinated warm-season cereal crop that originated in Ethiopia and has been domesticated and used all over the world due to its excellent nutritional value as grains for human consumption and cow feed (Baye 2014). Tef is environmentally adapted to Ethiopia's many agro-ecological zones and grows more efficiently under stress than wheat, barley, and other cereals (Refissa 2012). It tolerates low moisture conditions and is frequently used as a rescue crop, surviving and growing well in the season when early-planted crops fail due to water stress. Because of this, growers consider it a "low-risk" crop. For optimal performance, it requires an altitude of 1700-2400 meters above sea level (Ayalew *et al*., 2017), an annual rainfall of 750-850 mm, and a temperature range of 10-27 °C. Tef is an important cereal crop in Ethiopia, accounting for 24.02% of all land under cultivation (first in terms of land coverage) and generating 17.57% of grain production, following only maize in terms of overall the country's grain production (CSA, 2018).

Most Ethiopian farmers are driven to sow tef since it outperforms other cereals in terms of grain and straw utilization. Culturally, tef grain is used for human consumption as Enjera, a traditional Ethiopian food. Tef has cultural and economic significance for Ethiopian farmers. It has lately become a commercial crop, attracting a worldwide market because of its nutritional value and gluten-free claims. It is considered a low-risk crop due to its low sensitivity to pests and diseases. It is a daily staple diet for around 57.20 million Ethiopians, or more than 64% of the total population (ATA, 2013).

Tef is being grown on over 3.02 million hectares of land in Ethiopia. (Gemechu *et al*., 2018). Tef is now the country's leading cereal in terms of area covered. The average national yield of tef in the 2021–2022 cropping season is only 1.91 tons ha-1, which is

extremely low when compared to the yield produced at research stations, which ranges from 2.53 to 3.2 tons ha-1, and its yield potential (Solomon *et al*., 2017). Nevertheless, tef made up 17% (5.28 million tons) of the total cereal grain produced (CSA, 2018). Farmers in the area were introduced to some improved tef varieties, but they did not use the adapted tef variety in larger areas with its recommended tef production, and despite the presence of tef potential agro ecology in the area, productivity was below its potential.

From Worabe agricultural research crop directorate, adaptation of selected tef varieties was done; the highest tef yield obtained was 1629 kg ha^{-1}. I decided that it should be demonstrated in a wider farmers' field. Standing from this, I am initiated to demonstrate these adapted, improved tef varieties. Therefore, this was initiated to create awareness on improved tef varieties among farmers and stakeholders; to enhance farmers' knowledge and skill of application of the demonstrated technology; and to receive farmers and other stakeholders' preferences about introduced tef varieties.

2. MATERIALS AND METHODS

Description of the Study Area

The administration of the Silte Zone is one of the seven zones and three special Woredas that make up the 2700.04 square kilometer central Ethiopia region. It is approximately located between 7043' and 8010' N latitude and 37086' and 38053' E longitude, according to astronomy. The South Hadiya Zone, the north East Gurage Zone, the west Gurage Zone, the north-east Mareko Special Weda, the east Oromia Region, and the south-east Halaba Zone are its neighbours.

Geographically, the area The Wulbareg district is situated at latitude 7°47'N and longitude 38°08'E. The study site is located 215 kilometers from Hawassa, the regional city of SNNPRS, and 182 kilometers from Addis Ababa, the capital of Ethiopia (Figur 1). The district is bounded to the north by Hadiya Zone, to the south by Sillte woreda of Silte Zone, to the north-west by Mesrake Azernet of Silte Zone, to the east by Sankura Woreda of Silte Zone, and to the northeast by Shashogo Woreda of Hadiya Zone (Figure 1).

Dalocha District is one of Ethiopia's Silte Zone districts. Dalocha is located in the Silt'e Zone and is surrounded by Sankurra on the south, Wulbareg on the west, Silte on the north, and Lanfro on the east. The western section of Dalocha was used to establish Wulbareg woreda/district. Dalocha has 32 kilometers of all-weather roads and 36 kilometers of dry-weather roads, with an average road density of 98 kilometers per 1000 square kilometers (Figure 1).

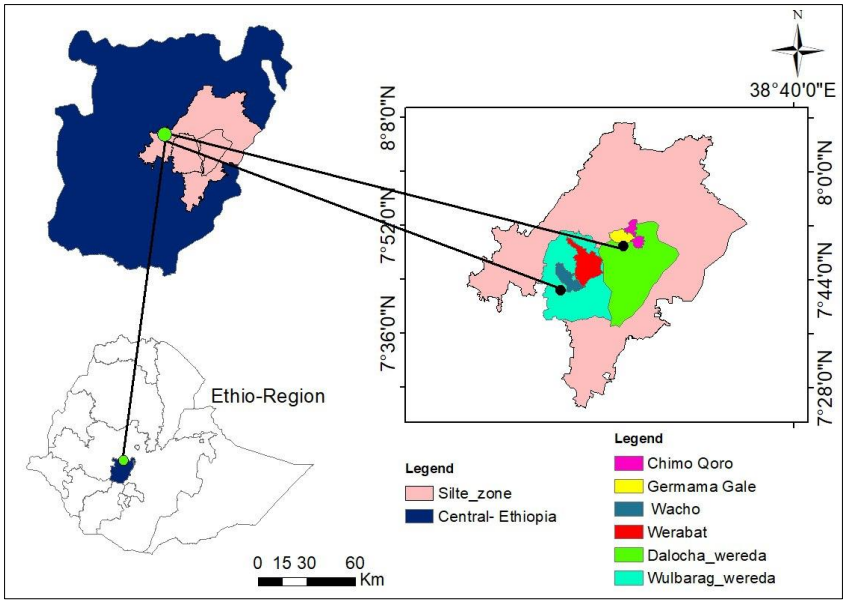

Figure 1: Map of the study area

Site and Farmer Selection

Dalocha and wulbareg districts were selected in the Silte zone. From each district, two representative Kebeles and two FCTs were selected purposefully as demonstration sites of the varieties based on their accessibility and potentiality. At each kebele, 5 farmers and 1 FTC (total 6 plots) were selected based on the willingness to participate in the activity and availability of sufficient farm land they have (a minimum of 0.5 ha), initiatives to implement the activity, good field management, and willingness to explain the technologies to others. These were the criteria used to select farmers. Gender and youth balance were strictly considered. Participant farmers shared knowledge and skills with other farmers at the end of the demonstration. The district

bureau of agriculture was to hand over the work at the end of the demonstration.

Implementation Procedures

Training

After farmers have been selected, informative training was given in both districts in order to develop their awareness based upon the activity. All concerned stakeholders, such as district agricultural extension bodies, farmers, researchers, and development Agents were participated in the training (Table 1).

Table 1: Number of total training participants at each kebele

Location		Farmers			Development Agents			Agricultural extensions			Researchers			Gross total
District	Kebele	M	F	T	M	F	T	M	F	T	M	F	T	
Dalocha	Germama	10	5	15	2	1	3	1	-	1		-		21
	Koroch	9	4	13	1	1	2	1	-	1	2	-	2	18
Wulbareg	werabet	5	1	6	2	1	3	2	-	2	2	-	2	13
	Wacho	11	3	14	2	-	2	2	-	2				18
Total		35	13	48	7	3	10	6	-	6	4	-	4	
		59			10			6			4			68

Agronomic Inputs and Practices

All the necessary inputs, such as tef seed and fertilizers, were provided to the farmer based on the recommended packages (Table 2). Tef sowing was done in collaboration with respective researchers and stakeholders based on the following method.

Table 2: Agronomic practices (packages)

Crop	Variety	Area (ha)	Farmer's site	FTC	Seed provided in kg	Amount of fertilizer utilized (kg)	
						NPS	UREA
Dalocha (germama & korochimo kebele)	Areka -1	3	10	2	50 (16kg/ha)	300 (100 kg/ha)	275(100 kg/ha)
	Standard check	3			50 (16kg/ha)	300 (100 kg/ha)	275
Wulbareg (werabet and wacho k)	CR-37	3	10	2	50 (16kg/ha)	300 (100 kg/ha)	300
	Standard check (Quinco)	3			50 (16kg/ha)	300 (100 kg/ha)	300
Total		12	20	4	200	1200 kg	1150

NB: FTC= Farmers Training Centre

Farmer's Plot: for Dalocha district = Areka-1 and standard check variety; for wulbareg district = Cr-37 and standard check variety.

Plot Size: 0.5 ha (0.25 ha for improved and 0.25 ha for S. check variety)

Seed Rate: 16kg/ha

Fertilizer: 100 kg/ha NPSB and 100 kg/ha urea split application (1/3 at planting and 2/3 after 40 days).

3. Data Collection

Data has been collected using appropriate data collection methods (random sampling, assessments, and preference rating), including focus group discussions (FGD), direct field observation, and measurements.

Yield data and the total number of farmers, developmental agents, and other stakeholders who attended training, field visits, and field days were gathered. Feedback on farmers' perceptions of the performance of the technology was also evaluated.

4. Data Analysis

The data was analyzed with SAS statistical software version 9.2. Data other than yield data was evaluated using descriptive statistics such as mean, frequency distribution, and percentages. In addition, descriptive approaches were used to assess farmers' perspectives and feedback from other stakeholders.

4. RESULTS AND DISCUSSION

Grain Yield Performances of the Demonstrated *tef*

In wulbareg district, the analysis of variance revealed that there was a statistically significant ($P< 0.05$) difference in grain yield between the two varieties (Cross 37 and the standard check), but it did not show a significant difference among farmer's plots or between locations (Table 3).

The grain yield table shows that Cross 37 (1969.6 kg ha^{-}) had a significantly higher grain yield than the standard check (1514.3 kg ha^{-}) (Table 4). Kebede and Korji (2017) reported that the grain yield of Cross 37/Tsedey Tef variety was higher than the local variety and this variety was preferred by farmers in the area.

Table 3: The ANOVA table in Wulbareg district

Source	DF	MS	P Value
Farmer	5	222179.542	0.4755
Variety	1	1243515.375	0.0347
Location	1	74037.042	0.5813
Error	16	233598.052	

DF = Degree of freedom; MS = Mean of square

Table 4: The mean grain yield of tef at wulbareg district

Variety	Grain yield (kg ha^{-})
Cross 37	1969.6a
Standard check (Quncho)	1514.3b
CV	27.75
LSD	418.29

CV = coefficient of variation; LSD = list significant difference. The letters 'a' and 'b' show there was a significant difference between the two treatment means.

In Dalocha district, the analysis of variance revealed highly significant ($p< 0.001$) variations among the tested varieties for grain yield and highly significant among the farmer's plot, but did not show a significant difference between locations (Table 5). The mean grain yield of the Areka-1 variety was 2006.75 kg ha^{-}, which is significantly greater than the yield of the standard check (Quncho) variety (1447.67 ha^{-}) (Table 6).

This result is similar with the findings of Bekele *et al*., 2024, who reported that demonstrated Areka-1 tef variety had higher yield over standard check (Quncho variety). Balcha. 2023 also reported similarly. The yield of the two improved Tef varieties was higher than the national average tef grain yield (CSA, 2022). These were due to its adaptation to the particular environment and its variety improvement.

Table 5: The ANOVA table of tef in Dalocha district

Source	DF	MS	P-value
Farmer	5	382711.342	0.0011
Variety	1	1875445.042	<.0001
Location	1	68373.375	0.2757
Error	16	53677.93	

DF = Degree of freedom; MS = Mean Square

Table 6: The mean grain yield of tef varieties of "Dalocha" district

Variety	Grain yield (kg ha^{-})
Areka-1	2006.75a
Standard check (Quncho)	1447.67b
CV	13.41
LSD	200.51

CV = coefficient of variation; LSD = list significant difference; the 'a' and 'b' show there was a significant difference between two treatment means.

Farmers Preference Ranking

At maturity, the cultivars were appraised using the farmers' selection criteria. Furthermore, 10 evaluation farmers' teams in each area assessed farmers' preferences for two varieties: Areka-1 and standard check variety in Dalocha, and Cross-37 and standard check checkvariety in Wulbareg. In this activity, farmers were selected based on their own evaluation criteria (Asredie *et al*., 2017) and then ranked using the score ranking technique (Kebede *et al*., 2018). Each variety was evaluated against the criteria and categorized based on the weight assigned to each parameter. At the final stage of the evaluation process, the results were displayed to the testers, and a discussion was held on the next steps. Farmers weighed each variety for specific traits that they felt were important, and the varieties were ranked on a scale of 1-5, with 1 being very poor and 5 representing superiority (Makosa, 2018). Based on the overall mean score, the best preferred variety was evaluated and ranked. Hence, in the Dalocha district, the improved Areka-1 variety was selected for all its attributes, including yield (Table 7). In the Wulbareg

district, the improved Cross-37 variety was selected for all its attributes, including yield, followed by the local check variety (Table 8). Areka-1 and Cross-37 varieties outperformed most of the evaluated preference criteria, including grain yield (Aliyi *et al*., 2016). The result of this demonstration was similar to Basha Kebede and Dembi Korji, 2017; Basha *et al*., 2021, who reported that both improved varieties used for demonstration were white, which demands the market.

Table 7: Preference ranking of Farmers in 'Dalocha' district

Variety Name	No	Criteria	Average score	Rank
Areka-1	1	Lodging resistance	4.5	1st
	2	Early maturity,	4.4	
	3	Disease tolerant	4.6	
	4	seed color	4.3	
	5	seed size	4.2	
	6	Tillering capacity	4.4	
	7	Grain yield	4.8	
	8	Marketability	4.7	
	9	spike length	4.4	
	10	plant heights	4.3	
		Total average	**4.46**	
S.check/ Quinco variety	1	Lodging resistance	4	2nd
	2	Early maturity,	3.6	
	3	Disease tolerant	3.7	
	4	seed color	3.6	
	5	seed size	4	
	6	Tillering capacity	3.5	
	7	Grain yield	3.9	
	8	Marketability	4.2	
	9	spike length	3.9	
	10	plant heights	3.6	
	Total average		3.8	

Table 8: Preference ranking of farmers in "wulbareg" district

Variety Name	No	Criteria	Average score	Rank
Cross-37	1	Lodging resistance	4.3	1st
	2	Early maturity,	4.2	
	3	Disease tolerant	4.5	
	4	seed color	4.2	
	5	seed size	4	
	6	Tillering capacity	4.3	
	7	Grain yield	4.7	
	8	Marketability	4.7	
	9	spike length	4.2	
	10	plant heights	4.2	
		Total average	**4.33**	
S.check/Quinco	1	Lodging resistance	3.9	2nd
	2	Early maturity,	3.8	
	3	Disease tolerant	3.7	
	4	seed color	3.8	
	5	seed size	3.7	
	6	Tillering capacity	3.4	
	7	Grain yield	3.8	
	8	Marketability	4.1	
	9	spike length	3.8	
	10	plant heights	3.5	
	Total average		**3.75**	

Cost Benefit Analysis

In Wulbareg district demonstration sites, the higher net benefit (Birr 145,317.20 ha^{-1}) was recorded from the Cross-37 variety than the standard check variety (Birr ha^{-1} 107,594 ha^{-1}). In terms of profitability, using Cross-37 can make it more profitable than standard check variety with an acceptable marginal rate of return (1428.9 %) (Table 9).

At Dalocha district demonstration site, the higher net benefit (Birr 146406.8 ha^{-1}) was recorded from the Areka-1 variety than the Standard Check (Quncho) variety (Birr 102214 ha^{-1}). In terms of profitability, using Areka-1 can make it more profitable than standard check variety with an acceptable marginal rate of return (1739.9%) (Table 10).

Table 9: Cost-benefit analysis of the TEF varieties for "Wulbareg" district demonstration sites

Benefits	**Cross-37**	**Standard check**
Yield obtained (kg ha^{-})	1969.6	1514.3
Seed Sale price (ETB/kg)	82	80
Gross benefit/Returns price	161,507.2	121,144
Variable Costs		
Cost for Land preparation, sowing, weeding harvesting (oxen and donkey).	5000	3500
Cost of Seed purchasing	2640	1500
NPS Fertilizers Purchase in ETB (NPS) (Birr 31X150kg)	4,650	4,650
Cost of fertilizers purchasing (UREA)	3900	3900
Total Cost (ETB/ha)	16190	13550
Net benefit (GR-TC)	145,317.2	107,594
MRR (%) = change in NB/change in TVCx100	1428.9 %	

Table 10: Cost Benefit Analysis of the TEF varieties for Dalocha district

Benefits	**Areka-1**	**Standard check**
AV Yield obtained (kg ha^{-})	2006.75	1447.67
TEF grain sale price (ETB/Kg)	81	80
Gross benefits/Returns price	162546.8	115814
Variable costs		
Price for land preparation, sowing, harvesting, and trashing	5000	3500
Seed purchasing price in ETB	2640	1600
Cost of NPS fertilizer purchase in ETB	4600	4600
Cost of UREA Fertilizer Purchase (UREA)	3900	3900
Total Variable Cost (ETB)	16140	13600
Net Benefit (GB-TC)	146406.8	102,214
MRR (%) = change in NB/change in TVCx100	1739.9%	

5. CONCLUSION AND RECOMMENDATION

During the tef pre-extension demonstration process, farmers learned about the importance and quality of improved tef varieties when compared to the standard check varieties. Results of tef yield in the Dalocha district showed that the improved Areka-1 tef variety recorded a higher yield than the local check tef variety. Based on economic analysis, the higher net return was obtained from the Areka-1 variety than the standard check (Quncho) variety. It was also preferred by participant farmers for its better agronomic performance. Results of the tef demonstration in Wulbareg district sites also showed that the improved cross-37 tef variety recorded a higher yield than the standard check tef variety. The yields of both improved varieties were higher than the national average yield. Based on economic analysis, the higher net return was obtained from the cross-37 variety than the standard check variety. It was also preferred by participant farmers for its better agronomic performance. Based on these facts, based on the preference of the farmers, grain yield obtained, and returns, both improved Areka-1 and Cross-37 tef varieties are recommended for further large-scale demonstration in each district and in their other similar agroecology.

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

Declarations

Ethical Statement and Approval

Prior to data collection through interviews, all participants (farmer, developmental agents, and other stakeholders) were fully informed about the purpose of the study, the nature of their involvement, and how the data would be used. They were assured that their participation was completely voluntary and that they could decline to answer any question or withdraw from the interview at any time without penalty or prejudice. Informed consent was obtained from all participants, ensuring they understood their rights and the confidentiality of their responses.

The protocol was approved by Worabe Agricultural Research Center evaluation and monitoring team in accordance with the center's guidelines and regulations.

Consent to Participate: All research involving human subjects, freely-given, informed consent to participate in the study must be obtained from this research participant.

Consent for Publication: we agreed on data in the manuscript and submit our final manuscript to this journal.

Competing Interest: The author declares no competing interest.

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