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RESEARCH ARTICLE

Evaluation of improved tef varieties in Oda Bultum and Chiro districts of West Hararghe, Ethiopia by extension based and participatory breeding approach

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Abstract

Tef is the most important cereal crop in Ethiopia, with the largest acreage among cereal crops. A research study was conducted in Oda Bultum and Chiro Districts to introduce new varieties and a new production system. A participatory breeding approach was used in the present study by involving farmers in selecting varieties suitable for their conditions and environments. The study was carried out in six villages in the Oromia Region's Chiro and Oda Bultum districts, purposefully selected due to the high number of Tef-producing farmers in these areas. The varieties used were Bishoftu, Ebba, Dagim, and a local variety taken from respective farmers. Simple statistical tools such as average and percent were used to calculate the technology gap, extension gap, and technology index of tef. ANOVA was used to analyze the data. The results of the study showed that the demonstration had a positive effect on enhancing the yield of tef in the study area. The Dagim, Ebba, and Bishoftu plots showed a significant increase in productivity, with average increases of 26.7%, 22.9%, and 55.9% over the district yield, respectively. The ANOVA results also revealed that there was a statistically significant interaction between the use of improved varieties and the yield of tef ($F (1, 28) = 7.79$, $P = 0.0094$). Furthermore, using improved varieties had statistically significant effects on yield. The study concluded that effective extension interventions for demonstrating the potential of tef varieties in farmers' fields.

Keywords: Demonstration, improved Tef varieties, yield

Introduction

Eragrostis tef, commonly known as tef is a type of warm-season annual cereal crop that is currently underutilized. Tef has the potential to contribute towards food security and crop diversification. The crop is rich in high and unique nutritional values, which makes it an excellent choice for health-conscious consumers. Moreover, it is a low-risk crop that can resist many biotic and abiotic stresses. Presently, Ethiopia is the largest producer of tef and the only country that has adopted it as a staple crop (Tadele and Hibistu, 2021). However, the production and value chain of tef in Ethiopia primarily rely on traditional methods. Additionally, the tef market in Ethiopia is constrained by the government's export ban. In contrast, other countries, such as the USA are increasingly taking part in the tef market (Lee and Hyejin, 218). Tef is the most significant cereal crop in Ethiopia, with the largest acreage among cereal crops.

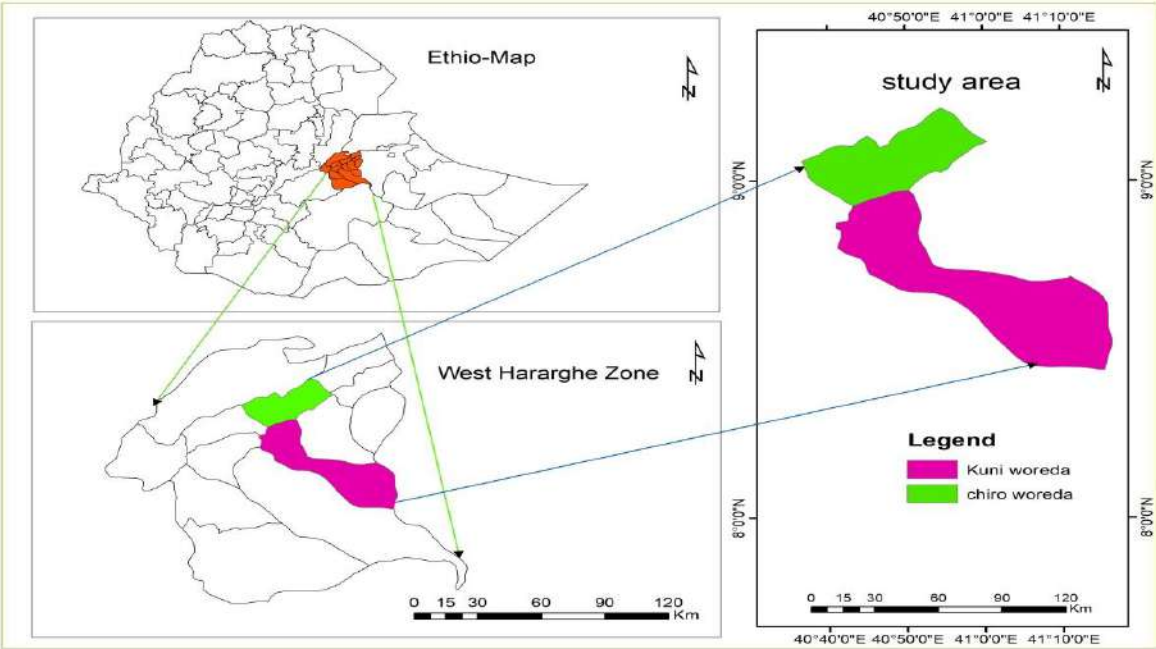
Over 7.15 million farmers, which constitute 45% of all cereal farmers in the country, cultivate tef annually on approximately 3.10 million hectares. About 5.73 million metric tons of grains are harvested from this cultivation, accounting for nearly 30% of the total acreage and 20% of the gross grain production of all cereals grown in Ethiopia (Bekele *et al.,* 2021). Tef is a highly profitable commodity in Ethiopia, with a market price that is frequently two to three times higher than that of maize, the country's most produced commodity (Bachewe *et al.*,2019). This makes tef an important cash crop for farmers. However, due to its high price, urban affluent consumers tend to consume more tef than rural poor (Zhu and Fan, 2018). In 2012, 35% of tef producers adopted improved tef seeds, compared to only 7% in 2002. Although it has increased over the decade, national production of tef still averages at 17.48 quintals per hectare. However, improved varieties of tef can produce more than 24 qt/ha (Ali *et al.,* 2019). Various factors can cause fluctuations in farm yield over time, and the significance of each factor may vary depending on the region and crop. The basic idea is that the primary factor driving FY progress is the adoption of consistently improving technologies, such as new crop varieties, better management techniques, and improved decision-making by farmers. Many others in the field share this assumption (Bell *et al.*,1995). Approximately 16,610.5 hectares of land in the West Harerghe zone is used for tef production. Shockingly, only 5% of the total cultivated land is planted with improved seed. This highlights a lack of tef extension services and other potential factors that hinder the area's adaptation to improved tef varieties. Currently, the Chiro National Sorghum Research Training Center (CNSRTC) has tested improved tef varieties for their adaptability, but the outreach has not yet been completed. In a participatory breeding approach farmers are involved in selecting genotype suitable for their conditions and environments and preferences. In most cases farmer's choice would be to select variety which will outperform locally grown variety. Therefore, the purpose of this initiative is to raise awareness among the farming community and increase the adoption of improved tef varieties by demonstrating and comparing improved tef varieties and cultivation practices with local varieties and farming practices in West Harerghe (WHZAO, 2021).

Materials and methods

Description of the study area

The study was conducted in Oda Bultum and Chiro Districts, which are part of the West Hararghe Zone in the Oromia National Regional State of Ethiopia. The West Hararghe zone is made up of 15 districts, including Oda Bultum and Chiro. Oda Bultum is located at an elevation of 1761 m above sea level, while Chiro is situated at an altitude ranging from 1830 to 3200 meters above sea level. These two districts are approximately 373 and 324 kilometers away from Addis Ababa, respectively. Chiro is located between longitudes 9° 4' 60" North and 40° 52' 0" East, while Oda Bultum is situated between latitudes 9.0701° N and 40.8688° E. The minimum and maximum temperatures experienced in Oda Bultum and Chiro are 22°C and 23.9°C, respectively, with annual precipitation totals of 950–1200 mm and 700–1100 mm. Both districts experience a bimodal rainfall distribution pattern. The first short rainy season, known as "belge", starts in the first week of March and ends in May. The second main rainy season, locally named "Gena," begins in the first week of June and ends late in September. The farming systems in both districts are categorized as crop-livestock farming systems. According to the District Office of Agriculture in 2022, major crops produced using irrigation includes onions, carrots, tomatoes, potatoes, cabbage, sugarcane, sweet potatoes, hot peppers, and chats.

Fig.1: Map of the study area



This research study was conducted in six villages in the Chiro and Oda Bultum/Kuni districts of Oromia Region to introduce new tef varieties and a new production system. These villages were selected purposefully due to the high number of tef-producing farmers in these areas. Twelve host farmers were also purposely selected based on their willingness to host the demonstration trial. The districts and villages were chosen in collaboration with zonal and district experts to ensure the sustainability of extension service delivery.

A participatory breeding approach was used in the present study by involving farmers in slecting genotypes suitable for their conditions and environments. Four different varieties of Tef seeds were sown on well-prepared soils with 20cm rows between them. The varieties used were Bishoftu, Ebba, Dagim (acquired from Debrezeiet Agricultural Research Center), and a local variety taken from respective farmers. Each demonstration field was carried out on 0.2 hectares of rain-fed land, and a seed rate of 15 kg/ha was used for the demonstration. All necessary agronomic management procedures, such as weeding, hoeing, and fertilizer application (NPS (20 kg/ha) and Urea 50 kg/ha), were applied uniformly to all demonstration plots. The appropriate technology packages were provided to the host farmers and their development agents. Field events, including village-level field days, were organized. Yield data for improved practices, farmers' practices, improved varieties, and local variety were recorded at the time of threshing. Before planting, a checklist and data collection sheet was created to gather agronomic and yield data. The data was collected from all the demonstration plot farmers through personal observations and interactions. The technology gap, extension gap, and technology index of tef were calculated. Simple statistical tools and ANOVA were used to analyze the data and examine the extent to which the two independent variables were statistically associated with yield in the study areas.

The CNSRTC scientist oversaw the demonstration plot and recorded the yield performance of different varieties, farmers' practices, and improved farming practices during demonstrations. The technology gap, extension gap, and technology index were calculated using the proposed methods by (Singh *et al.*, 2022).

$$(1)\quad \text{Impact on yield (\%)} = \frac{\text{Demonstrated yield}}{\text{Farm practice yield}} x100$$

$$(2)\quad \text{Extension gap} = \text{Demonstrated Yield} - \text{farm practice yield}$$

$$(3)\quad \text{Technology gap} = \text{Potential Yield} - \text{Demonstrated yield}$$

$$(4)\ \text{Technology index (\%)} = \frac{\text{Potential Yield} - \text{Demonstrated yield}}{\text{Potential yield}} x100$$

Results and discussion

The following report presents the impact of a pre-extension demonstration on awareness creation and the evaluation of yield performance for different varieties and improved row planting methods. The results are shown in table 1, where the average yield in Dagim, Ebba, Bishoftu, and local check demonstrated plots was 1.92 t ha-1, 1.8625 t ha-1, 2.3625 t ha-1, and 1.515 t ha-1, respectively. The average yield of farmer farming practices plots was 1.7 t ha-1, 1.6125 t ha-1 2.05t ha-1 and 1.3 t ha-1, respectively. This indicates that the average yield of the Dagim, Ebba, Bishoftu, and local check demonstration plots increased by 12.9%, 14.7%, 15.1%, and 13.97%, respectively, when compared to the farmers' farming practices. The results demonstrate the positive effect of the demonstration on enhancing the yield of tef in the demonstrated area. In particular, the Dagim, Ebba, and Bishoftu plots showed a significant increase in productivity, with average increases of 26.7%, 22.9%, and 55.9% over the district yield, respectively.

Based on growth, vigour and local test preferences Dagim, Ebba, Bishoftu varieties were preferred. During the demonstration period, there was a difference in yield between the potential yield and the yield in the demonstration plot. Specifically, the difference was 0.88 t ha-1, 0.2925 t ha-1, 0.4375 t ha-1, and 0.185 t ha-1 for Dagim, Ebba, Bishoftu, and local check, respectively, as shown in table 1. This difference indicates that there is a yield gap in the demonstrated technologies, which is a result of improved farming practices and varieties. The reasons for this gap could be attributed to factors such as soil type, individual farmer crop management skills, particularly harvesting and threshing, and local climatic conditions. To close these gaps, it is necessary to improve farmers' crop management skills, use improved high-yield varieties, and make location-specific recommendations. Extension gaps were observed as 0.22 t ha-1, 0.25 t ha-1, 0.3125 t ha-1, and 0.215 t ha-1 for Dagim, Ebba, Bishoftu, and local check, respectively, during the demonstration period (Table 1). The outcome indicated that various extension methods should be used to fill it. This emphasized the importance of educating farmers through various techniques for the adoption of improved agricultural production technologies to reverse the trend of wide extension gaps.

The increased use of cutting-edge production technologies with high-yielding varieties will eventually reverse the alarming trend of galloping extension gaps. The technology index reveals the practicality and importance of the showcased technology in the farmer's field. The average technology index was found to be 26.42%, 29.71%, 43.75%, and 10.79% for Dagim, Ebba, Bishoftu, and the local check, respectively (Table 2). The results indicate the need for technical interventions and the use of improved varieties to improve yields. This will encourage the adoption of demonstrated technological interventions to enhance the yield performance of the varieties. The variations from location to location in the results suggest that the outcome may vary depending on soil fertility, weather conditions, and crop management practices. By implementing improved practices, the technology gap can be minimized, resulting in a reduced technology index.

Table 2: Gap in grain yield production of Tef under pre extension demonstration

Technology demonstrated	**District**	**Potential yield of variety**	**Average yield (t ha^{-1})**		**Impact of yield (%)**	**Technology gap**	**Extension gap**	**Technology index (%)**
			Demonstration Plot	Farmers' practice		(t ha^{-1})	(t ha^{-1})	
Dagim	O/Bultum	28	1.975	1.725	14.49	0.825	0.25	19.46
	Chiro	28	1.865	1.675	11.34	0.935	0.19	33.39
	Average	28	1.92	1.7	12.915	0.88	0.22	26.425
Eba	O/Bultum	26.5	2.175	1.775	22.53	0.475	0.4	17.92
	Chiro	26.5	1.55	1.45	6.89	0.11	0.1	41.5
	Average	26.5	1.8625	1.6125	14.71	0.2925	0.25	29.71
Bishoftu	O/Bultum	28	2.625	2.25	16.66	0.175	0.375	62.5
	Chiro	28	2.1	1.85	13.51	0.7	0.25	25
	Average	28	2.3625	2.05	15.085	0.4375	0.3125	43.75
Local cheek	O/Bultum	17	1.68	1.35	24.44	0.02	0.33	1
	Chiro	17	1.35	1.25	3.5	0.35	0.1	20.58
	Average	28	1.515	1.3	13.97	0.185	0.215	10.79

The study aimed to determine if the use of improved varieties, namely Bishotu, Dagim, and Ebba, as well as different farming practices, affected the yield of tef in the study area. To investigate this, a two-way ANOVA was conducted to assess the impact of improved varieties and row planting on the yield of tef. The results of the ANOVA (Table 3) revealed a statistically significant interaction between the use of improved varieties and the yield of Tef ($F (1, 28) = 7.79$, $P = 0.0094$). According to the main effect analysis, using improved varieties had statistically significant effects on yield. Using raw planting, on the other hand, had no statistically significant effect on the yield. The CNSRTC organized a program called PED to promote the use of crop-recommended technologies. The program helped to expand the use of these technologies rapidly. The results showed that the average yield of Dagim, Ebba, Bishoftu, and local check demonstration plots increased by 12.9%, 14.7%, 15.1%, and 13.97%, respectively, when compared to the farmers' traditional methods. This demonstrates the positive impact of the demonstration on the yield of tef in the demonstrated area. A participatory breeding approach involving farmers in selecting genotypes suitable for their conditions and environments Dagim, Ebba, Bishoftu were preferred.

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Fig. 2: Comparison of the demonstration plot by district and variety.

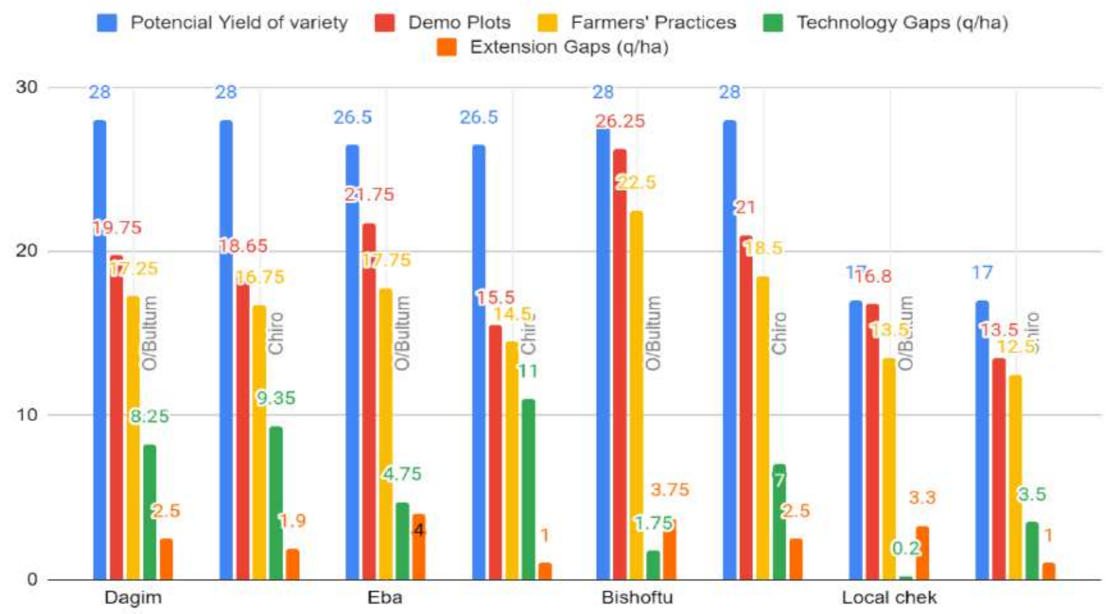

Table 3: Two way ANOVA result

Source of intervention	Seq. SS	df	MS	F	Prob > F
Model	199.994501	3	66.664833	4.86	0.0076
Interaction	106.88113	1	106.88113	7.79	0.0094
Use of improved varieties	67.4246676	1	67.424668	4.91	0.0349
Farming practice	25.688704	1	25.688704	1.87	0.1821
Residual	284.12099	28	13.718607		

The demonstrated technology of Dagem, Ebba, and Bishoftu produced average productivity that was 26.7%, 22.9%, and 55.9% higher than the yield of the districts, respectively. Through PEDs, farmers are made aware of the benefits of using improved varieties, weed management, fertilizer application, seed rate, sowing methodology, and other recommended practices for tef crops. The conclusion is that PEDs are effective extension interventions for demonstrating the potential of crop varieties in farmers' fields. The study recommends that extension agencies should play an active role in transferring and implementing agricultural technologies on farmers' fields. This will help increase crop productivity through the national agricultural research system. Additionally, stakeholders should provide sufficient financial support for large-scale production while agricultural scientists and extension professionals closely supervise the process.

Under the participatory breeding approach scheme involving farmers in selecting genotypes suitable for their conditions and environments Dagim, Ebba, Bishoftu were preferred by farmers. Using this demonstration work as a foundation, the agriculture offices at the woreda and zonal levels should scale up the technology. This strategy of replacing unproductive crop varieties with productive ones through PEDs and based on farmers preferences can help increase the productivity of tef and other crops at micro, and macro levels.

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