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Promotion of Improved Tef (Eragrostis Tef) Technologies through Cluster-based Large Scale Demonstration in Enemay and Shebelberenta Districts of East Gojam Zone, Ethiopia

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Abstract
Tef (Eragrostis Tef) is Ethiopia's most important cereal crop, and it plays an important role in the food and nutrition security of smallholder farmers. Despite its importance in terms of both production and consumption, the productivity of Tef grain is relatively low (18.5 qha^{-1}). The low productivity of Tef is mainly due to farmers' lack of access to improved varieties coupled with low adoption of the recommended package of practices. This activity is, therefore, conducted with the objectives of creating awareness and wider access to improved Tef varieties using cluster-based Large-Scale Demonstration (LSD) approach in two potential districts of East Gojam Zone, Amhara region. Two varieties, namely Dagim and Kora, were demonstrated along with the recommended packages of practice at farmers' land during the 2019/20 main planting season. Yield data was collected and analyzed using descriptive statistics. Whereas the preference of farmers and feedback on the varieties were analyzed using narration respectively. According to the results, the mean grain yield of 28.55 and 25.3 qha^{-1} was obtained from the Dagim and Kora varieties respectively implying that an increment of about 7.8 qha^{-1} yield advantage for Dagim and 4.5 qha^{-1} for Kora variety over the zonal average productivity of the reporting year. Thus, it is important to conclude that the approaches in general and the technologies demonstrated in the respective districts, in particular, are promising in terms of increasing the production and productivity and hence contributing to the food security of farmers in the respective area. Therefore, the selected varieties should be scaled up in the target areas and other unaddressed areas with similar agroecology by involving all the concerned stakeholders at various levels, including government sectors, non-governmental organizations and other private sectors.
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1. INTRODUCTION

Tef (Eragrostis *Tef*) is the most important cereal crop in Ethiopia. The crop is annually grown on over 3.1 million hectares of land, accounting for about one-third of the total cereal acreage and about one-fifth of the gross cereal grain production in the country (CSA, 2019). Moreover, it is one of the most important crops for Ethiopia's agricultural economy, both in terms of consumption and production. In 2017, *Tef* accounted for about 24% of the nationwide grain-cultivated area followed by maize 17% and sorghum 15%, and nearly half of the smallholder farmers grew it between 2004 and 2014 (Hyejin Lee., 2018 and CSA, 2017). For dietary requirements, the country relies on *Tef* for two-thirds of the daily protein intake and 11% of the per capita caloric intake (Anadolu Agency, 2015 and Crymes AR., 2017). Its high nutritional quality and the absence of gluten make *Tef* increasingly popular even outside Ethiopia, which increases the demand for *Tef* (Andersen and Winge, 2012).

Despite the crucial importance of *Tef* in the national food security, nutrition and income generation for smallholder farmers of Ethiopia in general and in the Amhara region in particular*,* both the total production and productivity of *Tef* is relatively low. According to the Central Statistical Authority of Ethiopia (CSA, 2019/20), the national average grain yield of *Tef* is about 18.5 qha^{-1}. The main contributing factor to *Tef's* low productivity is attributed primarily because *Tef* growers low access to technology/innovations coupled with low adoption of the recommended package of practice. (Kebebew *et al*., 2017).

Until 2019, the National Agricultural Research System (NARS), which primarily comprising of the Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Research Institutes (RARIs), released 49 improved *Tef* varieties in Ethiopia (MoANR, 2019). Parallelly, efforts have also been made to transfer and popularize those varieties to farmers in various areas of the country where Tef is intensively grown using the pre-extension demonstration and popularization approaches.

Despite the efforts made so far in generating and transferring agricultural technologies, the rate of adoption has remained low (Kebebew *et al*., 2017), owing to a lack of location-specific recommendations, insufficient capacity to multiply source technologies and uncoordinated demand creation demonstration activities. Moreover, the extension approaches commonly used so far in disseminating the research outputs have not been visible to create excitement among the wider community and best address the different agro-ecologies, production systems, and regions of the country. To address these issues, a new approach known as Large scale technology Demonstration (LSD) was designed forthe demonstration and dissemination of agricultural technologies, with a prominent feature of using a technology as a package instead of the variety alone, the use of clustered large scale farmer' fields, and the involvement of a coordinated multi-stakeholder partnership, training and technical backstopping supplemented with continuous monitoring and evaluation. (Assefa *et al*. 2011a, b; Assefa and Chanyalew 2018).

Therefore, this activity was carriedout to demonstrate recently released *Tef* varieties along with the recommended production packages using a large-scale clustered farm approach, to create awareness and broaden access to the varieties and thereby improve the production and productivity of farmers in potential Tef producing areas of Enemay and Shebelberenta districts of East Gojam Zone, Amhara region.

2. MATERIAL AND METHODS

2.1. Description of the Study Area

The activity was conducted in the Enemay and Shebelberenta districts of East Gojam zone of the Amhara regional state during the 2019/20 main planting season. The districts were selected purposively based on their production potential for Tef. The districts are located in the highlands, where there is a high potential for production and suitable climate for Tef production. These areas are generally characterized by a mixed crop-livestock farming system. Farmers in the study area produce primarily staple crops, such as, Tef, sorghum, maize, wheat, barley, potato, and fababean.

Enemay District is one of the districts in the Amhara Region of Ethiopia. Part of the East Gojam Zone and bordered on the south by Dejen, on the west by Debay Telatgen, on the north by Enarj Enawga, and on the east by Shebel Berenta.it is located geographically between 10° 39' 59.99" N Latitude and Longitude: 38° 00' 0.00" E. The district has 30 kebele administrations (KAs), of which five are semi-urban areas. The district is endowed with three agro-ecological situations: lowland, midland, and highland. The highland area coverage, which is above 2300 meters above sea level, accounts for more than 75% of the total land area coverage of the district. Like any other part of the country, 85% of the population exclusively depends on agriculture. Subsistence, rain-fed and smallholder agriculture is the mainstay for the district's rural population. *Tef* is the dominant crop, both for consumption and cash income. From 2009 -2013 of the top 25 producing districts in Ethiopia, the district ranked 2nd next to the Adea district of East Shewa (Jams Wraner, 2015). The average production of *Tef* is about 26 quintal per hectare. Barley, wheat, and maize are also other major crops of the district and their average production is 24, 29 and 30 quintals per hectare respectively. According to the Municipal Agriculture Office (MAO), the productivity of farmers has decreased significantly in recent years. Although farmers have adopted and are willing to use yield-increasing inputs such as inorganic fertilizer and improved seed varieties, shortages of the inputs and their inflated prices are hindering factors for the Enemay community. As a result, farmers are not obtaining the level of benefits expected. Shortages of yield-increasing inputs and the lack of improved farming practices hinder production and productivity in the district (World Vision - Ethiopia, 2020).

Shebel Berenta District is located in East Gojam Zone, situated in the North Central Highlands of Ethiopia in the Amhara region. It extends from 10° 15′ N to 10° 30′ N latitude and from 38° 15′ E to 38° 27′ longitude (CSA, 2007 cited in Tenalem A., 2010). It is bordered on the South-West by Dejen district; on the North-West by Enemay district; on the north by Enarj Enawga district, and on the South and South-East by Abay River Gorge, which separates it from the Oromia region. The district covers a total land area of 89,714 ha. Its altitude ranges from 1800 to 2150 masl. It has 2 agro-ecological zones with (28%) *Woyina-Dega* and (72%) *Kolla*. Shebel Berenta district has 26 Kebeles, of which 2 are urban and 24 rural Kebeles. Agriculture is the mainstay of the district livelihood activities for rural residents characterized by subsistence crop production, mainly dependent on rainfall, which is erratic in nature; the dominantly traditional farming system results in low input-output crop yields (Rämi H., 2009 and Mekuriaw A., 2006).

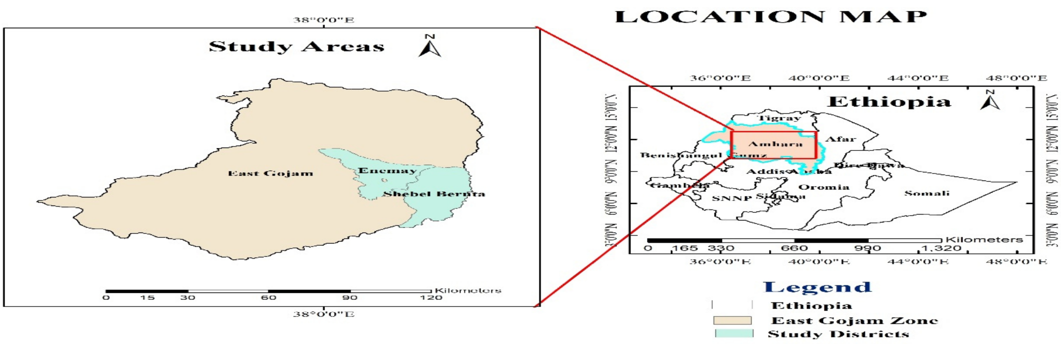


Figure 1. Map of the study area

2.2. Site and Farmers Selection

For this activity, two kebeles from Shebelberenta and three kebeles from the Enemay district were selected based on their production potential for *Tef*. Farmer's selection was conducted in collaboration with the Development Agents (DAs) of the respective Kebeles based on the availability of the required adjacent plots of land (0.25 hectares of land per head) and the willingness and interests of participation of farmers in the demonstration activity. Therefore, a total of five kebeles were selected, and 329 farmers (24 of whom were women) took part directly. Consequently, seven Tef technology demonstration clusters were established and 64 ha of land was covered by the large-scale Tef technology demonstration in the 2019/20 cropping season (Table 1).

Table1. Summary of the participating farmers and area covered from Tef technology demonstration

Location		No of Clusters	Area (ha)	No. of farmers participating		
District	Kebele			M	F	T
Shebelberenta	Gebsit	2	20	127	20	147
	Woyniye	2	25	119	1	120
Enemay	Endeshignit	1	6	25	1	26
	Adis-Alem	1	7	19	0	19
	Sir-Eyesus	1	6	15	2	17
Total		**7**	**64**	**305**	**24**	**329**

Source: field data, 2019/20

2.3. Implementation Design

2.3.1. Technology Demonstration and Evaluation Technique

Two recently released varieties, namely Dagim and Kora, were demonstrated along with the recommended production package using a cluster-based Large-Scale Demonstration (LSD) approach. Before implementing the activity, both theoretical and practical training was delivered for farmers, agricultural experts and development agents on planting methods, input application, and the general agronomic practices. A seed rate of 15 kg ha^{-1} and a fertilizer application rate of 100/100 kg ha^{-1} for N and P2O5 were applied, respectively. The participating farmers in the cluster carried out all the management practices from land preparation to harvesting.

A continuous follow-up was undertaken in the course of the implementation of the activity. Furthermore, field days were organized to evaluate the overall successes, challenges, and opportunities of the intervention, as well as to share the experiences, and lessons obtained with other similar areas. Besides, different extension materials (such as leaflets, brochures, etc.) and mass media (such as radio, and television broadcasts) were used as the technology dissemination tools for the wider dissemination of the technology in the target area.

2.4. Data Collection and Analysis

2.4.1. Type and Method of Data Collection

For this activity, both quantitative and qualitative types of data were collected through direct field observations, Focused Group Discussions (FGD), and Key Informants interviews (KII). Thus, the quantitative types of data such as the grain yield performance of the varieties, the number of farmers participating in the training, field visits and field days were collected using a structured checklist. While the qualitative types of data such as farmers' preference, and feedback from farmers on the technology were collected using FGD and KII.

2.4.2. Data Analysis

The quantitative types of data were analyzed through a simple statistical test such as percentage and mean. Whereas, the qualitative types of data such as farmers' perception, and feedback on the technology by users and other stakeholders were analyzed through narration. Furthermore, the yield gain in percent, technology yield gap and extension yield gap were also calculated using the following formula as suggested by Yadav et al. (2004).

Technology gap (qha^{-1}) = Potential Yield (qha^{-1}) - Demonstration Yield (qha^{-1})

Extension gap (qha^{-1}) = Demonstration Yield (qha^{-1}) - Farmers practice Yield (qha^{-1})

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

3. RESULTS AND DISCUSSION

3.1. Grain Yield Performance of *Tef* Technologies

The mean grain yield performance of the technologies was assessed and compared to the zonal average productivity in each district. As a result, the yield of 28.55 and 25.5 qha^{-1} obtained from the Dagim and Kora varieties, respectively. This implies that there is an increment of 37.52% yield advantage for Dagim variety and 21.87% for Kora variety over the zonal average productivity of the reporting year. The yield increment could be attributed to the application of the package approach (improved varieties along with all the recommended production and management practices) during the demonstration activity. This, in turn, implies that the technologies demonstrated in the respective districts are promising in improving the production and productivity and hence contribute to the food security of farmers in the respective area.

Table 2. The grain yield performance (qha^{-1}) of the demonstrated *Tef* technologies

Variety	Districts						Productivity (qha^{-1})		Yield gain (%)
	Shebel berenta			Enemay					
	Area (ha)	Yield (q)	Yield (qha^{-1})	Area (ha)	Yield (q)	Average yield (qha^{-1})	demo	Zonal	
Dagim	20	661.5	33.1	7	168	24	28.55	20.76	37.52
Kora	25	665	26.6	13	312	24	25.3	20.76	21.87

Source: field data, 2019/20

Note; The reported average demonstration yield and zonal average productivity of tef expressed in qha^{-1} is used as reported by the central statistics agency (CSA) for the reporting year in calculating the productivity gains of each variety at the selected districts. The zonal average productivity is used as a standard check to calculate the yield gain of the varieties demonstrated in each district.

The grain yield of the large-scale demonstration clusters across each district was also compared with the potential yields of the varieties to estimate the technological and extension yield gaps of the technologies. The technological gap was found ranges from -6.6 to 2.5 qha^{-1}, with an average technology yield gap of -0.43 qha^{-1}. The highest technological yield gap (2.5 qha^{-1}) was observed in Enemay district for both the Dagim and Kora varieties and the lowest technological gap (-6.6 qha^{-1}) was observed in Shebelberenta district. The observed highest technological yield gap might be attributed due to dissimilarity in soil fertility status, agriculture practices and local climatic situation.

Similarly, the extension yield gap during the study period varied to the extent of 3.24 to 12.34 qha^{-1} with an average extension gap of 6.17 qha^{-1} . the result further showed that the highest extension yield gap (12.34 qha^{-1}) was observed at shebelberenta district for the Dagim variety and the lowest extension gap observed at Enemay district for both the Dagim and Kora variety (3.24 qha^{-1}). The varied extension gap may be attributed to differences in soil fertility, unfavorable weather condition and local specific management situations during the study period. Therefore, the higher extension gap indicates that there is a strong need to motivate the farmers for adoption of improved technologies over their local practices. Moreover, the use of the latest production technologies with high yielding variety will subsequently improve the wide extension gap.

Table 3. The technology and extension yield gap of the demonstrated tef technologies

District	Varieties	Area (ha)	Yield (qha^{-1})			[a]Technology Gap (qha^{-1})	[b]Extension Gap (qha^{-1})
			Potential	Demo	Farmer's practice		
Shebelberenta	Dagim	20	26.5	33.1	20.8	-6.6	12.34
	Kora	25	26.5	26.6	20.8	-0.1	5.84
Enemay	Dagim	7	26.5	24.0	20.8	2.5	3.24
	Kora	13	26.5	24.0	20.8	2.5	3.24
Average						-0.43	6.17

Source: field data, 2019/20

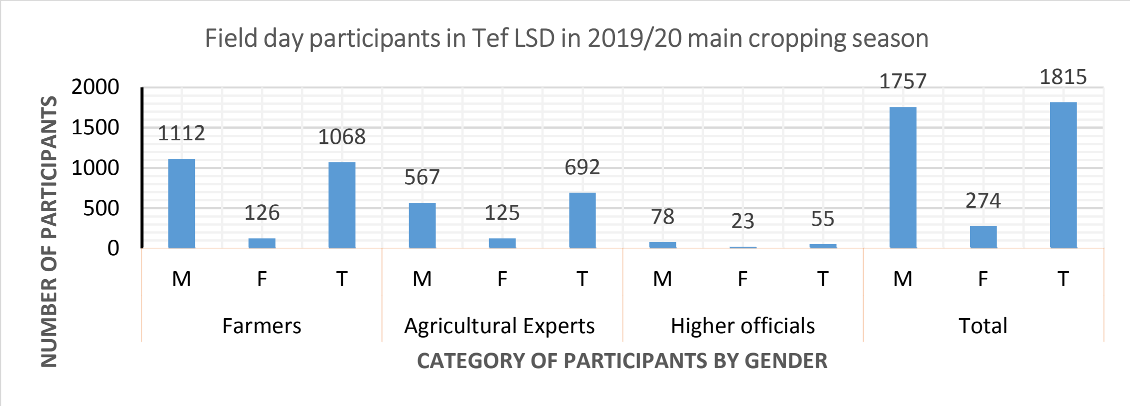
[a] Technological yield gap is the difference between yield potential and average yields of the demonstrated varieties expressed in q ha^{-}. Whereas, [b]the extension yield gap is the differences between the demonstration yield and the average yields of farmers practice expressed in q ha^{-} .Note that the yield of the farmers practice is computed from the zonal average productivity of tef as reported by the central statistics agency (CSA) for the reporting year.

3.2. Farmers and Stakeholders Feedback

Field days were jointly organized at various levels in collaboration with other stakeholders (Zone and District level Agricultural Development offices as well as participating farmers) to create awareness about the importance and availability of the technologies. Six (6) field days were held at different levels, with 1815 participants (of which 274 are women) participated in this event, including the host farmers. In the course of the field visit, the participants appreciated the practice of full package technology demonstration using the clustering approach.

"*The clusters on which technologies are tested on a larger scale than a parcel of plot is very educational, persuasive and convincing. Besides, the clustering approach motivates each other, makes it easy to share experiences, is good for getting clean seed because it prevents mixing, good for joint planning and rotation, is good and easy for applying protection measures such as pest and disease assessment as well as chemical application and good for mechanization."*

In general, during the field days, participant farmers expressed their interest in continuing the implementation of the technologies on a larger acre of land and promised to disseminate the seeds to other farmers in their vicinity. On the other hand, the non-participating farmers are convinced to adopt the technologies for the upcoming planting season and, hence, demanded the required amount of seeds from both the host farmers and the research center.



Source: field data, 2019/20
Fig1. Field day participants in Tef LSD during 2019/20 main cropping season

4. CONCLUSIONS AND RECOMMENDATIONS

According to the findings of this report, the technologies demonstrated have a higher yield than farmer's practices in all clusters of the implementing districts. The high performance of the technologies is mainly because of the use of the technology as a package (the new variety along with all the recommended management practices). It has clearly demonstrated the existence of an effective technology package that could relieve the country from food shortages and ensure food self-sufficiency. Thus, the application of a full package technology approach should be taken into consideration to improve and harness the production and productivity potential of the crop. Furthermore, the selected varieties should be promoted and scaled up to address more farmers in the target areas and other unaddressed areas with similar agroecology by involving the concerned stakeholders such as the government sectors, non-governmental organizations, and other private sectors at different levels.

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