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Research Article

Cluster based large scale demonstration and popularization of tef (*Eragrostis tef* (Zucc.)) technology at Laska Zuria District, Basketo Zone of South Ethiopia

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Abstract

In terms of production and consumption, tef is a very significant crop in Ethiopia and South Ethiopia. Urbanization, low incomes, and population increase are all contributing to the growing demand for tef. But the methodology for producing tef is still mostly reliant on conventional techniques. Consequently, the target level of agricultural yield has not been attained. In order to raise farmers' awareness of improved tef production technologies and practices, estimate improved tef production, and gauge farmers' perception of tef technology, a cluster based large scale demonstration of tef technology works was carried out in 2025 in the Laska Zuria district of Basketo Zone, South Ethiopia. The multidisciplinary teams of the Arba Minch Agricultural Research Center provided training on tef production and management to participating farmers, Kebele development agents, and district specialists. Cross-37 variety was applied to 134 farmers' fields using a seed rate of 15 kg/ha, NPS 100 kg/ha, and UREA 50 kg/ha in shallow planting with a depth of 2-4 cm. The activity covered an area of 50 ha. All data were collected from a 2 m × 2 m quadrat estimate of ten farmers' fields, and it was evaluated using basic descriptive statistics and a Likert scale to collect farmer perception.The average yield performance from the farmer's field was 1,825 kg/ha. Lastly, a planned farmer's field day visited the demonstration sites. The field activities were attended by 148 people in all. In contrast to their previous cultivars and agronomic methods, farmers valued the variety displayed as well as its agronomic techniques and practices.In comparison to the previously introduced tef variety, this one has the ability to mature early, has a high tillering rate, produces more, and is also resistant to logging. Tef technology is therefore urgently needed in every district. Thus, there is an urgent need for the area's extension.

Keywords: Cross-37, Method demonstration, Perception score, Grain yield, Basketo, Tef

Introduction

Tef is a self-pollinated, annual, warm season cereal crop; believed to have originated in Ethiopia and have been domesticated and used throughout the world. It is an ancient tropical cereal that has its center of origin and diversity in the Northern Ethiopian highlands from where it is believed to have been domesticated (Demissie, 2001). Outside Ethiopia, there is a growing interest in using tef. For example, small scale commercial production of tef has begun in a few areas of the wheat belts of the United States of America, Canada, and Australia. Tef has been introduced to South Africa and cultivated as a forage crop and in recent years cultivated as a cereal crop in Kenya and the Netherlands. As a gluten-free cereal, it is getting global attention and becoming one of the healthy grains (The Guardian, 2014). Tef is one of the major endemic staple food crops for Ethiopians.

Tef is adapted to environments ranging from drought stress to waterlogged soil conditions and diverse soil types (Miller, 2010; Refissa, 2012; Tadele & Assefa, 2012). It tolerates low moisture conditions and often considered as a rescue crop that survives and grows well in the season early planted crops fail due to moisture stress. Combined with its low vulnerability to pests and diseases, it is considered as a low-risk crop (Fufa *et al.,* 2011). It has to be between 1700 and 2400 meters above sea level for optimal yield performance, 750-850 mm of yearly rainfall and a temperature range of 10-270 degrees Celsius (Adera, 2016). Grain may be stored for a long time without weevil attacks, and no disease outbreak has jeopardized its performance (Melaku, 2020). Seeds are broadcasted on a well ploughed soil and lightly covered with the soil until germination. During the growing period, several weeding are often required.

About 70% of Ethiopians rely on tef, an endemic crop, as a daily staple diet (Vandercasteelen *et al.,* 2013). In the same order, maize, tef, wheat, and sorghum accounted for 28.75% (96,357,345.00 quintals), 17.11% (57,357,101.87 quintals), 15.86% (53,152,703.28 quintals), and 15.71% (52,655,800.59 quintals) of the grain production (CSA, 2020). Tef contributes 19.33% of Ethiopia's total grain yield and occupies more than 29% of the field each year. Depending on the color of the grain, it can be roughly classified as either brown or white seeded. Although maize is the most produced crop in Ethiopia, its price frequently surpasses the market price of maize by two to three times. Due to its high nutritional content, tef can be used for both human consumption and animal feed (Baye, 2014). Tef could be gathered and used as food in Ethiopia during drought years when there is a shortage of food (Hailu & Seifu, 2001). In Ethiopia, it makes up over 66% of daily protein consumption and 15% of total calories (Berhane *et al.,* 2011; Guush *et al.,* 2011; ATA, 2013; Crymes, 2015). According to studies, tef is a gluten-free crop, making it appropriate for those with celiac disease (Spaenij-Dekking *et al.,* 2005). In addition to being the most valued fodder for cattle, tef straw is also used to plaster the walls of homes and local grain storage facilities, fortify mud, and more (Adera, 2016; Minten *et al.,* 2016). Horses, llamas, alpacas, and other livestock that are comparable to them find tef to be a particularly pleasant straw. Calves that have just been weaned likewise swiftly adjust to tef hay. Other summer annual grasses, however, might be a better option because they often yield greater tonnage and are also suitable.

Currently, the productivity of tef is relatively low. The primary causes of tef's low production, according to Demeke and Di Marcantonio (2013) and Assefa *et al.* (2017) are growers' poor adherence to whole package recommended practices and restricted access to new technologies.Accordingly, the majority of farmers in the research regions have been utilizing their native varieties, which have low yields, are vulnerable to lodging, and are not as popular. In order to address this issue, the Arba Minch Agricultural Research Center performed adaptation trials of a few tef varieties in the Basketo Zone. The cross-37 variety's mean grain yield was 23.11 Kg/ha. Therefore, this activity was specifically initiated to demonstrate improved tef variety under farmers' condition through their participation for enhancing farmers' technology adoption and diffusion in the Laska Zuria district of Basketo zone.

The objectives of this study is to 1) popularize the importance of tef technology and practices under farmers condition, 2) estimate improved tef production by demonstrating improved technologies and practices and 3) assess farmers' perceptions of cluster-based, large-scale demonstrations of improved tef technology.

Materials and methods

Description of the study areas

Laska Zuria District is situated geographically at latitude 6°14'60" N and longitude 36°34'59" E (Figure 1). At an elevation between 780 and 2200 meters above sea level, the average annual rainfall is 1200 mm, and the average annual temperature is 21 °C, which is said to be appropriate for the production of tef. In all agro-ecologies, the district's soils are categorized as 18% clay, 52% loam, and 30% sandy (Kiflu, 2015).Vertisol is the type of soil used for the experiment. Tef, maize, common beans, and sorghum are the main crops farmed in the region. Mango, banana, and avocado are other possible fruits in the region.

The soils of the district are classified as 18% clay, 52% loam and 30% sandy in all agro-ecologies (Kiflu, 2015). The type of soil on which the demonstration was conducted is vertisol. The major crops grown in the area include tef, maize, common bean and sorghum. The potential fruits of the area also include avocado, banana and mango.

Site and farmers selection

Based on their potential for tef production, Doko Chare, Sasa, and Gimidha kebele were purposefully chosen. The district Agricultural Office experts and kebele Development Agents worked together to choose the farmers. Based on their availability of land and desire to share their methods with others, 134 farmers were chosen for the demonstration (Table 1). Together with district and Kebele agricultural partners, site selection and land preparation were carried out.

Method of implementation

Farmers were divided into six clusters, each of which covers roughly 134 hectares of land. The Farmers Research Extension Group (FREG) is a small group of extension agents and farmers, typically 12 to 15 in numbers, who have similar issues and are eager to collaborate in groups with research, extension, and other non-public organizations in the process of developing, validating, demonstrating, and improving technology (Chimdo, 2008). One to three FREG units, each with twelve to fifteen farmers, were set up in each Kebele. Ten trial/experimental farmers were chosen for each FREG unit;

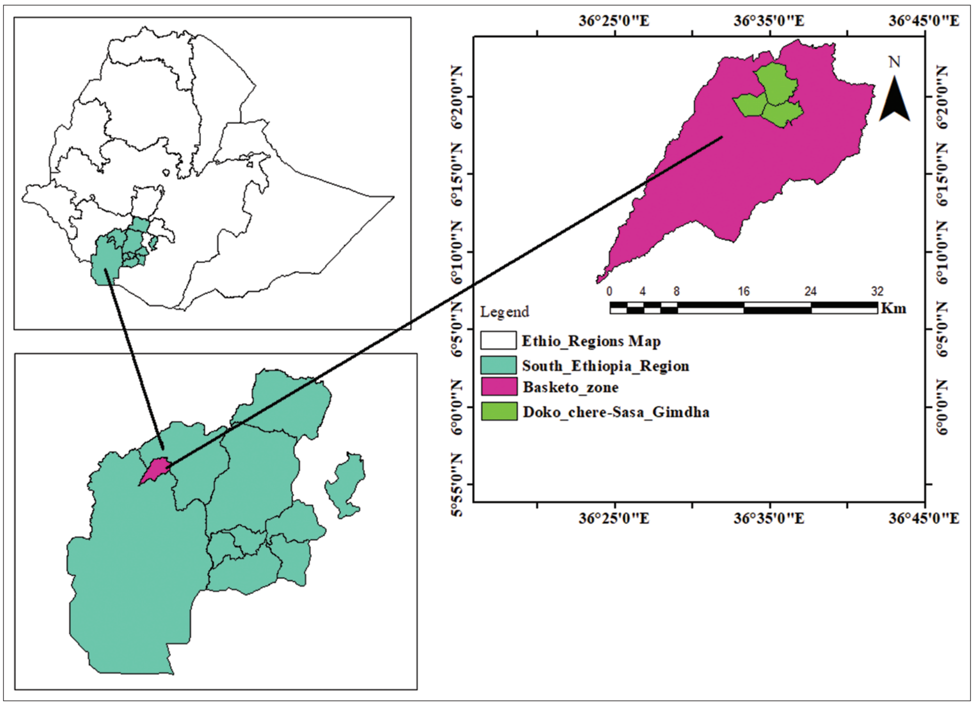

Figure 1: Map of the study area

the remaining farmers were participant farmers. The selection of FREG members was based on several criteria, including desire to share innovations with other farmers, accessibility for activity supervision, and a history of compatibility with group dynamics. Farmers, Development Agents, and experts were given a theoretical training session following the creation of the FREGs. District staff, Kebeles development agents, and participating farmers received training. Prior to conducting demonstrations, the training concentrated on the advantages and objectives of land preparation, sowing techniques, and the use of inputs such as fertilizer application, weeding, post-harvest management techniques, and the advantages of cluster-based large-scale demonstrations.

Through the Arba Minch Agricultural Research Centers, the South Ethiopia Agricultural Research Institute provided the farmers with all the required inputs (fertilizer and seed). Both theoretical and practical training sessions were held following an agreement with the farmers regarding the execution of the activities (Table 2).

Research design and agronomic practices

The improved tef variety was demonstrated through a method demonstration. The center promptly supplied the required inputs.The Tef variety, cross-37, was tested on 134 farmers in cluster-based large-scale demonstration bases using a seed rate of 15 kg/ha at a distance of 20 cm between rows and fertilizer NPS 100 kg/ha and UREA 50 kg/ha. In the presence of sufficient soil moisture, shallow planting with a depth of 2-4 cm was used.While half of the UREA was sprayed during sowing and planting and the other half was applied during crop tillering, all of the NPS was applied at this time. Regular weeding was carried out two or three times, and many specialists evaluated the improvement over time. Additionally, herbicide chemicals were used in accordance with current scientific guidelines. As a result, 32 farmers in all received 10 quintals of seed and 150 hectares of land.

Technology monitoring and evaluation techniques

Field day plays a significant role in showcasing new technology since it allows farmers to gain knowledge through field observation. The field events had 418 athletes in total. Among these, 363 farmers, 9 Development Agents, 20 Kebele administrators, 26 participants, and other invited special guests attended the field days and felt that awareness was raised among experts, Development Agents, and participating farmers. Compared to their previous cultivars and agronomic procedures, farmers valued the variety displayed and its agronomic practices and approaches (Figure 2). There were 315 participants at the tef maturity stage, including 192 men and 123 females (Table 3).

Methods of data collection and analysis

Both qualitative and quantitative data were gathered using appropriate techniques, such as focused group discussions and direct field observation and measurements. Yield data, farmers' perceptions of the performance of the technologies and their variety criteria, changes in farmers' knowledge and skill levels before and after the technology was implemented, the number of farmers who participated in extension/promotional events like training, field visits, and field days, stakeholder participation, and the total number of farmers who copied the technology or innovation are some of the types of data that are gathered. In response, the farmers expressed how much they thought the variety's agronomic methods were superior to those of previously introduced varieties.

Simple descriptive statistics like mean, minimum, maximum, and percentages were used to examine the data. In narrative style, the farmer's comments and suggestions were also included. Additionally, the technology gap was calculated which displays the discrepancy between the anticipated yield and the demonstration yield. Dhaka *et al.* (2010) claim that the observed technology gap is caused by variations in rainfall, acidity, fertility, and other natural calamities.

The yield differences can be further categorized using the technological index, which is meant to show the variety's viability at the farmers' field. As convenience and variety rise, the technology index's value falls. The following formulas were used to calculate the technology gap and technology index.

Table 1: Number of participants and area covered

Region	Zone	Kebele	Number of farmers		Varieties	Number of clusters	Hectares
			Male	Female			
South Ethopia	Basketo	Doko chare	83	19	Cross-37	4	50
		Sasa	17	5	Cross-37	1	8
		Gimidha	19	1	Cross-37	1	16
	Total		119	25			

Table 2: Summary of training participants

District	Kebele	Farmers			Develoment Agents			Administrative bodies			Agricultural Experts			Researchers			Others		
		M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Laska Zuria	Doko Chare	98	25	123	2	1	3	2	1	3	1	-	1	2	-	2	2	-	2
	Sasa	25	10	35	2	-	2	2	1	3	1	-	1	2	-	2	1	-	1
	Gimidha	29	5	34	2	-	2	1	1	2	2	1	3	2	-	2	1	1	2
	Total	152	40	192	6	1	7	5	3	8	4	1	5	6	-	6	4	1	3

M=Male and F=Female

Technology gap = Potential yield (qt/ha) – Demonstration yield (qtha-1) (1)

$$\text{Technology ndex} = \frac{\text{Potential Yield} - \text{Demonstrated Yield}}{\text{Demonstrated Yield}} * 100 \quad (2)$$

Extension gap (q ha^{-1}) =Demonstration yield (qt ha^{-1}) - Farmers yield (qt ha^{-1}) (3)

Results and discussion

Grain yield performance

Three Kebeles in the Laska Zuria district, Doko Chare, Sasa, and Gimidha were used for the activity. The activity at the three areas encompassed 50 hectares.Thirty farmers made up the yield estimation sample, which was computed to determine the variety's yield. The Ethiopian national average yield of tef (1700 kg/ha, CSA, 2020) is comparatively high for this type. Liben and Hirgo (2023) found 1476 kg/ha of the same variety at Shashago district of Southern Ethiopia which is lower than the current result. The variety has a relatively good yield with the Ethiopian national average yield of tef (1700 kg/ha, CSA, 2020). Mean yield of 1850 kg/ha, 1805 kg/ha and 1813 kg/ha was recorded in Doko Chare, Sasa and Gimidha Kebeles respectively (Table 4). The outcome is less than (1295 kg/ha)

Figure 2: Field level performance of cross-37 at Doko Chare, Basketo, 2024

the study carried out at mid-land areas of Guji Zone, Oromia region Ethiopia, using a comparable variety (Kebede & Korji, 2018). This is explained by the fact that it improves variety and is suitable for the specific environment. Despite this, the study area's participating/trial farmers' output and productivity have increased.

Yield gap and index

The outcome indicates that the demonstration yield is nearly identical to the potential output. This indicates that, in comparison to its on-station potential yield and performance, the variety was performing roughly to its potential.Unquestionably, a number of reasons led to the discrepancy between the prospective yields of the variety obtained on-station under breeder management and those acquired during on-farm demonstration on farmers' fields. This disparity was caused by a number of variables, including variations in soil fertility, variability on larger plots, follow-up and less regular supervision of the on-farm trial, and changing weather.

Technology gap for Cross-37 = 23.11 qt ha^{-1} -18.25 qt ha^{-1} = 4.86 qt ha^{-1}

$$\text{Technology ndex for cross} - 37 = \frac{23.11\ \text{qtha} - 1 - 18.25\text{qtha} - 1}{18.25\text{q t ha} - 1} * 100$$

which is 26.63%

That means the demonstrated cross-37 variety is feasible for the farmers in the study area and other similar agro-ecologies.

In a similar vein, the extension gap was calculated and found to be 10.6%. The results showed that the extension approach needs to be strengthened using a variety of strategies, such as providing farmers with training, sharing skills and experiences, raising awareness through information dissemination channels, and other relevant strategies. Additionally, it is thought that a production

Table 3: Summary of field day participants from the 3 locations

Participants	Kebeles						Gimidha		
	Doko chare			Sasa					
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Farmers	65	35	100	122	80	202	28	5	33
Development agents	2	-	2	2	4	6	2	4	6
Administrative bodies	4	-	4	4	1	5	8	1	9
Agricultural Experts	3	-	3	6	3	9	9	3	11
Researchers	3	-	3	4	-	4	7	-	7
Others	2	-	2	5	-	5	7	-	7
Total	143	88	231	79	35	114	52	23	73

Table 4: Grain yield of cross-37 across locations (Quintals per hectare)

District	Kebele	Variety	Number of Clusters	Hectare	Minimum	Maximum	Mean
Laska Zuria	Doko chare	Cross-37	7	50	18.2	18.9	18.5
	Sasa	Cross-37	2	16	17.8	18.3	18.05
	Gimidha	Cross-37	4	21	17.1	18.4	18.13
	Grand Mean						18.25

package with appropriate grain quality and advanced upgraded tef technology will alter the extension gap. Therefore, food security and farmer income will be greatly impacted by the distribution of recently released upgraded tef technology, including production packages. This data is crucial for identifying the program's weaknesses, removing obstacles, and hastening the implementation of better technologies.

Farmers' perception on tef technology

As a result, in terms of grain output, color (white), disease tolerance (leaf rust), good market price, lack of lodging, spike length, number of spikes per plant, and little straw across the three locations, the farmers highly favored the technique and noted its advantages above commercial kinds (Table 5). In contrast to their previous cultivars and agronomic methods, farmers valued the variety displayed as well as its agronomic techniques and practices. In comparison to the previously introduced Tef variety, this variety has the ability to mature early, high tillering, improved grain yield, and good logging resistance. The outcome is in line with Truayinet (2022) in Ethiopia's Tef-growing regions.

Lessons learned

On-farm demonstration is a two-way process where researchers and farmers exchange knowledge. Farmers saw firsthand how the cross-37 Tef variety and the demonstration package performed during the study. During the demonstration procedure, several lessons were learned, such as:

- Farmer researcher group linkage created opportunity for jointly participation in problem identification, planning, implementation and finding solution to the society using down to top extension approaches
- Participating different stakeholders in the evaluation the variety can help for easy acceptance and promotion of improved variety
- Farmers also appreciated the group approach in due of its quickness in sharing knowledge, responsibility sharing, team spirit and easiness in solving problems and easy operation
- Farmers also understood ownership of their activities, mainly through cost sharing of production in puts such as improved seeds and fertilizers in the demonstration process.
- The group approach also facilitated mechanization services for farmers.
- It opened the door for Development Agent's to contact more farmers once
- Multi-stakeholders participation in cluster based approach reduces the time of adoption of the technology in the community because of the multiple interactions of stakeholders through direct and indirect meetings.

Table 5: Farmers perception towards the tef technology

S. No.	Perception	Agree/Disagree/ Do not know
	Positive perception*	
1	Early mature	1
2	The variety resist even rain was very high	1
3	Good color	1
4	Resistant to logging	1
5	Resistance to disease (leaf rust)	1
6	Better grain yield compared to former varieties	0
7	High tillering capacity	1
	Negative perception**	-1
1	Sowing with line is labor intensive	-1
2	Few straw	1
3	Bad taste to home consumption	0

* For positive perception values will be agree=1, disagree=-1, do not know=0 **For negative perception values will be agree=-1, disagree=1, do not know=0

Conclusion and recommendations

In order to showcase the technique on a larger scale, the activity was carried out in the Doko Chare, Sasa, and Gimidha Kebele of the Laska Zuria region of the Basketo Zone of Southern Ethiopia during the 2025 major growing season. The results of the demonstration showed that employing the suggested technology for tef technology can boost productivity and production. Additionally, the tef grain yield was raised by introducing enhanced tef along with improved production methods such fertilizers in a clustering manner. The cluster-based large-scale demonstration of improved tef technology was well understood by participant farmers and stakeholders. As a result, there is an urgent demand for tef technology in the district. The variety for the current activity portrayed a remarkably higher yield advantage over that of farmers'practice. The trial farmers in the area were aware of the physical characteristics and field performance of tef. Thus; by using improved variety with its full package, farmers can earn more benefit than conventional and local varieties. As the variety is demanded by farmers' and other stakeholders' promotion and dissemination of the technology should continue sustainably on wider scope. Therefore, the demonstrated variety, cross-37 should be widely disseminated with its full package by the district Agricultural extension system and the new technology transfer should be continued in strengthened manner.

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Author contributions

Lakamo Liben: Conceptualization, material preparation, writing the original manuscript draft and editing analyzed data and wrote the whole manuscript, Abebaw Bergena, Melese Ejamo and Anteneh Bulke: field investigation, data curation, reviewed the whole manuscript. All authors approved the final manuscript version.

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