Global Journal of Agricultural Research, 12, (2), 53-61, 2024

Print ISSN: 2053-5805(Print),

Online ISSN: 2053-5813(Online)

Website: https://www.eajournals.org/

Publication of the European Centre for Research Training and Development -UK

On-farm Demonstration and Evaluation of Tef (*Eragrostis Tefabyssinica*) Bora Variety for Selected Moisture Stress Area of Amhara and Oromia Region, Ethiopia

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doi: https://doi.org/10.37745/gjar.2013/vol12n25361 Published August 25, 2024

Citation: Chiche W. and Ahmed M. (2024) On-farm Demonstration and Evaluation of Tef (Eragrostis Tefabyssinica) Bora Variety for Selected Moisture Stress Area of Amhara and Oromia Region, Ethiopia, *Global Journal of Agricultural Research,* 12, (2), 53-61

Abstract: *The study aimed to create awareness and evaluate the performance of the newly released tef variety, Bora, compared to the standard check variety, Boset, in moisture stress areas of Ethiopia. The demonstration took place in the moisture stress areas of Minjar Shenkora district of the North Shoa and, Lume and Bora districts of East Shoa in 2021 and 2022 production year. Ninety farmers' plot and 15 farmers' training center (FTC) were used for the demonstration. Selection criteria included willingness to provide plots and labor, adherence to recommended practices, experience-sharing with neighboring farmers, and collaboration with researchers. The farmers were educated about the availability and significance of the demonstrated technology through training sessions, participatory technology evaluations, and field day events. Based on farmers' evaluation, Bora variety was preferred over Boset only in Minjar Shenkora and Bora distritcts. The yield assessments indicated Bora's superiority, with yield advantages of 210 kg/ha, 230 kg/ha, and 253 kg/ha over Boset in Minjar Shenkora, Lume, and Bora districts, respectively. Thus, given its superior performance, scaling up Bora cultivation across all demonstration areas is recommended to enhance tef production and improve farmers' livelihoods.*

Key words: Demonstration; Evaluation; Moisture Stress; Tef; Variety; Yield

INTRODUCTION

Agricultural growth has been a cornerstone of Ethiopia's impressive economic development over the past decade (National Bank of Ethiopia, 2014). The country's major grain crops include tef, wheat, maize, barley, sorghum and millet, with cereals alone contributing to approximately 60% of rural employment and covering 80% of cultivated land (Abu and Quentin, 2013). Ethiopia is the center of origin and diversity for Tef (*Eragrostis abyssinica*). Although tef is adapted to a wide range of environments and diverse agro climatic conditions, it performs excellently at an altitude of 1800-2100 meters above sea level (m.a.s.l), annual rainfall of 750-850 mm, growing season rainfall of 450-550 mm, and a temperature of 10-27 ^{0C} (Seifu Ketema, 1993). Despite Ethiopia producing over 90% of the world's tef, the crop's potential in international markets remains underexploited (Tewabu and Hibistu, 2021).

In 2011, tef occupied 28.5% of Ethiopia's cereal cultivated area, surpassing maize at 20.3% (CSA, 2020). It is cultivated by over 7.15 million farmers across more than 3.10 million hectares of land (CSA, 2020). It is celebrated for its nutritional value, particularly in traditional Ethiopian cuisine such as injera (Fikadu et al., 2019). Among cereals, tef accounts for the largest share of the cultivated area 28.5 % in 2011, followed by maize (20.3). Tef is extensively cultivated by over 7.15 million farmers in Ethiopia; covering over 3.10 million hectares of land(CSA, 2020). Fikadu *et al.* (2019) stated that tef has many benefits and high nutritional value for baking injera and well-known traditional food in Ethiopia. Domestically, the income obtained from tef is much higher than income obtained from other cereals crops and even 34% higher than income obtained from coffee, and it is the major export crop; in Ethiopia (Fikre et al., 2022).

Despite its agricultural significance, tef faces challenges in productivity, with a national average yield of 1.85 tons per hectare (CSA, 2020). This productivity gap is attributed to the use of low-yielding varieties and the absence of climate-smart alternatives such as drought-tolerant and early-maturing varieties, which could potentially increase yields and benefit farmers (Kebede et al., 2018). Therefore, this study aimed to promote early-maturing improved tef technologies through demonstrations. The objectives were to raise awareness about the availability and significance of improved tef varieties, assess farmers' perceptions towards these innovations, and evaluate the yield performance of tef technologies under farmers' management.

MATERIALS AND METHODS

Description of the study area

Lume district is located to northeast of Debre Zeit at an altitude ranging from 1,700 to 2,100 m. It is situated between 80 12^0 to 80 50^0 latitude and between 390 01^0 to 390 17^0 longitude. July and August are the wettest months and April, May, and June are the hottest. The major soil type is vertisol and crops grown are tef, wheat, haricot beans, maize, chickpeas, barley, and faba beans.

Minjar Shenkora district is located in the North Shewa Zone, southern part of Amhara region. The geographical location extends from 8.9045^0N latitude to 39.4091^0 E longitudes. The main crops grown in the area include tef *(Eragrostis Tef)*, wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), maize (*Zea mays*), sorghum (*Sorghum bicolor*), chickpea (*Cicer arietinum*), field pea (*Cicer arietinum*), lentil (*Lens culinaris*) and different vegetables.

Bora district is located in the east Shewa zone of Oromia Regional state. It is located at a latitude and longitude of 8.30°N 38.95°E, with an elevation of 1,611 meters. The district is surrounded by the districts of Lomme, Lake Koka, and Dodota to the east, Dugda to the west, Liben to the north, and Zeway Dugeda and Lake Zeway to the south. The capital town of Alemtina is located 160 kilometres away from Addis Ababa and 105 kilometres away from Awassa. The district is mostly known for the production of vegetable crops, wheat, maize, and tef (Teshome *et al* 2022).

Table1. Description of improved tef varieties used for demonstration

Variety	Year of release	Maturity (days)	Research station yield (t/ha)
Bora	2019	74 - 85	1.8 – 2.4
Boset	2012	75 - 90	1.8 – 2.2

Source: EAA, 2021.

Farmers and Site Selection

The moisture stress areas of Lume, Minjar Shenkora, and Bora districts were purposively selected due to their significant potential for tef production and the substantial volume of tef cultivated in the East and North Shewa zones of the Amhara and Oromia regions. Farmers and demonstration sites were selected in collaboration with the Agricultural and Natural Resource Offices of their respective districts. Farmers were chosen based on their readiness to allocate plots and provide labor, adherence to recommended management practices, willingness to share their experiences with neighboring farmers, and ability to collaborate with researchers. Demonstration sites were selected based on several criteria, including suitability of the land, proximity to roads and community centers such as churches, distance to markets, opportunities for diverse farmers to learn, and well-drained soil conditions. Prior to planting, comprehensive training sessions on tef technology production and management, as well as extension approaches, were conducted for farmers, experts, and development agents (DAs). This preparation aimed to ensure that all stakeholders were equipped with the necessary knowledge and skills to effectively implement and manage the tef demonstrations. Demonstration activity engaged a total of 90 farmers and utilized 15 Farmers' Training Centers (FTCs) across Minjar Shenkora, Lume, and Bora districts.

Capacity Development

Training sessions were conducted to empower selected zonal and district subject matter specialists (SMS), development agents (DAs), and farmers on the production and management of tef technologies in the targeted regions. Figure 1 illustrates the capacity development training, with a total of 39 trainees participating, including 9 women.

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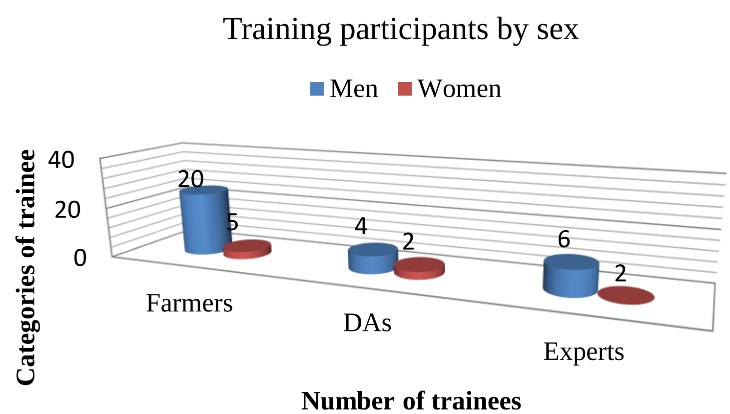

Figure.1 Training participants

Data collection and analysis

Based on the quantitative and qualitative data collected, the yield was directly measured in the field. Farmers' preferences for variety and traits were recorded using a data collection sheet. Qualitative data were gathered through focus group discussions with farmers who cultivated improved tef varieties, assessing their perceptions of the varieties under evaluation. Farmers of different ages and genders were purposively invited to evaluate the demonstrated varieties. Before beginning the evaluation, farmers were asked to establish their own criteria for evaluating tef varieties. Based on these criteria, farmers ranked the varieties on a ranking sheet. Finally, researchers thematically summarized the results and selected the preferred varieties for large-scale demonstration.

The quantitative data were analyzed into two categories based on concepts provided by Lobel et al. (2009). The first category involved assessing the gap between demonstration yields and farmers' actual yields. The second category focused on comparing the gap between the research station's potential yields and the yields observed in the demonstration fields. For this study, the potential yield data for the crop was sourced from the Crop Variety Registry Book (MoANR, 2021). This registry records the potential yields of crops under research management, assuming all environmental factors are optimal. The demonstration yield was derived from crop yield performance in on-farm demonstration plots. Specifically, the farmer-based yield was recorded from the on-farm demonstration performance of the Boset variety (used as a control or reference). Demonstration trials were conducted over two consecutive years across different locations, and the mean yield results were calculated for each district. The collected data underwent analysis using descriptive statistics, preference ranking, and yield analysis methodologies. Furthermore, an extension gap analysis was conducted by comparing the yield of the Boset variety (which farmers had been using for many years) with the yield of the newly released Bora variety. In summary, the study utilized quantitative methods to analyze various aspects of crop yield performance and demonstrated a systematic approach to evaluating and comparing different tef varieties under real-world farming conditions.

Extension gap = Demonstrated yield-Farmer's practice yield
Technology gap was calculated by yield of the newly demonstrated variety (Bora) from potential yield of the variety under controlled environment.
Technology gap = Potential yield- Demonstrated yield

RESULTS AND DISCUSSIONS

Farmers Varietal Preference

Farmers in all districts evaluated the demonstrated varieties based on their own criteria, which included factors such as panicle length and weight, field performance, seed color, tiller number, maturity, and straw palatability. The farmers' evaluations indicated that the Bora variety was ranked first in the Minjar Shenkora and Bora district and second in the Lume district (referenced in Table 3)

In addition to on-farm performance, farmers expressed a preference for varieties that offered higher yield advantages. This preference highlights the importance farmers place on not only qualitative traits but also quantitative yield potential when selecting varieties for cultivation. Overall, the study demonstrates how farmers' criteria and preferences influence their decisions in adopting and favoring specific crop varieties, emphasizing the practical considerations alongside yield performance in agricultural decision-making.

Table2. Farmers' varietal preference result

Varietal Selection Criteria (Traits)	Districts and Rank of the Varieties Demonstrated					
	Lume		Minjar Shenkora		Bora	
	Bora	Boset	Bora	Boset	Bora	Boset
Field performance (good)	2	1	1	2	1	2
Panicle length (large)	2	1	1	2	1	2
Seed color (white)	2	1	1	2	2	1
Tillering capacity(good)	1	2	1	2	NS	NS
Early maturity	NS	NS	2	1	1	2

Straw thickness (palatable)	2	1	2	1	1	2
Disease resistant (good)	NS	NS	1	2	1	2
Lodging resistance (good)	NS	NS	NS	NS	1	2
Seed size (large)	NS	NS	NS	NS	2	1
Not shattering	NS	NS	1	2	NS	NS
Acceptability score	9	6	9	12	10	14
Rank	2	1	1	2	1	2

Source: Own field data, 2021 and 2022 Note: NS = Not specified

Yield Performance

Based on the yield advantage observed over the past two years in the selected districts, as shown in Table 4, the productivity of the demonstrated Bora variety and the standard check variety Boset, varied across districts. The extension gap analysis revealed that the Bora variety outperformed in the Minjar Shenkora, Lume, and Bora districts, with yield advantages of 210 kg/ha, 230 kg/ha, and 253 kg/ha, respectively. Given these findings, it is recommended that the Bora variety be promoted for wider production in the Minjar Shenkora, Lume, and Bora districts. This recommendation is based on its demonstrated higher yield advantages over the standard check variety Boset in these specific regions over the two-year period of evaluation.

Table3. Productivity of the demonstrated variety

Districts	Productivity (Kg/ha)		Extension gap (Kg/ha)	Potential yield of Bora(Kg/ha)	Technology gap (Kg/ha)
	Bora	Boset			
Minjar	1730	1520	210	2100	370
Lume	1720	1490	230	2100	380
Alemtena	1768	1515	253	2100	332
Average	1739	1508	231		

Source: Own field data, 2021 and 2022

Cost of Production

Tef production involves several key inputs and management practices that contribute to overall costs. These include land rent, improved variety seed, land clearing, ploughing, fertilizer application, chemical application, harvesting, threshing, and transportation. Each of these activities incurs expenses which collectively determine the cost of production. In analyzing the cost structure, it is noted that the total investment in production costs is equal for both tef varieties considered, as they are both improved varieties even if released in different years. This equality in production costs indicates that the expenses incurred for inputs and management practices are comparable between the varieties.

Breaking down the costs incurred, fertilizer emerges as the most significant cost component, accounting for 23% of the total production costs. This is followed by harvesting costs at 16%, and ploughing costs at 15%. These figures highlight the financial importance of these activities in tef production. Additionally, the cost-benefit analysis conducted for the years 2021 and 2022 reveals that labor costs constitute a substantial portion of the overall expenses, amounting to 69% of the total costs. In contrast, input costs represent 31% of the total expenses, underscoring the significant role of labor expenditures in tef production.

Table4. Cost of tef production

Activity/input Cost	Average Cost (ETB/ha)		% of Cost	
Input Costs (ETB)	Bora	Boset	Bora	Boset
Seed price	1249	1249	8	8
Fertilizer	3700	3700	23	23
Subtotal	**4949**	**4949**	**31**	**31**
Labor Costs (ETB)				
Ploughing	2349	2349	15	15
Harvesting	2542	2542	16	16
Threshing	1683	1683	11	11
Transporting	1050	1050	7	7
Insecticide and Herbicides	3414	3414	21	21
Subtotal	11038	11038	69	69
Total Cost	**15987**	**15987**	**100**	**100**

Source: Own field data, 2021 and 2022

Benefit-cost ratio

The benefit-cost ratios are indeed crucial metrics for assessing the economic viability of agricultural investments. In this case, the benefit-cost ratio for the Boset variety is 1.6, indicating that for every unit of cost invested; there is a projected return of 1.6 units in benefits. Similarly, the Bora variety has a higher benefit-cost ratio of 1.98, suggesting a greater expected return of benefits relative to costs compared to Boset. Therefore, based on the benefit-cost analysis, Bora appears to be a more economically efficient choice compared to Boset. Farmers and stakeholders may consider this information when making decisions about which variety to prioritize for cultivation, aiming to maximize economic returns from tef production.

Table5. Benefit cost ratio of Bora and Boset

Operations	Varieties	
	Bora	**Boset**
Total variable cost	15987	15987
Fixed cost(Land cost/ha)	22000	22000
Total cost(including variable and fixed cost)	37987	37688
Grain Yield (Kg/ha)	1739	1508
Grain price (ETB/Kg)	65	65
Gross income	113035	98020
Net Benefit (Total Revenue)	97048	82033
Total Net benefit (including fixed cost)	75048	60332
Marginal benefit(ETB)	Base	-14716
BCR	**1.98**	**1.60**

Source: Own field data, 2021 and 2022

CONCLUSION AND RECOMMENDATION

In conclusion, Bora variety, when grown with improved management practices has shown to yield higher yield per hectare on a farmers' field in Minjar Shenkora, Lume and Bora districts compared to Boset variety. In addition, the yield gap analysis result indicates that using Bora variety with its recommended practices can significantly increase tef production and productivity in all districts. Furthermore, the characteristics of Bora tef variety such as field performance, panicle length and weight, seed color, tillering capacity, early maturity, animal feed quality, disease resistance, and lodging resistance make it a preferable choice for farmers in the mentioned districts. Minjar Shenkora.

Therefore, it is advisable to grow Bora variety in Minjar Shenkora, Lume and Bora districts replacing Boset variety on large-scale production to increase production and productivity of tef, and then contribute for livelihood improvement of farmers in the area. In addition, adoption of best management practices specific to Bora variety should be promoted among farmers to maximize yields and quality.

Acknowledgement
The authors are grateful to the Ethiopian Institute of Agricultural Research (EIAR) and thankful to Debrezeit Agricultural Research Center for the financial and technical support. We also thank

the host farmers, district, and kebele agricultural experts for their contributions in site selection, field management, and cooperation.

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