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# Participatory variety selection and pre scaling up of farmers' preferred improved tef varieties in Bure zuria district of West Gojam zone, Ethiopia

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## ABSTRACT

*The low uptake of yield enhancing technologies constrained tef productivity. The study hypothesized that participatory variety selection together with demonstration of the best-fit variety contributes to increasing adoption of the new variety. The objective of the study was to evaluate the performance of different tef varieties and demonstrate the selected ones to farmer's at large scale. Using a complete block design, the experiment was conducted on nine improved varieties and one local variety in Burie during 2017 and 2018 production seasons. The combined analysis of variance showed that there is significant variation among the tested new varieties in terms of grain yield, quality, and biomass parameters. The results revealed that the highest yield is obtained from "Estub" variety (2.1 t ha$^{-1}$), followed by "Dagem" (1.81 t ha$^{-1}$), with 91% and 70% yield advantage over the local variety, respectively. The result of analysis of variance is in line with the preference score of farmers. However, grain yield is not the overriding trait for farmers in selecting tef varieties. Varietal preference of male and female head households is positively correlated. The new high-yielding varieties with quality parameters preferred by panalist farmers were further demonstrated to farmers at large in 2019 and 2020 main cropping season. The results showed that participatory varietal selection along with demonstration at large scale contributes to wider dissemination of the new varieties and brings a difference in tef production and productivity.*

## 1. INTRODUCTION

Although a number of improved tef varieties have been released through the research system, their uptake by smallholder farmers remains low (Zegeye et al 2018). Variety development by itself has nothing to bring a difference unless it is adopted by the growers. Begna (2022) summarized the reasons for low adoption of improved varieties by farmers as follows: many farmers may not have access to or information about seeds of new varieties; variety testing programs are often conducted on-station, which does not represent farmers' fields; conventional breeding programs usually seek farmer input only at the very end of the process; furthermore, varietal release systems give more emphasis to grain yield whereas farmers consider other traits when selecting varieties. Wide agro-ecological variation due to differences in altitude, temperature, rain fall and soil type also leads to the need of a wide range of varieties. As farmers are not consulted during variety improvement process, many released varieties are not adopted (Ceccarelli and Grando 2007). This needs to improve the communication between farmers and breeders so that farmers' concerns and preferences are incorporated earlier in the research process, research is accelerated, and the adoption rate improves.

To the extent that technology compatibility and preference play a decisive role in adoption of new technologies, participatory varietal selection (PVS) has been practiced to resolve those problems (Begna 2022). PVS is the selection process of finished or near-finished products from plant breeding programs on farmers owned farm land. Several stakeholders including farmers, breeders/scientists, and development practitioner involve in the varietal selection process. In PVS, farmers are provided with a basket of genotypes to deepen their choice. PVS is more rapid and cost-effective approach in selection of varieties preferred by farmers and accelerating their adoption, dissemination and increasing cultivar diversity (Friew and Adugna 2017). Asredie et al (2017) argued that if farmers are allowed to participate in variety testing and selection, not only increase the rate of adoption of new varieties but also reduce the cost of the experiment. In addition, production increases when farmers adopt new varieties identified in participatory research (Begna 2022). PVS can be considered as a step in formal breeding process. The importance of PVS approach is becoming well recognized in Ethiopia as it has been implemented in many crops including, faba bean (Mulualem et al 2012), tef (Kebede et al 2019), sorghum (Friew and Adugna 2017), wheat (Islam et al 2008) and finger millet (Wolie and Fentie 2017). However, selecting farmers' preferred varieties through PVS may not guarantee their adoption unless they are pre scaled up to address a large number of farmers to harvest their benefits.

Tef, *Eragrostis tef* (Zucc.) Trotter is the most important cereal crop in Ethiopia where it is originated and diversified (Vavilov 1951). It is serving as a staple food for about three -fourth of the population in the country. It takes the lion's share in area coverage and number of farmers involved in cereal production of Ethiopia (CSA 2021). It is being cultivated in diverse agro-climatic conditions with a low risk of failure, and fetches higher market prices than the other cereals grown in the country. The crop is primarily grown for its grain, which is used for making the special Ethiopian pancake like bread known as *Injera*, the most popular food in the national diet. The preference of consumers for the best *Injera*-making quality has increased the demand, encouraging farmers to grow it on large areas. More than three million hectares of land is allocated for tef production annually (CSA 2021). Recently, tef has been receiving global attention as healthy food for its high nutritional content and gluten-freeness that makes it suitable for people suffering from gluten allergy known as celiac disease, (Spaenij-Dekking et al 2005). This creates an opportunity for Ethiopia to earn foreign currency through tef export.

Tef is also the major cereal crop in different zones of Amhara region where about 2.6 million families are involved in tef production and covers more than 1.1 million hectares annually from which about 2.1 million tons of tef grain is produced (CSA 2021). Bure zuria is one of the districts in west Gojam zone of the Amhara region where tef is the principal cereal crop which covers more than four thousand hectares annually. However, its productivity is below 1t ha $^{-1}$ which is far below its potential (Zegeye et al 2018). The low productivity of tef in the area stemmed from the widespread use of low yielding local cultivars coupled with traditional agronomic practices (Zegeye et al 2018). To our knowledge, there is no research outcomes that attempt to employ participatory varietal selection along with demonstration for wider adoption of tef varieties in Amhara region. Therefore, this study was conducted to assess and identify the most important farmers' varietal selection criteria for use in future breeding program, to increase farmers' awareness and their access to improved tef varieties, to enable farmers to assess the performance of improved tef varieties and to recommend and pre scale up varieties that most preferred by farmers and showed better agronomic performance.

## 2. MATERIALS AND METHODS

### 2.1. Description of the Study Area

Bure zuria is one of the 15 districts in west Gojam administrative zone of Amhara region (Figure 1). It is located between $10^0$ 17'-$10^0$ 49' latitude north and $37^0$ 00' - $37^0$ 11' longitude east with an altitude ranged from 700 to 2,300 meters above sea level (masl). The district is divided in to 22 rural and 2 urban kebeles. It receives mean annual rainfall of 1338 mm with a minimum and maximum of 1061 and 1576 mm, respectively and its annual mean maximum and minimum temperature ranges from $27^0$C to $30^0$C and from $15^0$C to $19^0$C. respectively (NMA 2021). According to a diagnostic survey report of IPMS (2007), three soil types were found in the district, namely humic nitosols (63%), eutric cambisols (20%) and eutric vertisols (17%).

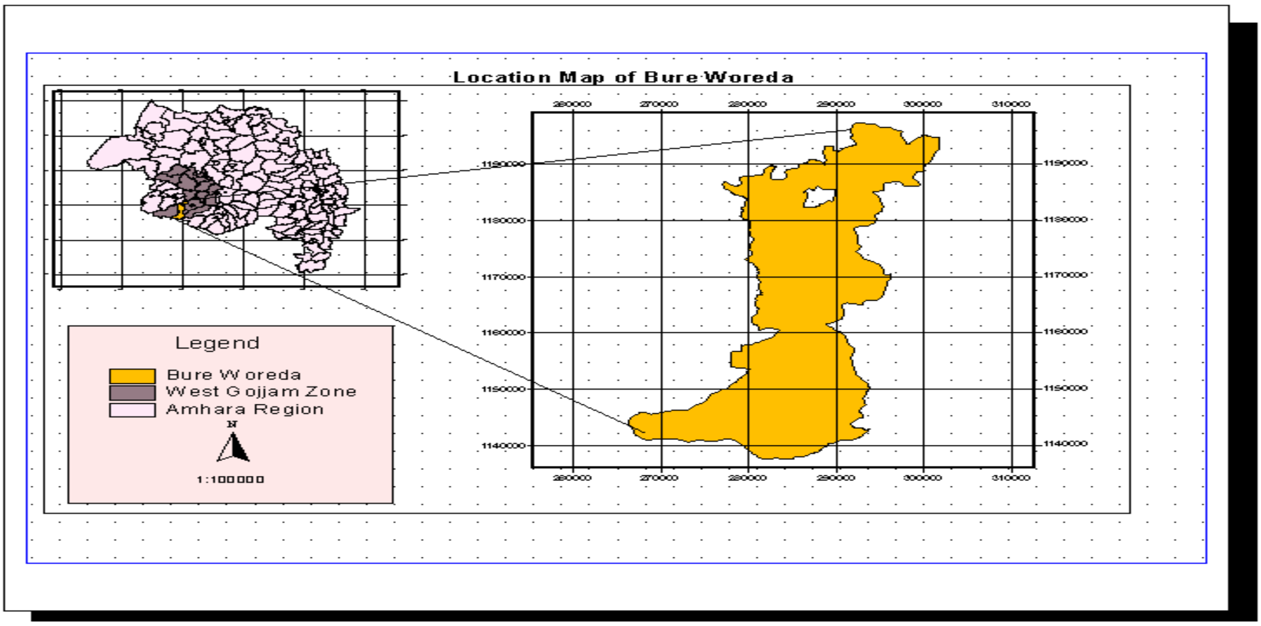

Figure 1: Location map of West Gojam zone and Bure zuria district (IMPS 2007)

### 2.2. Test Locations, Varieties and Trial Management

The participatory variety selection was conducted during the 2017 and 2018 main cropping season at two kebeles, *Jibgedel* and *Alefa*, which represent the highland and midland ecologies of the district, respectively. The selected varieties were further promoted in ten kebeles of the district during the 2019 to 2020 main cropping season following the pre scaling up protocol. To carry out a successful participatory variety selection, we have followed four different phases as outlined in (Witcombe et al 1996). These were: identifying farmers' needs in a cultivar, a search for suitable material to test with farmers, testing on acceptability of suitable material in farmers' fields and wider dissemination of farmer-preferred cultivars. Accordingly, baseline information about the farmers' need on tef production in the district was collected through focus group discussion (FGD). The improved varieties were selected and tested for their acceptability on farmers' fields.

The PVS was implemented following Paris et al (2011) "mother" trial approach. The mother trial also called researcher managed (RM) trial consisted of nine improved tef varieties with one local check (Table 1) was laid out in a randomized complete block design (RCBD) with three replications on Nitisols. A plot size of 15m$^2$ (15 rows of 5m length with 0.2m intra row spacing) was used. Fertilizer at the rate of 46 Kg ha$^{-1}$ $P_2O_5$ in the form of DAP and 41 Kg ha$^{-1}$ N in the form of UREA were applied. All DAP was applied at planting while UREA was applied half at 15 to 18 days after planting and the remaining half at 35 to 40 days after planting. A seed at a rate of 15 Kg ha$^{-1}$ was hand drilled in a row. Date of planting was adopted from the majority of farmers' practices in each respective kebele. All other relevant agronomic practices such as, land preparation, weeding, and time of harvesting were applied following research recommendations.

**Table 1:** List and passport data of improved tef varieties evaluated in this study

| No | Variety | Year of release | Releasing research Center | Adaptation altitude (masl) | Seed color | *Grain yield range (t ha$^{-1}$) |
|---|---|---|---|---|---|---|
| 1 | Quncho (DZ-cr-387(RIL-355) | 2006 | DZARC | 1500-2500 | Very white | 2.0-3.2 |
| 2 | Estub (DZ-01-31860 | 2008 | AARC | 1800-2600 | White | 1.9-2.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Kora (DZ-cr-438(RIL NO.133B) | 2014 | DZARC | 1700-2400 | Very white | 1.8-2.8 |
| 4 | Abola (7(Quncho*Keymuri(code 1) | 2015 | AARC | 1800-2600 | White | 1.6-2.7 |
| 5 | Enatit (DZ-01-354) | 1970 | DZARC | 1600-2400 | Dim white | 2.0-3.2 |
| 6 | Dagem (DZ-cr-438 (RIL NO.91A) | 2016 | DZARC | 1700-2500 | Very white | 1.8-2.8 |
| 7 | Ambo toke (DZ-01-1278) | 2000 | DZARC | 1800-2400 | White | 2.7-3.6 |
| 8 | Welencomi(DZ-01-787) | 1978 | DZARC | 1800-2500 | Dim white | 2.0-3.0 |
| 9 | Ziquala (DZ-01-358) | 1995 | DZARC | 1400-2400 | White | 2.0-3.4 |
| 10 | Local check | ----- | Bure zuria district | 1400-2300 | Dim white | <1.0 |

*Note: DZARC=Debre Zeit Agricultural Research Center; AARC= Adet Agricultural Research Center; masl= meters above sea level * Grain yield data of each variety is adopted from the passport data of each respective variety at the year of release which is available in the "**crop variety registrar** "of Ministry of Agriculture*

### 2.3. Farmers' Participation in Variety Evaluation and Selection

In consultation with kebele development agents, a group of male and female farmers were invited to participate in variety evaluation and selection. Farmers were selected considering the gender, experience in tef production, innovativeness, age, educational status and above all willingness to participate in variety evaluation and selection forum. The PVS participants included in this study can be characterized by mean of 38-year age and 18 years of experience in tef production. Almost all are literate, having about mean of six-year schooling and showed very active participation and interaction. A total of 57 persons attended the preference analysis (PA) session of which, 63%, 28% and 9% were male farmers, female farmers and researchers, respectively. The selected farmers were assumed to represent other farmers in their respective kebele. Multidisciplinary team of researchers composed of breeders, agronomists, research extensionists and development agents were in charge of this activity.

### 2.4. Biological Data Collection and Analysis

Biological data including days to maturity when 85% of the plants in a plot reached at physiological maturity stage, plant height (measured in centimeters as the distance from the base of the plant to the tip of the longest panicle), panicle length (measured in centimeters as the distance from the base of the panicle to the tip of the longest panicle), above ground dry biomass (which included both the straw and the grain and measured in Kg $ha^{-1}$ ), grain yield ( dry seed measured in Kg $ha^{-1}$) and harvest index ( determined by dividing the grain yield to above ground dry biomass and expressed in percent) were collected from the central thirteen harvestable rows and subjected to statistical analysis combined across locations following (Gomez and Gomez 1984) using the SAS version 8.1software.

### 2.5. Varietal Evaluation Procedure and Preference Analysis

Varietal evaluation and selection were done both in 2017 and 2018 cropping seasons using voting method as suggested by Paris et al (2011) when the varieties reached around 80% maturity. In order to implement the voting system and make preference analysis (PA), the following activities were done. Firstly, a stake with an envelope attached (to serve as the ballot box for the variety) was placed in front of each plot on the best replicate using a code. Participants were then oriented about the objectives of the study and allowed to walk through the trial and observe the varieties planted (Figure 2). Two ballot categories, (√) ballots and (**X**) ballots, each with three colors (green, yellow and red) were prepared for male farmers, female farmers and researchers, respectively**.** **(**√**)** ballots were used to vote for best preferred varieties and (**X)** ballots were used for least preferred varieties. Each participant was given two (√**)** ballots and two **(X)** ballots. The participants were allowed to go through the trial freely to vote for two most preferred (positive vote) and two least preferred (negative vote) varieties, using paper ballots and envelopes placed at the head of each plot. Names of varieties were kept anonymous with codes used for each variety throughout the voting process. Tally sheets were prepared to record the number of votes given to each variety by male farmers, female farmers and researchers. Farmers' and researchers' votes were counted separately and reported to the participants. After the votes had been counted, the whole group proceeded to observe the two varieties that received the highest number of votes and other two varieties that received the least number of votes. Then both farmers and researchers were interviewed to understand the reasons behind their choices. This resulted in two types of data; (i) the quantitative preference score (PS) for each variety generated by expressing the number of positive votes minus the negative votes divided by the total number of votes, and (ii) a list of characteristics considered as the basis for selecting the most and least preferred varieties.

The Spearman's rank correlation coefficient (r) was used for correlation analysis between male and female farmers' preferences, between all farmers' and researchers' preferences and between grain yield and all farmers' preferences. The 'r' value was used for comparing the extent of agreement or disparity in preference choices between any two groups. To rank the various farmers' varietal preference criteria, the rank-based quotient (RBQ) analysis was adopted (Mandal et al 2013). The criteria used by farmers for their selection of the most preferred varieties through PVS trials were listed first, and then they were asked to rank them according to their individual priority on a scale of 1–5. The most preferred criteria were ranked as 1, the least preferred as 5. A total of 52 farmers (30% females) were interviewed for this preference analysis. The analysis allowed ranking farmers' preferences based on RBQ. RBQ is a problem identification technique, mathematically presented as follows:

$$RBQ = \sum_{j=1}^{n} \frac{fi\,(n+1-i)*100}{N*n}$$

Where N= total number of farmers, n =total number of ranks (there are five ranks, n= 5), i= the rank for which the RBQ is calculated (for a problem), and f = number of farmers reporting the rank i (for the problem).

## 2.6. Pre-scaling up of Farmers' Preferred Improved Tef Varieties

As a prerequisite of PVS, we demonstrated the selected variety at large scale to farmers to facilitate the adoption of the new variety. Accordingly, the pre-scaling activity was conducted both in 2019 and 2020. In 2019, almost all of the farmers participated in PVS showed keen interest to host the pre scaling up of the selected varieties. However, due to shortage of seed only some farmers were selected. Each farmer was supplied with seed of the variety. The host farmers were informed and agreed to deliver seeds of their harvest to the other farmers either in the form of cash or seed exchange for the subsequent cropping season.

The success of technology promotion program depends on appropriate prior orientation given to participants on technologies and the stepwise implementation of subsequent activities (Islam et al 2008). Accordingly, training was given to the participant farmers and kebele development agents on recommended tef seed production and management package by team of researchers. Multi-disciplinary team of researchers and agricultural experts made regular field visits to observe the progress, fix problems and give advice on proper field and crop management practices starting from land selection to harvesting. In 2020, one hundred twenty more farmers were involved in the pre scaling up of the selected improved varieties in ten kebeles of the district and they were given training on quality seed production. Seed quality inspection both at field and laboratory level was conducted by plant quarantine authority staff from Bahir Dar branch. Grain yield data (t $ha^{-1}$) of the varieties was collected from 60 host farmers' farms for each variety. Grain yield data of the local cultivar was also collected from the adjacent non-host farmers' farm for comparison purpose.

## 2.7. Field day

To promote the new varieties at a wider scale, a field day was organized at the maturity stage. A total of 92 participants including female and male farmers, district agricultural experts, kebele development agents, experts from Amhara seed enterprise, researchers and journalists from Amhara mass media attended the field day. The field day was communicated by Amhara television program to disseminate information for wider community. Each host farmer was allowed to describe to the field day participants about the activities and the observations he/she had during the course of growing the new variety. The field participants acknowledged the host farmers who did the seed production following the right protocol of seed production and also the best performance of the varieties. During the events, experiences and knowledge were shared among farmers and other stakeholders. Group discussion was conducted to grasp field day participants' feedback on the strength and weakness of the varieties. Finally, general discussion was made on how to enhance the production and productivity of tef in the district in general, how these varieties could reach to other interested farmers in the district and how to link seed producers with Amhara Seed Enterprise (ASE).

# 3. RESULTS AND DISCUSSIONS

## 3.1. Agronomic Performance of the Tested tef Varieties

The result of the combined analysis of variance for all measured parameters is indicated in Table-2. Significant ($P < 0.05$) variation for days to maturity and harvest index and highly significant ($P < 0.01$) variation for plant height, panicle length, dry shoot biomass and grain yield was detected among the tested varieties. This variation indicates the variability among the tested genotypes. In agreement with this study, Kebede et al (2019) and Tariku et al (2018) noted that in a PVS study variation was detected among improved tef varieties for phenological and morphological characters.

Wide variation was observed among the genotypes for days to maturity (107 to 117), plant height (100.6 to 122.4 cm), panicle length (22.6 to 35.4 cm), dry shoot biomass (5.2 to 6.6 t $ha^{-1}$) and harvest index (21.8 to 32.3%). The mean grain yield ranged from 1.1 to 2.1 t $ha^{-1}$ (Table 2). The highest grain yield (2.1 t $ha^{-1}$) was obtained from Estub followed by Dagem (1.81 t $ha^{-1}$), Kora (1.8 t $ha^{-1}$) and Quncho (1, 79 t $ha^{-1}$) while the lowest grain yield (1.1 t $ha^{-1}$) was obtained from the local variety (Table 2). Estub and Dagem showed about 91% and 70% grain yield advantage over the local variety. The overall grain yield performance of the varieties included in this study (Table-2) was found lower than what was reported during the variety releasing performance testing (Table-1). This might be due to the genotype by environment interaction. Gauch and Zobel (1996) noted that the same genotype when subjected to different environments can produce a range of phenotypes.

## 3.2. Ranking of Farmers' Varietal Preference Traits

Farmers' varietal preference traits were ranked using the RBQ analysis (Table 3). The results revealed that among farmers' varietal preference traits medium maturing followed by white seed color; high grain and biomass yield were the most preferred traits. Farmers prefer medium maturing varieties than the early ones because their area receives ample rain fall and hence early maturing varieties are liable to seed shattering by the extended rainfall. Farmers also prefer white seeded tef varieties than the red ones for the former fetches higher market price. On the other hand, high biomass yield has also comparable benefit to that of grain yield.

**Table 2:** Combined analysis of variance and mean performance of 10 tef varieties for grain yield and yield components as evaluated in a researcher managed PVS trial at *Alefa* and *Gibgedele* kebeles of Bure zuria district

| No. | Variety | Days to maturity | Plant height (cm) | Panicle length (cm) | Dry shoot biomass (t ha$^{-1}$) | Grain yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| 1 | Quncho(DZ-cr-387(RIL-355) | 117.2 | 114.8 | 32.0 | 6.64 | 1.73$^{b}$ | 23.1 |
| 2 | Estub (DZ-01-3186) | 110.5 | 115.9 | 34.9 | 5.53 | 2.10$^{a}$ | 32.3 |
| 3 | Kora (DZ-cr-438(RILNO.133B) | 105.8 | 122.4 | 35.0 | 6.19 | 1.80$^{ab}$ | 25.9 |
| 4 | Abola (7(Quncho*Keymuri (code 1) | 113.3 | 117.0 | 34.5 | 6.37 | 1.78$^{b}$ | 22.5 |
| 5 | Enatit (DZ-01-354) | 108.6 | 121.2 | 35.4 | 5.88 | 1.57$^{bc}$ | 23.4 |
| 6 | Dagem (DZ-cr-438 (RIL NO.91A) | 112.3 | 115.1 | 31.9 | 5.91 | 1.81$^{ab}$ | 27.3 |
| 7 | Ambo toke (DZ-01-1278) | 110.1 | 115.5 | 33.6 | 5.16 | 1.56$^{bc}$ | 26.3 |
| 8 | Welencomi (DZ-01-787) | 112.8 | 116.8 | 35.0 | 5.58 | 1.63$^{c}$ | 21.8 |
| 9 | Ziquala (DZ-01-358) | 115.5 | 109.5 | 31.8 | 5.19 | 1.64$^{bc}$ | 27.8 |
| 10 | Local check | 107.8 | 100.6 | 22..6 | 5.23 | 1.11$^{d}$ | 32.1 |
| | Mean | 111.4 | 114.9 | 33.8 | 5.77 | 1.67 | 26.3 |
| | CV (%) | 3.9 | 9.1 | 12.4 | 11.9 | 10.1 | 16.1 |
| | Genotype(G) | * | ** | ** | ** | ** | * |
| | Location(L) | * | ** | ** | ** | ** | * |
| | G*L | * | ** | ** | ** | ** | * |

*Note: *, ** refer to significant difference at 5% and 1% probability level, respectively*

### 3.3. Farmers' Varietal Preferences

The result of varietal preference analysis is indicated in Table 4. According to the farmers' evaluation, the improved varieties performed better than the local variety in terms of grain yield and yield related traits. Farmers' preferences for the improved varieties, however, varied due to varietal differences in terms of both qualitative and quantitative traits. Among the tested varieties Estub followed by Dagem were the most preferred varieties. This study is indicating that released varieties from the research system may not perform well everywhere due to the effect of genotype by environment interaction and may not also meet farmers' traits of interest. Hence, farmers should be provided with a range of improved varieties for selection with their participation under their circumstances. Traits of preference for farmers in the study area included uniform maturity, high biomass, best adaptability, no shattering, long panicle, high tillering capacity, white seed color, and medium maturity, soft *injera* making quality, good lodging tolerance and high grain yield. In agreement with Jifar et al (2019) some of farmers' quantitative traits of preference have positive correlation with grain yield (data not shown).

**Table 3:** Ranking of farmers' preference criteria for selection of tef varieties*

| SN | Preference criteria | RBQ[a] score | Rank |
|---|---|---|---|
| 1 | High no. of seeds/floret | 3.4 | 12 |
| 2 | Uniform maturity | 13.3 | 6 |
| 3 | High biomass | 22.3 | 4 |
| 4 | Better adaptability | 15.2 | 5 |
| 5 | No shattering | 5.3 | 11 |
| 6 | Long and loose panicle | 10.3 | 7 |
| 7 | High tillering capacity | 4.9 | 10 |
| 8 | White seed color | 29.6 | 2 |
| 9 | Medium maturity | 36.9 | 1 |
| 10 | Soft injera quality | 6.5 | 9 |
| 11 | Good lodging tolerance | 8.8 | 8 |
| 12 | High grain yield | 22.7 | 3 |
| N | Number of observations | 52 | |

*Note: RBQ[a], Rank Based Quotient. *** P < 0.001.* Preference traits were established based on farmers' feedback and 52 farmers involved in ranking of varietal preference criteria*

**Table 4:** Varietal preference scores (PS) of male farmers, female farmers, all farmers and researchers

| Variety | Varietal preference scores | | | | Grain yield |
|---|---|---|---|---|---|
| | Male farmers | Female farmers | All farmers | Researchers | (t ha$^{-1}$) |
| Quncho(DZ-cr-387(RIL-355) | 0.03 | 0.02 | 0.03 **(3)** | -0.01**(8)** | 1.73 **(5)** |
| Estub (DZ-01-31860) | 0.14 | 0.10 | 0.13[a] **(1)** | 0.15 **(1)** | 2.05 **(1)** |
| Kora (DZ-cr-438(RILNO.133B) | -0.05 | -0.01 | -0.03 **(8)** | 0.02**(3)** | 1.80 **(3)** |
| Abola (7(Quncho*Keymuri(code 1) | -0.04 | -0.06 | -0.02 **(7)** | 0.01**(5)** | 1.78 **(4)** |
| Enatit (DZ-01-354) | 0.02 | 0.01 | 0.02 **(4)** | 0.11**(2)** | 1.57 **(8)** |
| Dagem (DZ-cr-438 (RIL NO.91A) | 0.11 | 0.07 | 0.09[b] **(2)** | 0.02**(3)** | 1.81 **(2)** |
| Ambo toke (DZ-01-1278) | -0.04 | -0.03 | -0.01 **(6)** | 0.01**(5)** | 1.56 **(9)** |
| Welencomi(DZ-01-787) | 0.03 | -0.03 | 0.01 **(5)** | -0.2**(9)** | 1.63 **(7)** |
| Ziquala (DZ-01-358) | -0.03 | -0.01 | -0.04[d] **(9)** | 0.01**(5)** | 1.64 **(6)** |
| Local check | -0.06 | -0.08 | -0.07[c] **(10)** | -0.06**(10)** | 1.11 **(10)** |

*Note: [a] the first most preferred variety, [b] the second-best preferred variety, [c] the first least preferred variety, [d] the second least preferred variety, () numbers in parenthesis refer to ranking*

### 3.4. Correlations between Preferences

Spearman's rank correlation coefficient (r) analysis between preference scores of male and female farmers was significant and positive (p = 0.01) (Table 5). This agreement showed that both male and female farmers in the study district have similar requirements in new varieties. Men and women farmers often work together for a range of different agricultural operations. However, there remain some discrepancies between male and female preferences. In addition to agronomic characters of new varieties, the PVS process can also be extended to include post-harvest characteristics, where obviously women will have some additional preference criteria such as good eating quality, softness after cooking, and high market value. The relatively low correlation in varietal preferences between farmers and researchers indicated that farmers often had different priorities than the researchers. In agreement with this study, Mulualem et al (2012) noted that farmers and the researchers used different parameters and methods to evaluate the tested genotypes and hence breeders should consider farmers' varietal selection traits in their variety development program.

To take into account farmers' preference in the varietal releasing process, we conducted preference scoring. This concern is particularly highlighted by the weak correlation between the preference scores of all farmers and grain yield (Table 5), with the latter being a central criterion in most breeding programs. Significant and positive correlations between preference scores of all farmers and grain yield were observed in only 65% of the farmers (Table 5). This low correlation indicates more frequent mis-matches between characteristics of highest yielding tef varieties and breeding lines selected by breeders versus farmers' preferences. Thus, grain yield was not the overriding trait for farmers in the area while other traits have also considerable importance for the selection of best tef varieties. The result of this study is in agreement with other PVS studies which have shown that above a certain minimum yield, the acceptability of a variety is determined by factors other than yield (Kitch et al 1998). The results of this study also ascertained that there is a need for involving farmers to clear their uncertainties about new technologies. This suggestion is consistent with the finding of Scoones et al (2009) who noted that lack of adoption of improved varieties has been attributed to the linear character of agricultural knowledge and information systems, which do not involve users of the varieties.

**Table 5:** Spearman's rank correlation coefficient (r) analysis of varietal preferences between male and female farmers, between all farmers and researchers and between all farmers and grain yield

| | Male Farmers | Female farmers | All farmers | Researchers | Grain Yield |
|---|---|---|---|---|---|
| Male farmers | 1.00 | 0.9*** | __ | __ | __ |
| Female farmers | __ | 1.00 | __ | __ | __ |
| All farmers | __ | __ | 1.00 | 0.58 | 0.65* |
| Researchers | __ | __ | __ | 1.00 | __ |
| Grain yield | __ | __ | __ | __ | 1.00 |

*Note: *, *** refer to level of statistical significance at P < 0.05 and 0.001, respectively*

### 3.5. Pre scaling up of Farmers' Preferred Improved Tef Varieties

One of the important components of participatory variety selection is to scale up farmers selected new varieties and to harvest their advantages. Based on the results of biological data and farmers' varietal preference analysis, Estub and Dagem varieties were selected and recommended for pre scaling up. Accordingly, they were pre scaled up both in 2019 at two kebeles and in 2020 at 8 more kebeles.

In 2019, almost all of the PVS participant farmers showed keen interest to multiply the selected varieties. However, due to shortage of seed the selected varieties were given to 20 farmers only (10 farmers/ variety). Each host farmer was given 3.75 Kg seed of the selected variety to multiply on quarter of a hectare so that a total of 5 hectares were covered (2.5 ha/variety) in a cluster form. Nowadays a clustered approach has become more successful than the scattered one (Lilja and Ashby 2001). Cluster approach creates a good opportunity for farmers to compete each other for the production of high quantity and better-quality yields by applying the recommended agronomic practices. Moreover, it helps to control pests, attract eye of the other farmers and thereby stimulates them to ask, observe, and finally adopt the technology. The host farmers were informed and agreed as they will deliver the extra seed from their produce to the other farmers following farmer to farmer seed exchange approach.

### 3.6. Field day

Field day was used as tool to address large number of farmers and other stakeholders to create massive awareness. Every field day participant recommended the varieties for further scaling up in one voice. Especially male and female participant farmers were very much inspired by the best performance of the varieties which meet their traits of interest. The farmers then agreed with host farmers to have seed of the varieties for further scaling up in their respective kebeles. Amhara seed enterprise also promised to include both of the varieties in its seed production plan.

### 3.7. On farm Grain Yield Performance of the Pre scaled up Improved Tef Varieties

The grain yield data of the two pre scaled up varieties plus the local cultivar as a comparison both in 2019 and 2020 is indicated in Table 6. The average grain yield obtained from Estub and Dagem varieties was 1.91 t ha$^{-}$

[1] and 1.79 t ha $^{-1}$and ranged from 1.5 to 2.4 t ha$^{-1}$ and 1.5 to 2.1 t ha$^{-1}$, respectively. This wide variation with in the variety stemmed from soil fertility difference among host farmers' farm, crop management differences among the host farmers and some uncontrollable factors that happened in some host farmers' farm. A total of 76.84 and 72.65 tons of seed of Estub and Dagem varieties, respectively was produced when the pre-scaling up was conducted in the district. Estub and Dagem showed 55 to 68% and 49 to 58% grain yield advantage over the local variety, respectively (Table 6). From table 6 one can estimate the economic benefits of applying improved tef technologies as compared to the traditional system. For instance, if 50% of tef growers in the district use improved technologies, about 4599 tons of tef can be produced, where as if all tef growers in the district apply the improved technologies, about 9198 tons of tef can be produced. In both cases about 56% more tons of tef can be produced as compare to the traditional system of production.

**Table 6:** Grain yield data of the pre scaled up tef varieties

| Variety | Year | No. of host farmers | Total area covered in ha | Total prod. in tones | Mean (t ha$^{-1}$) | Sta. dev. | Min. | Max. | % Yield advantage over the local cultivar |
|---|---|---|---|---|---|---|---|---|---|
| Estub | 2019 | 10 | 2.5 | 18.94 | 1.89 | 0.21 | 1.50 | 2.30 | 68.7 |
| Dagem | 2019 | 10 | 2.5 | 17.45 | 1.74 | 0.15 | 1.53 | 2.00 | 55.3 |
| Local | 2019 | 10 | 2.5 | 11.21 | 1.12 | 0.15 | 0.90 | 1.20 | ----- |
| Estub | 2020 | 60 | 30 | 57.9 | 1.93 | 0.17 | 1.55 | 2.40 | 58.1 |
| Dagem | 2020 | 60 | 30 | 55.2 | 1.84 | 0.13 | 1.50 | 2.10 | 49.1 |
| Local | 2020 | 60 | 30 | 36.6 | 1.22 | 0.14 | 1.00 | 1.20 | ----- |

## 4. CONCLUSION AND RECOMMENDATION

Significant variations were detected among the tested tef varieties of which Estub (DZ-01-3186) and Dagem (DZ-cr-438 (RIL NO.91A) showed better performance in grain yield and other agronomic traits. These varieties were also preferred by farmers most on the merits they demand. Farmers considered multiple traits as varietal selection criteria. The preference for these two varieties signifies that necessarily not all improved varieties could be adopted by farmers The selected varieties gave an extra yield advantage over the local variety during pre-scaling up. A strong demand on the varieties was created to farmers and other stakeholders. They were extending very rapidly through farmers-to-farmers seed exchange approach. Based on the lessons learned from this study, it can be recommended that for plant breeders, it may be difficult to predict which traits or trait combinations are of prime importance for a particular target group of farmers. Therefore, future breeding program should include the participation of farmers' and their selection preferences early during varietal development program.

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