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Farmers' Selection Criteria of Tef Varieties in Halaba, South Ethiopia

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Abstract
Ethiopia extensively grows its ancient cereal crop, tef [*Eragrostis tef* (Zucc.) Trotter]. The existing tef varieties have low yield and limited acceptance by farmers. August to November, 2021 of main cropping season was used to conduct an on-farm experiment in Halaba, South Ethiopia, to determine farmers' criteria in choosing varieties of tef as well as to identify farmers' preferred high-yielding varieties. Nine improved tef varieties were planted using three replications of a randomized complete block design. On average, plant height, panicle length, days to heading, days to maturity, biomass yield, and grain yield were 97.98 cm, 35.81 cm, 58 days, 105 days, 4.82 tons ha^{-1}, and 1.30 tons ha^{-1}, respectively. The highest grain yield (1.54 tons ha^{-1}) was obtained for variety Tsedey, followed by Filagot (1.43), Ebba (1.41), Bora (1.38), Areka-1 (1.37), and Hiber-1 (1.28). Farmers' selection criteria showed that variety Tsedey obtained the highest score (4) for earliness in maturity, grain yield, and panicle yield. In terms of overall farmers' preferences, variety Tsedey was ranked first, followed by varieties Hiber-1, Bora, and Ebba. The present study showed that varieties Tsedey, Bora, Ebba, and Hiber-1 would be recommended for widespread cultivation for their high grain yield and farmers' preferences.

Keywords: Farmers 'Selection Criteria, Grain Yield, Participatory Varietal Selection, Tef, *Eragrostis Tef*

Introduction

Ethiopia extensively grows its ancient cereal crop, tef [*Eragrostis tef* (Zucc.) Trotter]. Tef is capable of growing between sea level and 2800 m above sea level in a variety of soil types and climates with varying levels of temperature and rainfall. A very small grain of tef is used to make *injera* (a soft bread that resembles a flat pancake), porridge, and local alcoholic beverages such as *tella* and *areke*. Moreover, tef straw is a valuable source of feed for livestock (Ketema, 1997) [11].

After maize, tef comes second in annual cereal production and first in area covered. It contributes more than 5 million tons of grain (19.33% of the cereal production) and covers more than 3 million hectares of land (29.60% of the cereal area) annually. Tef is grown on more than 8,224 hectares of land (21.26% of the cereal area) in Halaba, Southern Ethiopia, and produces more than 11835 tons of grain (9.29% of the cereal production) annually. Low yield potential and farmers' limited acceptance of existing varieties contribute in part to low tef yield nationally (1.85 tons ha^{-1}) and in Halaba (1.44 tons ha^{-1}) (CSA, 2020) [6]. This is despite the fact that tef yield in experimental plots has been estimated to be between 5 and 10 tons ha^{-1} (Ketema, 1997) [11]. Adoption rates are usually low for new varieties that are not accessible to farmers, have low adaptation to certain environmental conditions (Courtois *et al*., 2001) [5], and do not meet farmers' quality expectations (Joshi and Witcombe, 1996) [8].

By engaging farmers in decision-making and incorporating their preferences into crop breeding programs, it can be possible to increase the diversity and adoption of crop varieties. Participatory varietal selection refers to that farmers make their selections from improved and advanced materials during demonstrations or on-farm trials (Witcombe and Joshi, 1996) [8]. Thus, the involvement of farmers in breeding programs not only minimizes the time required for the release of the new variety (Assefa *et al*., 2005) [2], but also increases the acceptance and diversity of crop varieties (Joshi and Witcombe, 2002) [8] and improves breeders' knowledge of the farmers' selection criteria (Sperling *et al*., 2001) [13]. The purpose of the current study was to determine farmers' criteria for choosing varieties of tef as well as to identify farmers' preferred high-yielding varieties.

Materials and Methods

Guba Shiraro village ($07^0$17'19"N, $38^0$12'10"E, and 1865 m above sea level), 12 km from Halaba-Kulito town ($07^0$17'60''N, $38^0$06'60" E, and 1726 m above sea level), Halaba, South Ethiopia, was used to conduct an on-farm experiment from

August to November, 2021. Halaba experiences a mean temperature of 22.22˚C and 857 mm of rainfall per year. On August 5, 2021, nine improved tef varieties were planted at a 15 kg ha^{-1} seed rate using three replications of a randomized complete block design. Tef seed was drilled in a plot of 3 m by 3 m, consisting of ten rows with 20 cm of space between rows. Replications and plots were spaced apart by 1.2 m and 80 cm, respectively. Each plot received 100 kg ha^{-1} of each of urea and NPS fertilizers at planting. Weeds were frequently hand-weeded during the experiment duration.

For the purpose of scoring the preferences of farmers, 12 farmers (10 males and 2 females), including the host farmer and his neighbors who have experience with tef cultivation and are willing to evaluate the experiment, were used. Farmers' preference scores were taken during the heading and maturity stages of the crop. Each of the five farmers' selection criteria (grain yield, panicle yield, straw yield, earliness in maturity, and seed color) was scored with 1, 2, 3, and 4 representing poor, good, very good, and excellent, respectively. Farmers agreed on the final scores for each selection criterion after discussing and resolving their differences (De Boef and Thijssen, 2007). For each plot, the average plant height and panicle length (cm) were measured for five randomly selected plants, whereas the entire plot was used to record days to heading and maturity, biomass yield (tons ha^{-1}), and grain yield (tons ha^{-1}). Genstat software (VSN International, 2012) [14] was used to analyze the data.

Results and Discussion

Besides the variation in variety significantly affected grain yield, biomass yield, plant height, panicle length, days to heading, and days to maturity, there was substantial variation among varieties for these traits. While biomass yield (tons ha^{-1}) varied from 3.96 (variety Mena) to 5.41(variety Filagot), gain yield (tons ha^{-1}) ranged from 1.05 (variety Washara) to 1.54 (variety Tsedey) (Table 1).

Table 1: Significant of F-ratios and mean values for six grain yield and yield-related traits of nine tef varieties grown during the main cropping season of 2021 in Halaba, Ethiopia

Variety	DTH	DTM	PHT	PL	BY	GY
Areka-1	60	103	85.87	30.20	4.26	1.37
Bora	55	101	97.47	37.40	4.70	1.38
Ebba	56	108	99.60	35.67	5.23	1.41
Filagot	57	104	87.20	31.00	5.41	1.43
Hiber-1	62	107	104.27	37.73	5.26	1.28
Jitu	62	110	121.93	48.07	5.37	1.20
Mena	55	102	99.20	36.27	3.96	1.05
Tseday	55	101	82.07	27.80	5.04	1.54
Washara	62	105	104.20	38.20	4.11	1.05
Mean	58	105	97.98	35.81	4.82	1.30
F-ratio						
Replication (2)	ns	ns	ns	ns	ns	ns
Variety(8)	**	**	**	**	*	*
CV%	2.69	1.13	5.26	9.06	11.24	13.96
$LSD_{0.05}$	2.71	2.05	8.92	5.62	0.94	0.31

DTH = days to heading, DTM = days to maturity, PHT = plant height (cm), PL = panicle length (cm), BY = biomass yield (tons ha^{-1}), GY = grain yield (tons ha^{-1}); *, ** = significant at 5% and 1% probably level, respectively; ns = non-significant; numbers in the parentheses are degree of freedom

The five farmers' selection criteria had mean scores that ranged from 1.2 (variety Jitu) to 3.40 (variety Tsedey). In addition, the highest average scores were obtained for varieties Hiber-1 (3.0), Bora (2.6), and Ebba (2.6). Early-maturing varieties Mena and Tsedey obtained the highest score for earliness (4), whereas late maturing varieties Filagot and Jitu obtained the lowest score (1). The high-yielding variety Tsedey received the highest score for grain yield (4), while varieties Bora, Ebba, Filagot, and Hiber-1 received the next-highest score (3). Variety Tsedey received the highest score (4) for panicle yield, while varieties Filagot and Washara received the next-highest score (3). Varieties with either pale white (Jitu) or brown (Filagot) seeds were rated the least (1) when compared to those having more white-colored seeds. In terms of overall farmers' preferences, variety Tsedey was ranked first, followed by varieties Hiber-1, Bora, and Ebba (Table 2).

Table 2: Farmers' preference scores and ranks for five farmers' selection criteria for nine tef varieties grown during the main cropping season of 2021 in Halaba, Ethiopia

Variety	Year of release	Registered seed color	GY	PY	SY	EL	SC	Sum	Mean	Rank
Areka-1	2017	White	2	2	3	2	2	11	2.2	5
Bora	2019	Very white	3	2	2	3	3	13	2.6	3
Ebba	2019	Very white	3	2	3	2	3	13	2.6	3
Filagot	2017	Brown	3	3	4	1	1	12	2.4	4
Hiber-1	2017	White	3	2	4	3	3	15	3.0	2
Jitu	2019	White	1	1	2	1	1	6	1.2	7
Mena	2019	Very white	1	1	1	4	3	10	2.0	6
Tsedey	1984	White	4	4	2	4	3	17	3.4	1
Washara	2019	Very white	2	3	1	2	4	12	2.4	4
Mean			2.4	2.2	2.4	2.4	2.6	12.1	2.4	

GY = grain yield, PL = panicle yield; SY = straw yield, EL= earliness in maturity, SC = seed color; scores: 1= poor, 2 = good, 3 = very good, and 4 = excellent

As to the present study, previous studies (Ashamo *et al*., 2020; Balcha, 2020) [1, 3] also showed that tef has genotypic variability for grain yield and yield-related traits. Similarly, the existence of substantial variability in test varieties would suggest the possibility that these materials would be subjected to selection to obtain superior genotypes. In addition to the high grain yield, farmers preferred white seed because of its high market value. The significance of seed color as a farmers' selection criterion for tef (Sida, 2017; Kebede *et al*., 2018) [12, 10] and wheat (Workineh *et al*., 2014) [16] has also been demonstrated in earlier studies.

In addition to high straw yield, farmers favored varieties that have weaker stalks because they are better suited for animal feed and mixing with mud for house construction. Farmers also preferred early-maturing varieties because Halaba frequently experiences drought. Early maturity is the most important factor to minimize the adverse effect of moisture scarcity on crop yield (Balcha and Tigabu, 2015; Kebede *et al*., 2018) [4, 10]. The current study revealed that farmers favored high-yielding, early-maturing, and white-seeded varieties. Therefore, varieties Bora, Ebba, Hiber-1, and Tsedey would be used to increase farmers' acceptance and varietal diversity.

Conclusion

The substantial variation observed for grain yield and yield-related traits would suggest that test materials would be subjected to selection to improve these traits. This study showed that, besides grain yield and straw yield, seed color and earliness in maturity are the most important selection criteria for tef farmers. Thus, combining grain yield and yield-related traits with farmers' selection criteria in breeding programs would enhance varietal adoption and diversity in tef.

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