

TEF [*Eragrostis TEF* (ZUCC.) Trotter] Seed Quality Variation in East Gojjam Zone, Ethiopia

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ABSTRACT

East Gojjam is one of the major tef seed growing areas of Ethiopia. The main themes of this study were to assess the physical, physiological and health quality of seed in Gozzamin and Enarji Enawga districts, Amhara Regional state, in 2009/2010 cropping season. Data were done by employing SAS (9.0) softwares to analyse the physical, physiological and health quality of seed samples. There was a significant difference in physical purity among seed samples. The analytical purity of the tef seed grown in all PAs was above the national standards for commercial seed. The most abundant seeds of other species in purity analysis were Vitrogoe, Sitaris spp, Trampgrass samples which appeared in 31% (4), 23% (3) and 15% (2), respectively. The overall average mean germination percentage was 88.2% with the range of 76.6% to 93.0% and the highest value was recorded for seed obtained from Enarji Enawga F8 (93.0%) followed by F1 (92.3) from Gozzamin. The lowest vigor index I was recorded for F7 from Enarji Enawga because of short root length (199.99cm). The highest vigor index II was recorded for samples collected from ESE with 1.68mg mean because of higher seedling dry weight. There was a positive and highly significant correlation ($r = 0.603^{**}$, $p < 0.001$) between germination percent and seedling emergence percent. These indicated that as the germination percent increased and seedling emergence percent also increased. Seed storage facilities at farmers are inferior to those at the Ethiopian Seed Enterprise but during shipments should therefore be timed so that seeds can be sown with the minimum delay after receipt. So, shipment of sensitive seeds by air is desirable. Other, wise in conclusion, to enhance tef productivity in east Gojjam zone through supply of improved varieties and quality seed it is important to integrate formal and farmer (informal) seed system.

Key words: Quality, Seed, TEF, Variation

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INTRODUCTION

Seed is the most important agricultural input; it is the basic unit for distribution and maintenance of plant population. It carries the genetic potential of the crop plant. It thus dictates the ultimate productivity of other input, such as fertilizer, pesticide, irrigation, water, etc., which build the environments that enable the plant to perform well (Mugonozza, 2001). Saving the best grains, roots or tubers from consumption, farmer's storage and planting developed over centuries into structured local seed systems. The objective of farmer seed systems is to produce sufficient quantities of seed for the preferred crops and varieties of optimum quality available for each farming unit every planting season (FAO, 1998).

The quality of the seed, among others, determines to a large extent the success of the crop in terms of yield and product quality. It, thus, contributes to food security and the value of crop products in the market. The quality of seed encompasses genetic purity, the germination rate, seed health and physical purity of the seed (Temba, 1998). High quality seed is essential for the successful establishment, uniform growth and maximum productivity of agricultural crops and forage species. This highlights the need for effective seed quality assurance as an integral part of any seed supply system. As consumers become more discerning, they increasingly recognize the relationship between high quality seed and crop performance; thereby increasingly demand for better quality seed. It then becomes more important to ensure that seed producers have the necessary technological skills to produce good quality seed, thereby complementing improvements made through new cultivars and improved agronomic practices (Beavis and Harty, 1999).

However, there is little information on informal seed sector, farmers indigenous knowledge in seed selection and maintenance, farmers seed sources, seed quality and seed management practices. Moreover, research work on

determining quality of tef used for seed is lacking in various seed system. Hence this study was undertaken with the following objectives: To assess the physical, physiological and health quality of seed.

MATERIALS AND METHODS

The study was undertaken in Gozamin and Enarji Enawga district of Eastern Gojjam Zone (EGZ) of Amhara National Regional State (ANRS), Ethiopia. The tef production area was 210,523 ha with a total production of 263,153.96t and its productivity was 1.25t per ha for private peasant holdings for meher season. Gozamin is near the capital of East Gojjam (Debre Markos) (3-5 km) while Enarji Enawga is 115km from Debre Markos (Melkam et al, 2014). The soil types of the district include black soil (25%), red soil (60%) and brown soil (15%). The Gozamin district has two Rural *Kebele* Administration Units consisting of 40 peasant associations, 47,199 household farmers and a total human population of 256,974. Over 98% of the populations of Gozamin have been involved in agriculture. Listed in order of importance, tef, wheat, maize and barely were the dominant crops cultivated in the Gozamin district (GDAO, 2003).

The soils type of the district includes black soil (28%), red soil (54%) and brown soil (18%). The Enarji Enawga district rural *Kebele* administration units consisting of 27 peasant associations has 165,415 household farmers and a total human population of 185,124. Over 98% of the populations of Enarji Enawga were involved in agriculture Enarji Enawga District Agricultural office (EEDAO, 2009).

SEED QUALITY ANALYSIS

Tef variety (Dz-01-354) was dominantly and widely grown for a long period of time in both districts and was selected to determine physical, physiological and health quality analysis. Samples were taken from Dz-01-354 growing farmers, 3 farmers per PAs and 6 farmers per district and a total of 12 farmers in the EGZ and one sample representing formal seed system, from Ethiopian Seed Enterprise (ESE).

DETERMINATION OF PHYSICAL QUALITY

A sample of 1kg seed was drawn from the farmers' saved seed intended for planting purpose to make laboratory seed quality analysis. Seed samples of 1 g from different sources were obtained for laboratory tests including purity, vigor and seed-health tests. Quantities of submitted sample were 25 g and working sample was 1 g which was separated in to 0.5 g by weighing on sensitive balance after remixing each sample by using *boerner* divider. Each sample was sorted to three components that include (i) pure seed, (ii) other crop seed, and (iii) inert matter. The components were weighed on precision balance to the nearest two decimal places and the percentage of each component was determined (ISTA, 1996).

DETERMINATION OF PHYSIOLOGICAL QUALITY

All samples collected during the survey were analyzed for physiological seed quality (Germination, Vigor). All tests were conducted according to ISTA rules (ISTA, 1996). Physiological quality tests were conducted at the seed testing laboratory in Ethiopian Seed Enterprise (ESE).

STANDARD GERMINATION (STG) TEST

Standard germination (StG) test was done for all seed samples obtained from different sources (treatments). Four hundred (400) seeds of the pure seeds component were divided into four replicates of 100 seeds which were then sown on top of paper medium. In order to determine the germination percentage, the seeds were incubated at a temperature of 20°C for 10 days as specified by International Seed Testing Associates (ISTA, 1996) and on the final day of the StG test, seedlings were grouped into (i) normal seedlings, (ii) abnormal seedlings (iii) ungerminated and (iv) dead seeds.

SEED VIGOR TEST

Seedlings shoot and root length: The seedlings shoot and root lengths were determined in the standard germination test after the final count. Ten normal seedlings were randomly selected from each replicate after 10 days of sowing. The shoot length was measured from the point of attachment to the embryo (endosperm) to the tip of the seedling. Similarly, the root length was measured from the point of attachment to the embryo (endosperm) to the tip of the root. The average of shoot and root lengths were computed by dividing the total shoot or root lengths by the total number of normal seedlings measured (ISTA, 1996).

Seedling dry weight: Ten randomly selected seedlings from each replicate were cut from the embryo and placed in paper bags to be dried in an oven at 80°C for 24 hours. The dried seedlings were weighed to the nearest milligram using sensitive balance and the average seedling dry weights were calculated.

Vigor index-I and Vigor index-II: For each sample, two vigor indices were calculated. Seedling vigor index-I was calculated by multiplying the standard germination with the average sum of shoot and root length after ten days of germination and vigor index-II by multiplying the standard germination with mean seedling dry weight.

Speed of germination: 100 seeds were replicated into four from each sample and sown on top of blotter paper and kept at room temperature (20°C) for maximum of 10 days. Then speed of germination (GS) were calculated as suggested by Maguire (1962). The number of normal seedlings were counted daily up to 10 days and divided by number of days. The same were added till final count as per the following formula.

$$GS = \frac{\text{number of normal seedlings}}{\text{number of days to first count (4}^{\text{th}})} \oplus \dots \oplus \frac{\text{number of normal seedlings}}{\text{number of days to final count (10}^{\text{th}})}$$

SEEDLING EMERGENCE PERCENT AND RATE EVALUATION

Tef variety Dz-01-354 was planted in pots (26.5 cm diameter) at planting depth of 10 mm in the greenhouse to assess the impact of agronomic and post harvest systems on seedling emergence. Four hundred (400) pure seeds were divided into four replicates of 100 seeds each (percent), which were then sown in soil in pots and each pot was watered whenever needed. The number of seedlings emerged from soil were counted daily and divided by number of days till final emergence to planted.

DATA ANALYSIS

The treatments were laid out in complete randomized design (CRD) for the laboratory and seedling emergence tests. The treatments were assigned randomly and each treatment was replicated four times. Collected data from laboratory experiments were transformed then subjected to analysis of variance as per the design of the experiments using SAS (9.0) and treatment means were separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

PHYSICAL QUALITY ANALYSIS

The physical quality of seed sampled from farm saved seed varied greatly. The mean of physical purity ranged from 98.2% Farmer 5 (F5) and Farmer 6 (F6) from Enarji Enawga to 99.5% Farmer 1 (F1) from Gozzamin and ESE seed sample obtained from Farmer 5 being with the highest inert matter (Table 1). The results showed that the physical quality of seed from the informal sector was equal or comparable to the seed from formal sector, (ESE). The purity analysis test showed that all of the 13 collected seed samples were greater than 96% which were physically pure by the minimum national seed standard for certified seeds class including tef seed in Ethiopia (Appendix Table 1). There was no difference in physical purity level between seed samples of different PAs. The analytical purity of 13 seed samples was significantly different for only other crop seed ($P < 0.05$) (Appendix Table 2).

In this study almost all 13 samples were with inert matter contamination of less than two percent as prescribed in the standard (Table 1). All seed samples maintained the minimal analytical purity percentage and inert matter contamination except other plant seeds (weed seed). Some of the highest levels of contamination with other plant seed were observed on samples of F2, F10 and F12 from Gzzamin and F6, F7 and F9 from Enarji Enawga districts because farmers lack proper crop rotation, at threshing floors or in storage facilities. Alemayehu *et al.*, (1999) reported that most of the samples collected from farmers satisfied the physical purity standards set for wheat seed production in Ethiopia which is agreeable with tef in this study. Similarly, a high level of contamination with dirt, stones, and weed seeds would greatly reduce the value of the seed to farmers (Nicholas *et al.*, 2007).

Contamination might have been occurred during pre-harvest activities of seed production, harvesting, threshing, or poor storage conditions. A total of 13 other crop species were identified in the samples with maximum of three and minimum of one species per sample. The major weed species were *Lolium* sp, *Guizotia* sp, *Vitgro* sp, *Setaria* sp, *Phalaris* sp, *Polygonum* sp, and *Amarantus* spp, found in the tef seed. The most abundant seeds of other species were *Vitgroe* (*Poa Annum*), *Setaria* sp., *Trampgrass* (*Polygonum aviculave*), in a few samples appeared in 31% (4), 23% (3) and 15% (2) (Appendix Table 5). In the Arsi Region, major weeds reported in early growth period were *Polygonum nepalense*, *Guizotia scabra*, *Amaranthus* spp., *Setaria pumila*, and *Avena* spp., while *Phalaris paradoxa* was dominant after the rainy season is over (Berhanu, 1986; Zerihun, 1993).

Generally, the incidence of the three other weed species in terms of their presence in some of the samples is more important than the crude results of analytical purity. Hence, weed seeds is the most important factor that influenced the physical purity of the tef seed in the surveyed area. Similar findings were reported by other workers in wheat seed. Hassan (1995) found that 82.3% of the wheat seed samples were contaminated with barley seed in Jordan. Zewdie (2004) found significant differences in physical purity, other crop seed and weed seed contamination of wheat seed samples collected from different sources in Ethiopia attributed to the different ways that farmers used to produce, select, save and acquire wheat seeds. Farmers do not conform fully to the Distinctiveness, Uniformity, and Stability (DUS) criteria (UPOV, 2002). Farmers know their varieties with clear quantitative and qualitative markers for identification of farmers' varieties when planted alone and together with other varieties (Mekbib, 2006b).

Table 1: Analytical physical purity test

Seed sample	Composition by weight %		
	Pure seed	Inert mater	Other crop seed
F1	99.5 ^a	1.11(0.4 ^b)	0.56(0.1 ^e)
F2	98.7 ^{abc}	1.53(0.8 ^b)	1.25(0.5 ^{abcd})
F3	99.5 ^a	1.05(0.35 ^b)	0.68(0.15 ^{de})
F4	99.25 ^{ab}	1.28(0.6 ^b)	0.68(0.15 ^{de})
F5	98.2 ^c	2.24(1.6 ^a)	0.79(0.2 ^{cde})
F6	98.2 ^c	1.48(0.9 ^b)	1.66 (0.9 ^a)
F7	98.9 ^{abc}	1.28(0.55 ^b)	1.17(0.55 ^{abcde})
F8	99.1 ^{abc}	1.48(0.7 ^b)	0.79(0.2 ^{cde})
F9	98.5 ^{bc}	1.48(0.7 ^b)	1.58(0.8 ^{ab})
F10	98.7 ^{abc}	1.48(0.7 ^b)	1.37(0.6 ^{abc})
F11	99.42 ^{ab}	0.93(0.28 ^b)	0.97(0.3 ^{bcde})
F12	99.3 ^{ab}	0.96(0.3 ^b)	1.08(0.4 ^{abcde})
ESE	99.5 ^a	1.05(0.35 ^b)	0.68(0.15 ^{de})
Mean	98.98	1.33	1.02
CV (%)	0.46	23.9	30.75

Figures followed in the same latter in the same column are not significantly different among each other. F1 - F12 = Seed samples from farmer, ESE = seed sample from Ethiopian Seed Enterprise.

PHYSIOLOGICAL SEED QUALITY

Standard germination test

The value of germination percentage, abnormal seedlings, ungerminated and dead seeds in a working sample during germination was recorded. The overall average mean germination percentage was 88.23% with the range of 77.25% up to 93.0% and the highest value was recorded for seed obtained from Enarji Enawga of F8 (93.0%) followed by F1 (92.25%) from Gozzamin. Moreover, the majority of samples (nearly 85%) were above the average germination percentage except one sample from Enarji Enawga districts as prescribed in the Ethiopian National Seed Standard Certified Seed of tef (Appendix Table 1). Ensermu et al. (1998) also found similar results where almost all wheat samples collected from farmers reached the minimum germination standards for certified seed.

Table 2: Standard germination test

Seed sample	Laboratory			
	GP	AB	FU	DS
F1	92.25 ^{ab}	5.0 ^{cd}	1.5 ^{ab}	1.25 ^a
F2	91.75 ^{ab}	4.75 ^{cd}	1.75 ^a	1.25 ^a
F3	86.0 ^{bc}	10.43 ^{ab}	1.46 ^{ab}	1.75 ^a
F4	90.5 ^{ab}	7.0 ^{b-d}	1.8 ^a	1.25 ^a
F5	88.74 ^{ab}	8.0 ^{bc}	1.25 ^{ab}	1.51 ^a
F6	88.0 ^{ab}	9.0 ^{bc}	1.75 ^a	1.25 ^a
F7	85.0 ^b	11.5 ^{ab}	1.75 ^a	2.0 ^a
F8	93.0 ^a	4.0 ^d	1.5 ^{ab}	1.75 ^a
F9	77.25 ^c	19.25 ^a	1.25 ^{ab}	1.75 ^a
F10	90.0 ^{ab}	7.5 ^{bc}	1.0 ^b	1.5 ^a
F11	89.25 ^{ab}	8.5 ^{bc}	1.0 ^b	1.25 ^a
F12	86.0 ^{ab}	11.5 ^{ab}	1.25 ^{ab}	1.25 ^a
ESE	92.0 ^{ab}	5.75 ^{cd}	1.25 ^{ab}	1.0 ^a
Mean	88.23	7.61700	1.31	1.364
CV (%)	5.1	18.4200	25.0	29.14

GP, AB, FU, DS, = Germination percentage, abnormal, ungerminated and dead seed in the laboratory respectively. Figures followed by same letters in the same column are not significantly different at $p < 0.05$. F1- F12 = Seed samples from farmer, ESE = Seed sample from Ethiopian Seed Enterprise.

The mean germination percentage for certified seed in ESE was lower (92.0%) as compared to seed obtained from F1 (92.25%) of Gozzamin (wonka) and F8 (93.0%) of Enarji Enawga (Ambager) PAs or districts. In contrary, Al-Faqeeh (1997) found that certified seed had significantly higher germination in lentil compared to seed from other sources. There were highly significance differencant ($p < 0.01$) in normal and abnormal seedling among different tef seed of farmers and ESE (Appendix Table 5). Seed sample of F9 from Enarji Enawga showed the lowest value of germination percentage (77.25%) (Table 2). More abnormal seedlings obtained from F9 (19.25%) and more ungerminated seed from F4 (1.8%) were observed.

TEF seed vigor test

Several physiological tests such as standard germination speed of germination, seedling shoot and root length and seedling dry weight were measured to assess the vigor of tef seed lots collected from farmers and ESE. A thorough and careful root and shoot length measurements were taken for seed from different samples. Seed sample of F5 (1.58 cm) and F6 (1.29 cm) showed the highest and the lowest shoot length from Enarji Enawga district, respectively (Table 3).

Table 3: Seed vigor test in the laboratory

Seed sample	SL	RL	SDW	GR	VI (cm)	VII (mg)
F1	1.36 ^{ab}	1.89 ^a	0.015 ^b	5.620 ^{ab}	299.46 ^a	1.385 ^b
F2	1.34 ^{ab}	1.59 ^b	0.02 ^{ab}	5.570 ^b	268.870 ^{ab}	1.835 ^{ab}
F3	1.37 ^{ab}	1.21 ^{de}	0.02 ^{ab}	5.71 ^{ab}	221.460 ^{def}	1.720 ^{ab}
F4	1.42 ^{ab}	1.49 ^{bcd}	0.018 ^b	5.730 ^{ab}	263.28 ^{bc}	1.588 ^b
F5	1.58 ^a	1.52 ^{bc}	0.02 ^{ab}	5.770 ^a	274.660 ^{ab}	1.775 ^{ab}
F6	1.29 ^b	1.63 ^b	0.02 ^{ab}	5.750 ^a	256.66 ^{bcd}	1.760 ^{ab}
F7	1.35 ^{ab}	1.01 ^e	0.018 ^b	5.7800 ^a	199.99 ^f	1.530 ^b
F8	1.49 ^{ab}	1.26 ^{cde}	0.02 ^{ab}	5.69 ^{ab}	254.83 ^{bcd}	1.860 ^{ab}
F9	1.45 ^{ab}	1.24 ^{cde}	0.018 ^b	5.67 ^{ab}	207.680 ^{ef}	1.380 ^b
F10	1.42 ^{ab}	1.26 ^{cde}	0.018 ^b	5.75 ^a	241.29 ^{bcd}	1.570 ^b
F11	1.53 ^{ab}	1.22 ^{de}	0.018 ^b	5.7 ^{ab}	245.44 ^{bcd}	1.560 ^b
F12	1.34 ^{bc}	1.05 ^e	0.02 ^{ab}	5.64 ^{ab}	205.840 ^f	1.720 ^{ab}
ESE	1.30 ^b	1.22 ^{de}	0.025 ^a	5.69 ^{ab}	231.820 ^{def}	2.29 ^a
Mean	1.39	1.352	0.019	5.7	243.47	1.68
CV (%)	11.13	13.01	20.17	1.7	8.9	21.54

SL = shoot length, RL = root length, SDW = seedling dry weight, VI = vigor index one, VII = vigor index two, GR = germination rate. Figure followed by the some letters in the same column are not significantly different $p < 0.05$. F1- F12 = Seed samples from farmer, ESE = Seed sample from Ethiopian Seed Enterprise.

Seed sample of F1 (1.89 cm) from Gozzamin showed the highest root length; seeds obtained from F7 of Enarji Enawga and F12 (1.01 cm) from Gozzamin district showed the lowest root length. Seedlings with well developed shoot and root length would withstand any adverse conditions and provide better seedling emergence and establishment in the field (Zewdie, 2004) which is in agreeable with seed sample obtained from Farmer 5. Shoot emergence took place when the temperature was lowered to 20°C (Radford and Key, 1993).

The highest germination rate was recorded seed sample obtained from F7 (5.78%) from Enarji Enawga and the lowest was from F2 (5.57%) of Gozzamin district. Apart from the other parameters, germination rate was the other method used to test seed vigor. At 20 °C temperature, the highest speed of germination was 44% on genotype Gea-Lamie and the lowest 28% for genotype Beten (Ayenew, 2003). Seeds which have high germination rate can escape drought condition, thus helping to choose early varieties (Maguire, 1962). Similarly, it is the rate at which the seeds are germinating and those seedlings with higher index or highest on first count are expected to show rapid germination and seedling emergence and to escape adverse field conditions (Zewdie, 2004). Seed with a low germination rate can have disastrous effects on a farmer's income by the time it is apparent that the seed would not germinate; it may be too late to plant again in that season (Nicholas *et al.*, 2007).

Vigor was usually measured by testing the germination rate, seedling weight, root and shoot length of the seed. The lowest vigor index I was recorded for samples collected from F7 of Enarji Enawga with 199.99 cm mean because of short root length. The highest vigor index II was recorded from samples collected from ESE (1.68 mg) because of higher seedling dry weight. There were significantly different ($p < 0.01$) root length and vigor index I among the seed samples (Appendix Table 5). Tef seed samples from Gozzamin (F1) gave the highest values for vigor index I and root length.

Seedling emergence percent and rate

Mean of seedling emergence percentage from the seed samples was 86.01 with the range of 69.25% to 95.0%. The mean percentage 86.1% indicating good percentage of all samples tested for vigor. Only five of the 12 samples (42%) two sample from Gozzamin, three from Enarji Enawga district showed seedling emergence percentage less than 85% which was the Ethiopian National Standard of Certified tef seed (Table 5). For instance, germination is reduced in soybean plant that experienced stress during seed filling, where the largest reduction occur when high air temperature and water stress occur at the same time (Crop Talk, 2002); in one study a drop of 22% (from 91% to 69%) in average germination was recorded.

The highest seedling emergence rate was recorded from seed sample obtained from F7 (5.49) from Enarji Enawga district and the lowest was on ESE (5.03). There were highly significant differences ($p < 0.01$) in seedling emergence percent and seedling emergence rate ($p < 0.05$) (Appendix Table 6). A similar finding was observed as eleven tef

genotypes were planted in open air to see seedling emergence and speed of emergence in eleven genotypes. Significant differences observed ($p < 0.05$) on eleven tef genotypes (Ayenew, 2003).

Table 4: Seedling emergence test

Seed sample	Seedling emergence %	Seedling emergence Rate
F1	85.50 ^{ab}	5.14 ^{cde}
F2	94.75 ^a	5.11 ^{de}
F3	69.25 ^c	5.07 ^e
F4	94.25 ^a	5.35 ^{a-d}
F5	91.75 ^{ab}	5.38 ^{a-c}
F6	84.75 ^{ab}	5.26 ^{a-d}
F7	83.75 ^b	5.49 ^a
F8	85.5 ^{ab}	5.11 ^{de}
F9	70.75 ^c	5.46 ^{ab}
F10	90.25 ^{ab}	5.40 ^{a-c}
F11	91.0 ^{ab}	5.24 ^{b-e}
F12	81.75 ^b	5.34 ^{a-d}
ESE	95.0 ^a	5.03 ^e
Mean	86.01	5.27
CV (%)	1.723	2.91

Figures followed by the same letters in the same column are not significantly different at $p < 0.05$. F1- F12 = Seed samples from farmer, ESE= seed sample from Ethiopian Seed Enterprise.

Functional relationship among physiological quality parameters are presented in Table (6). There were a positive and highly significant correlation ($r = 0.603^{**}$, at $p < 0.001$) between germination percent and seedling emergence percent. These indicate that as the germination percentage increases and seedling emergence percent also increases. The correlation between germination rate and seedling emergence rate was weak, positive and significant ($r = 0.389^{**}$, at $p < 0.01$). Which revealed that as seeds were become weakly germinating, seedling emergence rate also decreased.

The correlation between seedling emergence rate and germination percentage were significant, weak and negatively correlated ($r = -0.36^{**}$, at $p < 0.01$). Foster *et al.* (1998) reported significant correlation between germination test and field emergence of previously sprouted hard red wheat. The correlations between speed within the pot and the standard germination test do support the findings of Adkins *et al.* (1996) that single vigor tests are not adequate for determining seed vigor.

Table 5: Functional relationship among physiological quality parameters

	GR	VGI	VGII	SEP	SER
NP	-0.072 ^{ns}	0.445 ^{**}	0.098 ^{ns}	0.603 ^{***}	-0.359 ^{**}
GR		0.18 ^{ns}	0.064 ^{ns}	-0.049 ^{ns}	0.389 ^{**}
VGI			0.055 ^{ns}	0.443 ^{**}	0.001 ^{ns}
VGII				-0.049 ^{ns}	0.251 ^{ns}
SEP					-0.062 ^{ns}

^{**}, ^{***}, Indicates significant at $p < 0.01$ and 0.001 probability level, respectively GR= standard germination rate (speed in lab) in the laboratory, NP = germination percent, VGI = vigor index I, VGII = vigor index II, SEP = seedling emergence percentage, SER = seedling emergence rate.

RESULT AND DISCUSSION

There was difference in physical purity level between seed samples. The mean physical purity however, ranged between 98.2% from Enarji Enawga to 99.5% from Gozzamin and Ethiopian Seed Enterprise. The highest physical purity was recorded from Gozzamin and ESE (99.5%). The results showed that the physical quality of seed from farmers was equal or comparable to the seed from the formal sector (ESE). The purity analysis test showed that almost all of the 13 collected seed samples were greater than 96% which were physically pure by the minimum national seed standard for certified seeds of tef in Ethiopia. Almost in all 13 samples inert matter was of less than 2% as prescribed in the standard. Averages mean percent of 1.02, other crop seed were identified in the samples with the maximum of 0.9% from Enarji Enawga districts seed samples and minimum of 0.1% from Gozzamin plant species per sample. The most abundant seeds of other species were *Vitgroe*, *Sitaria* spp., *Trampgras*, in a few samples appeared in 31% (4 samples), 23% (3 samples) and 15% (2 samples).

There were significant differences ($p < 0.01$) in normal and abnormal seedlings among different tef seed of farmers and ESE. More abnormal seedlings obtained from F9 (16.29%) and more ungerminated seed from F6 (1.72%) were observed. In other words, only one of the 12 samples from Enarji Enawga district showed germination rate less than 85 % which is the Ethiopian National Seed Standard. The lowest vigor index I was recorded for samples collected F7 from Enarji Enawga with 199.99 cm mean because of low root length. The highest vigor index II was recorded for samples collected from ESE with 1.68 mg mean because of higher Seedling dry weight. There were significantly different ($p < 0.01$) root length and vigor index I among the seed samples. Tef seed samples collected from Gozzamin gave the highest values for standard germination and root length though the latter was not significant.

There were a positive and highly significant correlation ($r = 0.603^{**}$, $p < 0.0001$) between germination percentage and seedling emergence percent. Which indicated that as the germination percentage increases and seedling emergence percent also increases. In the experiment, as temperature causes variation in germination percentage (rate) and seedling emergence rate and percent, there is also a great variation among farmers having a germination capacity in the same temperature level. Main recommendation was correct site selection, good crop establishment and management, together with careful harvest and storage of the seeds are essential to ensure productivity and quality. Attempts have to be made by concerned institutions to popularize and disseminate other improved tef varieties. Chemical treatment of harvested seed can improve germination and decrease infection of seedlings grown from diseased seeds.

In general the role of formal seed system in the tef seed system is very low. The farmers' seed system dominated. The efforts being made by the BoA to supply improved tef variety did not commensurate with the demand. Hence, to circumvent the challenges and establish sustainable seed system in EGZ, integrating formal and farmer seed system at variety development, seed production, seed management, seed protection, seed processing and marketing is indispensable.

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Appendices

Appendix Table 1: Minimum Requirements of tef seed certification

Laboratory standard	Pre-basic seed	Basic	Certified(C1)	Certified(C2)	Certified(C3)	Certified(C4)	Commercial
Pure seed (min %)	96	95	93	92	91	90	
Other crop seed (max %)	0.05	0.10	0.3	0.5	0.5	0.5	1
Weed seed (max %)	0.1	0.1	0.3	0.5	0.5	1	1
Infected / infested seed (max %)	N.S	N.S	0.03	0.05	0.05	0.05	1
Inert mater (max %)	1	2	2	2.5	2.5	3	4
Germination (min %)	95	94	85	85	85	85	85
Moisture content (max %)	11	11	11	11	11	11	11

Source: Ethiopian National Seed quality Standard

Appendix Table 2: Mean square of Result of analytical physical purity on the tef seed sample

Source of variation	DF	Mean square		
		Pure seed	Inert mater	Other crop seed
Treatment	12	0.467 ^{ns}	0.245 ^{ns}	0.265*
Error	12	0.208	0.101	0.098

*= Significant at ($P < 0.05$), **= highly significant ($P < 0.01$), ns = Non-significant ($P > 0.05$). Treatments means tef seed samples

Appendix Table 3: Mean square of Physiological seed quality test

Source of variation	DF	Mean square									
		Normal seedlings	Abnormal seedlings	Ungerminated	Dead seed	Shoot length	Root length	Seedling dry weight	Germination rate	VI	VII
Replication	3	0.00015	0.0395	0.0017	0.0093	0.0125	0.012	0.00001	0.012	170.5	0.055
Treatment	12	71.8**	0.105**	0.0095 ^{ns}	0.0075 ^{ns}	0.0312 ^{ns}	0.253**	0.00002 ^{ns}	0.015 ^{ns}	3553.8**	0.096 ^{ns}
Error	36	20.3	0.028	0.0082	0.0119	0.0244	0.0324	0.00002	0.0094	475.4	0.131

*= Significant at ($P < 0.05$), **= highly significant ($P < 0.01$), and ns = Non-significant ($P > 0.05$), VI= vigor index one, VII= vigor index two

Appendix Table 4: Mean square of Seedling Emergence Evaluation

	DF	Mean square	
		Seedling Emergence Percent	Seedling Emergence Rate
Replication	3	0.00079	0.041
Treatment	12	0.00795**	0.00053*
Error	36	0.0011	0.00008

*= Significant at ($P < 0.05$), **= highly significant ($P < 0.01$), and ns = Non-significant ($P > 0.05$), VI= vigor index one, VII= vigor index two

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