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Research Article

Seed System and Quality Analysis of Eragrostis teff in Central Gondar, Northern, Ethiopia

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ABSTRACT

Tef (Eragrostis tef (Zucc.) Trotter) is an important cereal crop in Ethiopia that contributes substantially to food security, household income, and the national economy. However, low productivity is partly associated with limited access to improved varieties and quality seed. This study evaluated the existing tef seed system, the varietal preferences, and physical and physiological quality in West and East Belesa districts of Central Gondar Zone, Amhara Regional State. A multistage sampling technique was used to select four kebeles and 277 tef-producing households. Quantitative data was collected using semi-structured questionnaires, while qualitative information was obtained through four focus group discussions and interviews with 32 key informants. Furthermore, seed samples representing three commonly cultivated types of tef (Nech, Key, and Sergegna) were evaluated under laboratory conditions using a completely randomized design with replications. Descriptive statistics and variance analysis of variance analysis were used to analyze survey and laboratory data, respectively. The results showed that farmers relied on locally maintained seed and informal seed sources, with Nech, Key, and Sergegna being the main varieties cultivated. Nech was the most preferred type, mainly due to its white grain color, market preference, and perceived quality. The physical purity of the seed samples ranged from 98.0% to 99.33%, with an overall mean inert matter content of 1.16%. Although overall physical purity was relatively high, weed seeds and other crops were detected in some samples, indicating deficiencies in seed cleaning and handling. Standard germination ranged from 85.0% to 92.0%, with an overall mean of 88.33%. Significant differences were also observed between seed samples in root length, seedling dry weight, and seed vigor index 2, while some other vigor and emergence parameters did not differ significantly. The findings demonstrate that farmers have access to relatively good quality seed in terms of physical purity and germination, but weaknesses remain in the formal supply of improved seed and in seed cleaning, processing and quality assurance. Strengthening formal and community seed multiplication, improving seed cleaning and storage practices, improving extension services, and establishing accessible local seed quality testing facilities are recommended to improve the availability and use of quality tef seed in the study area.

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1. Introduction

Tef (Eragrostis tef (Zucc.) Trotter) is a distinctive cereal crop with a long history of cultivation in Ethiopia, where it is believed to have originated and diversified (Vavilov, 1951). It is a self-pollinated tetraploid species ($2n = 4x = 40$) and an annual C_4 cereal belonging to the family Poaceae (Gramineae). The genus Eragrostis, one of the larger genera within the grass family, comprises approximately 350 species (Watson and Dallwitz, 1994). Tef is cultivated by approximately 6.9 million households on 2.93 million hectares. It accounts for approximately 27.79% of the total cereal-cropped area and has an annual production of approximately 55.1 million tonnes (CSA, 2020/21). Tef can be cultivated across a wide range of elevations, from near sea level to approximately 3,000 m above sea level, with optimal production occurring between 1,100 and 2,950 m (Hailu and Seyfu, 2001). The crop generally performs best under annual rainfall of 950–1,500 mm and temperatures ranging from 10 to 27 ° C (FAO, 2011). A notable characteristic of tef is its ability to tolerate relatively low rainfall compared to other cereal crops. Although many cereals experience substantial yield reductions under water-limited conditions, tef can still produce moderate yields with annual rainfall as low as 450–550 mm (Abiyu et al., 2013).

According to Ebba (1969), tef is a highly versatile crop with a wide range of uses. In addition to serving as a staple food, tef provides valuable resources for the production of feed and livestock beverages. The grain is also naturally gluten-free and contains essential amino acids, minerals, vitamins, and dietary fiber, contributing to its high nutritional value (Spaenij-Dekking et al., 2005). Tef is also characterized by its adaptability and resilience in various environmental and agricultural conditions. It can perform relatively well in drought-prone areas, regions affected by pests and diseases, and water-logged soils. Its flexibility also allows it to be integrated into various cropping systems, enabling farmers to integrate it effectively into existing agricultural practices. Furthermore, tef can be grown in a broad range of altitudes and soil types, making it suitable for diverse geographical and agroecological conditions and providing farmers with greater flexibility in crop production (Ketema, 1997; Chanyalew et al., 2019).

The Amhara Regional State is the largest producer of tef in Ethiopia, accounting for 37.1% of the national tef area, 38.0% of the total production and 19.30 kg ha^{-1} of productivity. Within the region, Central the central Gondar zone contributes 9.97% of the the tef area and 8.60% of total production, with a productivity of 16.56 kg ha^{-1} (CSA, 2020/21).

Despite its considerable economic and nutritional importance, the productivity of tef remains relatively low at the national, regional, and zonal levels, with average grain yields of 1.88, 1.93, and 1.65 t ha^{-1}, respectively (CSA, 2020), compared to its potential yield of approximately 6 t ha - 1 under favorable conditions (Ketema, 1997). Low productivity is largely associated with the limited availability and accessibility of improved seed, which is considered one of the main constraints to increasing agricultural productivity in Ethiopia (Ojiewo et al., 2015). Sustained increases in crop production and productivity depend largely on the development and adoption of improved varieties, supported by an efficient seed system capable of delivering quality seed to farmers in the right quantity, at the right time, and in the appropriate location (Girma Abebe and Amanuel Alemu, 2017).

In the Central Gondar Zone, particularly in the West Belesa and East Belesa districts, the limited availability of improved tef varieties, poor seed quality, and inadequate access to the appropriate varieties in the right place, time, and quantity are major challenges. These limitations are further compounded by weaknesses in the agricultural extension system. On the contrary, farmers rely predominantly on seed obtained through informal seed systems, including seed saved, selected, and exchanged among farmers. The widespread dependence on informal seed sources, together with deficiencies in the formal seed supply system, contributes to inadequate access to quality seed and limits the availability and use of improved tef varieties. These challenges highlight the need to strengthen the efficiency and effectiveness of the tef seed system in the study area.

Therefore, understanding the existing seed system and assessing seed quality are crucial to improving tef production and productivity. Accordingly, this study aimed to evaluate the existing tef seed system, seed quality and varieties used for cultivation, and to identify effective options for the production and supply in West Belesa and East Belesa districts of the central Gondar Zone, Amhara Regional State.

2. Research methodology

2.1. Study site description

The survey was carried out in two adjacent Districts; West Belesa and East Belesa of Central Gondar Zone, Amhara

Regional State. West Belesa is 80 and 120 km from Gondar, the zonal capital, whereas 140 and 180 km from Bahir Dar, the regional city, respectively. The geographical and soil descriptions of the experimental area are presented (Table 1).

Table1. Geographical and soil description.

Location	Elevation (masl)	Soil types %			Temperature ^{o}C		Annual rain fall (mm)
		Red	Black	Brown	Max	Min	
West Belesa	1200- 1800	10	65	25	33.5	10	1200 –1800
East Belesa	<1500 & >1800	10	58	32	29	18	700 –1200

Source: CGZAD, 2020

2.2. Data Sources

The main data sources were focused on household characteristics, including household type, educational status, age and family size; household resource-based characteristics; farmer adoption of improved seed and sources of seed; farmers' agronomic practices and perceptions.

2.3. Sampling technique, sample size, and participants

A multistage sampling technique was used to select districts, *kebeles*, and households. In the first stage, the East and West Belesa Districts of Central Gondar Zone were purposively selected based on their potential for teff production, in consultation with zonal agricultural experts. In the second stage, two *kebeles* from each district were purportedly selected based on their suitability for the study, with recommendations from *Woreda* agriculture experts. A complete list of teff-producing households was prepared by the Village Agricultural Extension Officers (VEOs). In the third stage, 200 seventy-seven household heads were randomly selected from the sampling frame using probability proportional to size (PPS) sampling. The sample size was determined using Yamane's (1967) formula.

In addition, four focus group discussions and individual interviews were conducted with 32 key informants, of whom 82.5% were men and 17.5% were female. Key informants were selected based on their in-depth knowledge of the study areas, farming practices, crops, local conditions, and the challenges faced by farmers' associations. The selection of participants was carried out in consultation with development agents and a farmer association leader who resided in the study area and had a strong knowledge of the local farming community.

Table 2. Sample Size Determination.

District	Kebele	Sampling frame	Sample size
East Belesa	Chama Qorach	572	56
	Dengora	881	85
West Belesa	Tala	431	56
	Baja	615	80
Total sample size		2499	277

Source: Agriculture Office of the East and West Belesa Districts (2020)

2.4. Treatments and Experimental Design in the Laboratory

Twelve (12) treatments (Nech teff, Key teff, and Sergegna) from two districts and four Kebeles (Chamaqorach, Dengora, Baja, and Tala) were used in the laboratory experiment. It was arranged factorially by a completely randomized design and replicated three times.

2.4. Methods of Data Collecting

2.4.1. Survey data collection

Various data collection techniques were used to collect quantitative and qualitative data. Using a semi-structured questionnaire, contact/sample household heads were interviewed in person to gather primary data. Both the survey and the interview questions were written in English and translated into Amharic. The translated survey and interview questionnaires were pretested to identify areas that require further review and refinement, thereby ensuring their completeness, clarity, and suitability to obtain reliable and meaningful data from respondents. Training data collectors who work with small holders, known as development agents (DA), conducted the interviews. Interviewees were fully informed of the purpose before the survey was administered. Secondary data was obtained from report of district agricultural offices, relevant institutions, previous studies, and other relevant publications in the study areas.

2.4.2. Laboratory Experimental Data Collection

Physical purity and physiological quality (standard germination percentage, seed vigoristy, and seedling emergence percentage and rate) were collected and assessed for seed quality analysis.

$$\text{Germination percentage} = \frac{\text{Number of total germinated seed}}{\text{Total number of seeds tested}} \times 100$$

$$\text{Purity per seed} = \frac{\text{Weight to pure seed}}{\text{The total mass of the working sample}} \times 100$$

$$\text{Inert mater percentage} = \frac{\text{Mass of inert matter}}{\text{Whole mass of working sample}} \times 100$$

$$\text{Additional percentage of crop seed} = \frac{\text{Weight in other crop seed}}{\text{The total weight of the working sample}} \times 100$$

Source (Nega and Gudeta, 2019)

2.5. Data Analysis

Tables and percentages were used in the descriptive statistics analysis of the data. Non-quantifiable data from open-ended and closed-ended questions and observations were examined using qualitative description, and frequency tabulation was also utilized for statistical description. Narration, triangulation, problem explanation, and interpretation were used to analyze qualitative data. Each treatment was replicated four times and assigned at random. Following data transformation from laboratory experiments, SAS (9.4) was used for variance analysis and the LSD (list significant difference) test was used to separate treatment means (SAS Institute Inc., 2013).

3. Results and discussion

3.1. Tef Seed System Analysis

3.1.1. Farmer's characteristics and household resource bases

In the East Belesa district, the average number of male and female family members over 15 years who assisted the farmer with crop production (economically active labor force) and below 15 years were1.48 (Standard deviation = 0.68), 1.44 (Standard Deviation = 0.61) and 2.72 (Standard Deviation = 2.38), 3.44 (Standard Deviation = 2.26), respectively. The contribution of male and female family members under the age of 15 years of age to farm work was not statistically significant (P > 0.05).

Table 3. Data collected on livestock holdings, household size, farmer's age, farming experience in years, and land area allocated during the 2021 production season.

Parameter	West Belesa		East Belesa		t-test
	Mean	SD	Mean	SD	
Male>15 years	1.96	1.05	1.48	0.68	-2.66**
Female>15 years	1.43	0.66	1.44	0.61	0.04^{ns}
Male <15 years	2.22	1.29	2.72	2.38	1.27^{ns}
Female <15 years	2.61	1.87	3.44	2.26	1.96^{ns}
Number of Cattle	5.82	3.39	12.1	4.62	7.75**
Number of Oxen	2.00	1.29	3.52	1.43	5.57**
Farmers Age	42.76	7.49	44.8	12.09	0.98^{ns}
Farming experience	14.86	5.33	15.90	6.45	1.07^{ns}
Own land	1.62	0.65	2.34	0.74	5.18**
Hired land	0.75	1.33	0.53	0.32	-3.39**
Share cropped	1.50	0.68	0.83	0.67	-5.01**

*Note: SD = standard deviation; * indicates significance at P < 0.05; ** indicates high significance at P < 0.01; and ns indicates no significance at P > 0.05.*

However, there was a highly significant difference ($P < 0.01$) in the number of male family members older than 15 years between the two districts (Table 2). The crop was ploughed, harvested, and threshed by farmers in both districts who shared labor. This analysis was essential for the evaluation of the value chain, as it evaluated the technologies used in the development and dissemination of different varieties of teff and projected the future production and productivity. In the study districts, the production of Nech, Key, and Sergegna teff required both human labour and animals (Table 3).

Furthermore, Table 3 shows that the mean number of cattle and oxen was highly significant ($P <0.01$) between two districts. Sample farmers (n=100) had an average household head age of 44.8 years (SD = 12.09), ranging from 28 to 70 in East Belesa and 42.76 (SD = 7.5), ranging from 20 to 55 in West Belesa. In East Belesa, the average number of years of agricultural practice was approximately 16 (SD = 6.45), while in the West Belesa district it was 15 (SD = 5.33). The age and years of farming experience did not differ statistically between the farmers in the two districts (Table 2). Although the remaining farmers were landless and worked on shared crops and for hire, approximately 98% of the growers have ownership human rights on their land. In the past, farmers (n=277) had hired (94% farmers) and shared (90% farmers) more land for teff production from households led by women, the elderly or indolent farmers. The average size of the owned, rented, and shared land holdings in the two districts differed significantly ($P < 0.01$) (Table 4). Ethiopian farmers receive seed from certified suppliers, cooperatives, local markets, neighbors, relatives, and their own farm-saved seed through interactions between formal, informal, and intermediary seed systems (Westengen et al., 2023). Thus, the source and quality of the seed used for crop production can be significantly influenced by the socioeconomic and demographic characteristics of farmers. Inadequate availability, accessibility, quality, and prompt delivery of improved seed have historically been problems for Ethiopia's seed system (Mulesa et al., 2021). In general, older farmers are more knowledgeable about crop management, seed selection, storage, varietal adaptation, and local production circumstances. Farmers may be able to maintain locally adapted varieties and find favorable seed qualities due to this experience. However, older farmers might also be less inclined to embrace recently introduced enhanced varieties, as they have a stronger attachment to well-known varieties and conventional seed management techniques. Wosene et al. (2025), who found a negative correlation between household age and the adoption and intensity of improved tef seed use in Northwest Ethiopia, corroborate this conclusion.

Table 4. Characteristics of the type of house and educational level of the respondents.

	West Belesa		East Belesa	
Item	N	%	N	%
House hold type characteristics’				
Male headed	130	95.59	133	94.33
Female headed no husband	6	4.41	8	5.67
Educational level of the respondent				
Illiterate	72	52.94	89	63.12
Elementary	41	30.15	27	19.15
Junior	23	16.91	25	17.73

Table 4 shows that the farmers who were interviewed had male heads in their households (95.59% in West Belesa and 94.33% in East Belesa). Educational backgrounds were classified as junior, elementary and illiterate. Consequently, 52.94% of the respondents in the West Belesa were illiterate, 30.15% had an elementary education, and 16.91% had a junior high education. Similarly, 63.12% of the respondents in East Belesa were illiterate, 19.15% had an elementary education and 17.73% had a junior high education (Table 3). The demographic characteristics of the respondents provide important information on the socioeconomic context in which the tef seed system operates in West and East of the Belesa. As shown in Table 3, the households surveyed were overwhelmingly male-headed, accounting for 95.59% and 94.33% of the households in West Belesa and East Belesa, respectively. Female-headed households represented only a small proportion of the sample. This gender structure is important because the head of the household can influence access to agricultural information, extension services, credit, input markets, and improved seed. Evidence from Eastern Amhara indicates that male-headed households were more likely to adopt improved maize seed than female-headed households, with gender significantly associated with improved seed adoption (Neway and Zegeye, 2022). Similarly, research on Ethiopian wheat seed systems has shown that access to improved seeds and participation in seed-related networks can differ according to gender and other socioeconomic characteristics (Mulesa et al., 2021).

3.1.2. Local landraces grown and farmers' seed system

Among the landraces they have cultivated are *Nech, Sergenga, and Tikur* (key). *Nech* teff seed is the variety that all farmers prefer, according to the farmers, and it has a delicate white color. Compared to other teff varities in both districts, the Tikur variety had a lower selling price, a deeper brown color, limited adaptability, and low land coverage in all production seasons. Eighty percent of the farmers surveyed grew *Tikur, Nech* and *Sergenga* teff varieties. The seed systems were primarily dependent on their cultivars (Table 4). Farmers in West and East Belesa cultivate several regionally favored tef landraces, especially *Nech*, *Sergenga*, and *Tikur*, according to the results shown in Table 5. Due to its beautiful white grain color, Nech was reportedly the most popular type among growers. Because consumers and markets often link white-grained tef with acceptable injera quality and better market value, grain color is a key varietal feature in tef. Thus, it seems that consumer preferences and financial gains, in addition to agronomic factors, are what motivate the preference for Nech. This preference is consistent with previous studies showing that grain color is one of the most important criteria used by Ethiopian farmers, traders, and consumers when evaluating the quality of tef. Abewa et al. (2021) reported that grain color was one of the main quality attributes influencing the preference and market value of tef in Central and Northwestern Ethiopia. The current result, however, deviates slightly from indicating that farmers may favor different varieties of tef based on whether production is meant for sale or domestic consumption. According to Belay et al. (2006), brown-seeded tef varieties might be kept for domestic use, while very-white tef varieties were selected by farmers primarily for market-oriented output.

3.2. Seed Quality Analysis

3.2.1. Physical Quality

There was no discernible difference between the various types of teff collected from various Kebeles in the study area (Table 5). Physical quality varied between 98% and 99.33%. Denotes the purest seed ever found in Sergegna teff in the districts of East Belesa (Baja Kebeles) and West Belesa (Chama Qorach). However, inert materials and other seed crops also have an impact on the physical purity of the seeds. Sergegna teff in Tala Kebele had the highest inert material recorded at 1.5%, while Key teff in Dengora Kebele had the lowest at 0.92 percent. However, the physical quality of teff was also affected by other crops seeds. In both Dengora and Tala Kebeles, the highest percentage of other crop seed (1.07%) was found in Sergegna and Key teff. In Chama Qorach Kebele, Nech teff accounted for the smallest percentage of other ancient crop science, and farmers in the study area have used their own landrace seed for cultivation (Table 5).

Table 5. Analytical physical purity test.

District	Kebele	Teff Variety	Inert mater
East Belesa	Chama Qorach	Nech	1.0^{b}
		Key	1.33^{ab}
		Sergegna	1.0^{b}
	Dengora	Nech	1.5^{a}
		Key	0.92^{b}
		Sergegna	1.17^{ab}
West Belesa	Baja	Nech	0.95^{b}
		Key	1.17^{ab}
		Sergegna	1.17^{ab}
	Tala	Nech	1.0^{b}
		Key	1.17^{ab}
		Sergegna	1.5^{a}
Mean			1.16
LSD (5 %)			0.48
Sig. D			**
CV (%)			14.00

Note: * = ** *extremely significant (P <0.01), ns = non-significant (P >0.05), sigd = significant difference and significant (P <0.05)*

The presence of three weed species in some of the tef seed samples is an important finding because it indicates that, despite the apparently acceptable analytical purity, some seed lots were contaminated with undesirable weed seeds.

Analytical purity is an important component of seed quality because the presence of weed seeds can reduce the proportion of pure seed available for planting and may introduce undesirable species into farmers' fields. The appearance of weed seeds in the present study may be associated with inadequate field sanitation, harvesting and threshing practices, incomplete cleaning, or contamination during storage and handling. Therefore, the presence of weed seeds should be considered an important indicator of the effectiveness of seed production and post-harvest management practices of farmers. The current result is in general in line with earlier research on Ethiopian tef seed quality. According to Abewa et al. (2021), farmers, traders, and consumers in the tef value chain in Central and Northwestern Ethiopia place high priority on seed purity and the lack of impurities. Their research revealed that the perceived quality and marketability were influenced by its physical purity and cleanliness. Therefore, the finding that contamination is still a significant quality concern in Ethiopian tef seed systems is consistent with the identification of weed seeds in some samples in the current investigation. The current findings are also consistent with those of Anteneh, M. (2015), who documented differences in the physical attributes of seed quality between Ethiopian tef seed sources. Variations in production, harvesting, cleaning, storing, and marketing techniques can lead to differences among seed sources. The fact that weed seeds were detected in only a few of the study samples further implies that contamination varied depending on the seed's source and management history rather than being consistent across seed lots.

3.2.2. Physiological Seed Quality

A. Standard germination test Germination Test

The percentage of a working sample, aberrant seedlings, ungerminated seeds, and dead seeds were all noted. The overall mean percentage of germination was 88.33%, ranging from 85.0% to 92.0%. More germination percentages were recorded in Nech teff-derived seed in Chama Qorach Kebele in East Belesa (92.0%), followed by Nech teff from Tala Kebele in West Belesa (92.25%) (Table 5). Furthermore, according to the certified seed of the Ethiopian National Seed Standard of Teff. Barriga and Fiala (2020), the majority of samples (nearly 85%), and both districts of Belesa had above-average germination rates.

Table 6. Standard Germination Test.

District	Kebele	Teff Variety	Un germinated
East Belesa	Chama Qorach	Nech	1.5^{ab}
		Key	1.48^{ab}
		Sergegna	1.0^{b}
	Dengora	Nech	1.25^{ab}
		Key	1.08^{ab}
		Sergegna	1.25^{ab}
West Belesa	Baja	Nech	1.35^{ab}
		Key	1.52^{ab}
		Sergegna	1.52^{ab}
	Tala	Nech	1.60^{a}
		Key	1.52^{ab}
		Sergegna	1.25^{ab}
Mean			1.37
LSD (5 %)			0.60
Sig. D			*
CV (%)			14.54

Note: *** = LSD stands for list of significant differences, sigd for significant difference, ns for non-significant (P > 0.05), and highly significant (P < 0.01).*

B. Seed Vigor Test

Table 7. Seed Vigor Test

District	Kebele	Teff	Root	Seedling

		Variety	Length	Dry weight
East Belesa	Chama Qorach	Nech	1.87 [a]	0.015[b]
		Key	1.57[abc]	0.02 [a]
		Sergegna	1.23[bc]	0.02 [a]
	Dengora	Nech	1.17[c]	0.018[ab]
		Key	1.18[c]	0.018[ab]
		Sergegna	1.55[abc]	0.018[ab]
West Belesa	Baja	Nech	1.25[bc]	0.018[ab]
		Key	1.54[abc]	0.02 [a]
		Sergegna	1.54[abc]	0.02 [a]
	Tala	Nech	1.66[ab]	0.018[ab]
		Key	1.54[abc]	0.02 [a]
		Sergegna	1.73[c]	0.018[ab]
Mean			1.44	0.018
LSD (5 %)			0.45	0.0038
Sig. D			*	*
CV(%)			10.49	6.79

Note: ** *CV stands for coefficient variance, LSD for list significant difference, sigd for significant difference, V for vigor, and ns for non-significant (P > 0.05).*

Table 7 shows that the longest root length (1.87 cm) was displayed by a *Nech teff* seed sample from Chamaqorach Kebele in the East Belesa region, followed by 1.66 cm from Tala Kebele in the West Belesa district. On the contrary, the Nech teff seed in Dengora Kebele, district of East Belesa, had the smallest root length (1.17 cm). The average length of the roots was 1.44 cm. In addition to surviving unfavorable circumstances, seedlings with fully grown shoots and root length would also have better field emergence and establishment. The dry weight of the seedlings (Table 7) revealed more significance differences (P <0.01) between the various teff treatments. The lowest dry seedling weight (0.015 g) and the highest (0.02 g), with a mean value of 0.018 g. Sergegna and Key teff from Chamaqorach Kebele (East Belesa district) and Baja and Tala Kebeles (West Belesa district) had the highest dry seedling dry weight (Table 7). The Nech teff of Chamaqorach Kebele (East Belesa district) has the lowest dry seedling weight. When the temperature was reduced to 20 ° C, the shoots began to sprout (Radford and Key, 1993).

Table 8. Seed Strength Test.

District	Kebele	Teff Variety	Seed. Vigour Index 2
East Belesa	Chama Qorach	Nech	1.30[b]
		Key	1.72 [a]
		Sergegna	1.70 [a]
	Dengora	Nech	1.51 [ab]
		Key	1.59 [ab]
		Sergegna	1.60 [ab]
West Belesa	Baja	Nech	1.57 [ab]
		Key	1.62 [ab]
		Sergegna	1.62 [ab]
	Tala	Nech	1.47 [ab]
		Key	1.62 [ab]
		Sergegna	1.51[ab]
Mean			1.57
LSD (5 %)			0.39
Sigd			*
CV			8.41

Note: *** = extremely significant (P < 0.01), ns = non-significant (P > 0.05), CV = coefficient variance, sigd = significant difference, V = vigor and LSD = list significant difference.*

The analysis of variance indicated that there was a significant difference for the seed vigor index 2 (Table 8). While, seed vigour index 1, seed emergence, and seed emergence R had no significant differences (Table 7). Samples taken from *Nech* teff in Baja Kebele (West Belesa) had the lowest vigor index I (55.55 mg), while samples taken from

Nech teff in Chamaqorach Kebele (East Belesa district) had the highest value (80.46 mg). This was due to the short root length. However, samples taken from Key Teff in Chamaqorach Kebele (East Belesa district) had the highest vigor index II (1.72 mg). The length of the seed samples and the vigor index I varied significantly ($P < 0.05$). East Belesa teff seed samples (F1nech) had the highest values for both root length and vigor index I (Table 78).

4. Conclusion and recommendation

The study revealed that the tef seed system in West and East Belesa districts is largely dependent on informal and farmer-managed seed sources, with *Nech*, *Key* and *Sergegna* being the major types cultivated and *Nech* being the most preferred due to its desirable white grain color, market demand and perceived quality. Although the evaluated seed samples generally showed relatively good physical and physiological quality, with physical purity ranging from 98.0% to 99.33% and mean germination of 88.33%, the occurrence of inert materials, weed seeds, and other crop seeds in some samples indicates weaknesses in seed cleaning, processing, storage, and quality assurance. Significant variation was also observed between seed samples in root length, seedling dry weight, and seed vigor index 2, indicating differences in seedling performance between varieties and locations. Overall, the main constraint appears to be limited access to reliable, improved and consistently quality-assured seeds rather than extremely poor seed quality. Therefore, formal and community-based seed production and multiplication must be strengthened, particularly for farmers' preferred and locally adapted varieties, while district agriculture offices, research institutions, cooperatives, and seed enterprises should improve timely availability and distribution of quality seed. Farmers should also be trained in proper seed selection, harvesting, threshing, cleaning, grading, and storage practices to minimize contamination and maintain seed quality. Additionally, accessible local seed testing services and stronger extension support should be established to improve farmers' awareness of seed quality and varietal selection. Strengthening linkages among farmers, cooperatives, agricultural offices, research institutions, and seed producers, together with inclusive participation of women and other underserved farmers, is recommended to improve the efficiency of the tef seed system and contribute to increased productivity in West and Belesa districts.

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