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Evaluation of Different Finger Millet (*Eleusine coracana* L.) Varieties for Early Maturing and Blast Resistant in Tigray, Ethiopia

Hintsa Meresa [a*] and Fantaye Belay [a]

[a] Tigray Agricultural Research Institute, Abergele Agricultural Research Center, P. O. Box 44, Abi-Adi, Ethiopia.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: In Northern Ethiopia, a major obstacle to the production and productivity of finger millet is the lack of extensively adaptable, high-yielding, and disease-resistant varieties. Due to this intervention: the study was to evaluate and choose disease-resistant, early-maturing, high-yielding finger millet varieties for the target locations. Methods: A field experiment was carried out during the 2019-20 cropping season; six finger millet cultivars were assessed at the Farmers' Training Center (FTC) using a randomized complete block design with three replications under rainfed conditions. Days to maturity, plant height, grain yield, and blast disease severity score were collected and evaluated. Results: Significant differences were found in the combined analysis of variance. Among the variants for the characteristics examined, Mereb-1 produced the highest grain yield (2034 kg ha

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**Corresponding author: E-mail: hintsa1982@gmail.com;*

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$^{-1}$), the shortest days to maturity, and the lowest disease severity score(1=blast-resistant). Conclusion: Therefore, the current research indicates that Mereb-1 outperforms the other types in terms of yield, maturity, and resistance to blast disease. As a result, this variety might be suggested for the research locations and comparable agro-ecologies in the northern Ethiopian Tigray region. Further studies may need to assess many varieties across locations and years and resistance to disease.

Keywords: Eleusine coracana L.; varieties; blast disease; finger-millet; grain yield.

1. INTRODUCTION

"Finger millet (*Eleusine coracana* L. Gaertn., 2n = 4x = 36) is a staple food cereal crop in the country's drought prone areas of Ethiopia, particularly the northern region, its ranks sixth in importance among major crops, following teff, wheat, maize, sorghum, and barley. Finger millet makes up 4.5% of all cultivated area used for cereal production; nevertheless, its average national grain output is only 2.01 tons/ha, despite its potential to produce up to 3 tons/ha" [1] "It is a member of the *Poaceae* family. Furthermore, it is most likely indigenous to the highlands of Ethiopia. The lowland and midaltitude areas of Tigray, Gojam, Gondar, and Wellega are the primary locations for its cultivation. Because of its vast range of altitudes, temperature extremes, copious amounts of rainfall, and diverse soil qualities, Ethiopia is thus one of the centers of origin for finger millet and many other crops" [2].

The crop's grain is used to make the traditional drinks "Tela" and "Areki," as well as "injera," which is a high-quality human food. The crop's leftovers, or straw, are used to make nutritious animal feed. In addition, it has a high ash, calcium, and iron content, all of which are nutritionally rich and help to build teeth and bones and lower the risk of anemia [3-4]. Thus, it helps farmers to develop ability to survive famine. This is why finger millet is frequently referred to as a crop of drought prone areas to straggle famine [5].

"Finger millet Productivity and production are low in Ethiopia, however, for a number of reasons. These include: a lack of improved varieties; inadequate agronomic management; little emphasis on crop research; no adoption of improved technologies; a negative attitude toward the crop; diseases like blast, the most serious disease; weeds; lodging and moisture stress in dry areas; and issues with threshing and milling. The lack of improved varieties, inadequate agronomic management, lack of emphasis on crop research, no adoption of improved technologies, unfavorable attitude toward the crop, weeds, lodging and moisture stress in dry areas, threshing and milling issues are just a few of the production constraints that contribute to Ethiopia's low finger millet productivity and production" [6].

"Blast is a biotroph ascomycete fungus that is highly diverse in nature. Even though the pathogen has a broad range of hosts among the grasses and sedges, a particular strain has only a limited number of hosts. Blast spreads as air borne conidia which upon reaching an ideal host, infects the cell through the stomata and germinates under high relative humidity and temperature ranging from 25 ^{to} C to 28 ^{o}C. Blast conidium is attached to the host cell tissue using a spore mucilage tip, that aid tip to grow and divide itself mitotically leading to formation of an appressorium" [7] "The appressorium infects plant tissues by forming penetration peg" [8]. "The maximum damage is caused when neck is infected because blast destroys tissues that translocate and remobilize photosynthates for kernel formation, leading to shriveled kernel and low productivity" [9].

"Incorporation of genetic resistance in improved high yielding varieties has been recommended for the control of finger millet blast (Pyricularia grisea) since use of fungicide is cost prohibitive for most farmers" [10]. "Developing enhanced types with large yields and broad adaptability is one of the main goals of Ethiopia's national finger millet development program. In the nation, more than 20 enhanced varieties have been made available thus far. These enhanced varieties, however, did not make it to the smallholder farmers in the Kola Temben and Hawzen regions and have not been examined for potential adaptation. Hence, this study was initiated with the objectives of selecting early-mature, high-yielding, and disease-resistant finger millet svarietie" [10].

2. MATERIALS AND METHODS

2.1 Study Areas

This experiment was carried out at the farmers' training center (FTC) at Kola Temben and Hawzen, northern Ethiopian. Kola Temben and Hawzen are located in the middle and eastern regions of the Tigray regional state. The study area's comprehensive description is provided in Table 1.

2.2 Materials, Experimental Design, and Trial Management

In this study, five released finger millet varieties, sourced from Axum and Melkasa Agricultural Research Center (MARC), along with one local check, were evaluated (Table 2).

The varieties were planted in a plot with five 3-meter-long rows and Randomized Complete Block Design (RCBD) was used to set up the experiment. Two border rows were left unharvested in order to eliminate the border effect, while three middle rows were harvested. Plant and row spacing were maintained at 10 and 40 cm, respectively. There were 1.5 meters between each block in the 1.2 m x 3 m = 3.6 m^2 net-harvested plot. A consistent application of NPSZnB (100 kg ha -1) and urea (50 kg ha -1) fertilizer was made to each experimental plot.In accordance with crop recommendations, weeding and other management techniques were consistently applied as per need in each experimental plot.

2.3 Data Collected

Following the finger millet descriptor [11], a number of significant agronomic traits were recorded. Days to physiological maturity were calculated as the length of time between plant emergence and the point at which a plot's plants had reached physiological maturity. Plant height (pH) (cm) was calculated by measuring the height of plants at the hard dough stage from five randomly selected plants, starting from ground level. Grains yield was calculated by threshing the central three rows of each plot and adjusting the seeds obtained from them to the standard moisture level (12%) per plot in grams before converting them into kg per hectare for analysis.

Resistant to disease (foot rot and head blast): 1–5 scale scoring was used for disease reaction, where 1 = no lesion (resistant), 2 = moderately resistant, 3 = moderately susceptible, 4 = susceptible, and 5 = highly susceptible. The varieties resistant to disease (foot rot and head blast): 1–5 scale scoring was estimated based on 1-5 progressive rating scale [12]

Table 1. Description of the study areas

Variables	Kola Temben (KT)	Hawzen (HZ)
Soil type	Silt Loam	Chronmiccambisols
Altitude (m.a.s.l.)	1758	2130
Latitude	$13^0$37'37" N	$13^0$97'66" N
Longitude	$38^0$55'46" E	$39^0$42'700" E
Annual Temperature (^{0}C)		
Minimum	17	10
Maximum	30	24
Annual rainfall (mm)		
Minimum	450	650
Maximum	500	800

Table 2. Description of finger millet varieties

Genotype	Adaptation m.a.s.l.	Year of release	Maintainer
Tadesse	1600-1900	1999	MARC/EIAR
Tessema	1600-1900	2014	MARC/EIAR
Axum	1600-1900	2016	MARC/EIAR
Tekeze-1	1600-1900	2018	Shire ARC
Mereb-1	1300-2100	2016	AxARC/TARI
Local	-	-	Local landrace

Where m.a.s.l. = meter above sea level; NA= not available, AxARC = Axum Agricultural Research Center, TARI= Tigray Agricultural Research Institute, MARC = Melkasa Agricultural Research Center, EIAR= Ethiopian Institute of Agricultural Research.

2.4 Data Analysis

Using Bartlett's test, which measures the ratio of the larger mean square error (MS_e) from the separate analysis of variance to the smaller mean square error, homogeneity of error variance was tested prior to combined analysis for each trait [13]. Statistical analyses were conducted using Genstat, a statistical program, version 16th edition [14]. The Fisher's least significant difference (LSD) test was used to calculate the mean separation at the 5% probability level.

3. RESULTS

3.1 Analysis of Variance (ANOVA) for Agronomic Traits

The study displays the combined analysis of variance (ANOVA) mean squares. The findings showed that there was significant genetic variation among the variations for every attribute, with the majority of the characters showing highly significant ($P \leq 0.01$) variances. This demonstrates the variability of the genotypes studied, which opens up possibilities for the genetic enhancement of the finger millet crop. It is implied that there were different genotype responses for those attributes under the two locations where the majority of genotypes showed substantial differences in genotype-location interactions.

3.2 Garin yield (kg ha $^{-1}$)

As shown in Table 3, the individual and combined analysis of variance for grain yield revealed a very highly significant ($P<0.001$) difference amongst finger millet varieties. Grain yield ranking may be regarded as a valid indicator of genotypic performance because yield is the end product of multiple plant traits that interact with various external influences during the course of the plants' lives. Consequently, Mereb-1 produced the maximum grain yield (2034 kg ha $^{-1}$) among all sites, while local produced the lowest yield (1388 kg ha $^{-1}$). The average grain yield of the varieties was 1566 kg ha $^{-1}$.

3.3 Days to Maturity(day)

Days to maturity ranged from 118.8 to 141 days on average for the cultivars, with an average of 132.83 days reached, as indicated in Fig.(1). The variety Mereb-1 had the lowest days to maturity (118.8 days), whereas the variety Axum had the longest (151.8 days).

3.4 Plant height (cm)

The variety with the tallest plant height was Tessema, followed by Axum and Tadesse with 78.27, 77.53, and 72.63 cm, respectively, whereas Tekeze-1 recorded the shortest plant height (57.28 cm) as indicated in Fig.(2).

3.5 Reactions to the Finger Millet Blast and the Disease Severity Score

A substantial ($P < 0.01$) variation in blast severity score was found among the finger millet types, as indicated by Table 4's combined analysis of variance over sites. According to the results, the variety Mereb-1 was resistant (blast score = 1) to the most severe blast disease, which includes foot rot, neck, and head blast, while the remaining five varieties were susceptible (blast score = 2.75–3.83).

Table 3. Mean grain yield (kg ha $^{-1}$) and other traits of six finger millet varieties grown at two locations during the 2019 cropping season

Variety	Kola Temben	Hawzen	Grand Mean
Mereb-1	2702^{a}	1366^{a}	2034^{a}
Tessema	1617^{c}	1177^{b}	1397^{c}
Tekeze-1	1815^{c}	1129^{ab}	1522^{bc}
Tadesse	1837^{bc}	1131^{bc}	1484^{bc}
Axum	2128^{b}	1020^{c}	1574^{b}
Local	1794^{c}	982^{c}	1388^{c}
EM	1982	1151	1566
CV (%)	5.8	7.1	8.8
LSD (5%)	292.8	149	234.3

Where: GM= Genotypic means, EM= Environment means; CV = coefficient of variation, LSD= least significance differences and values with the same letters in a column are not significantly different at P≤ 0.05.

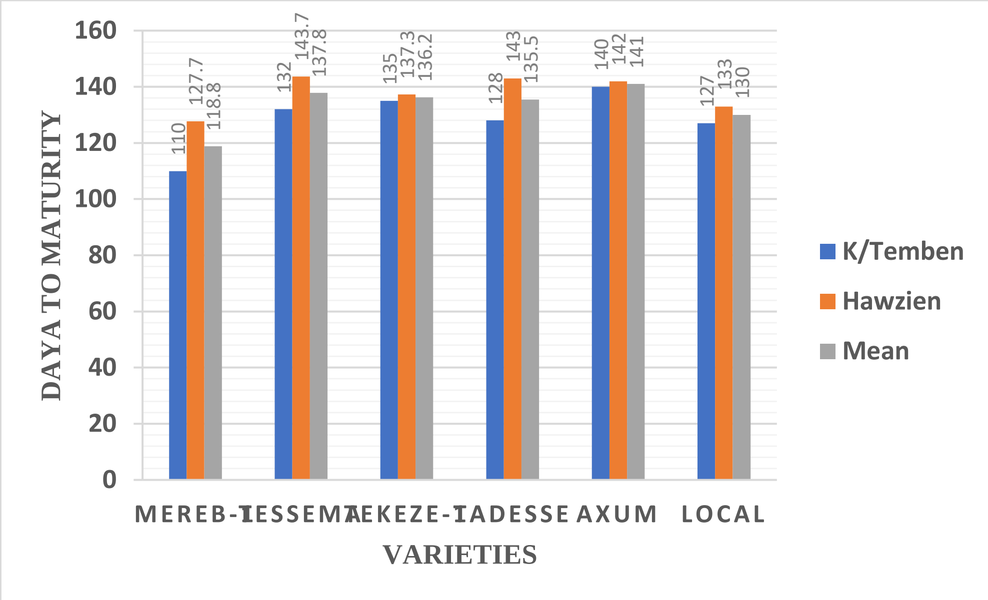

Fig. 1. Mean values of days to physiological maturity different finger millet varieties

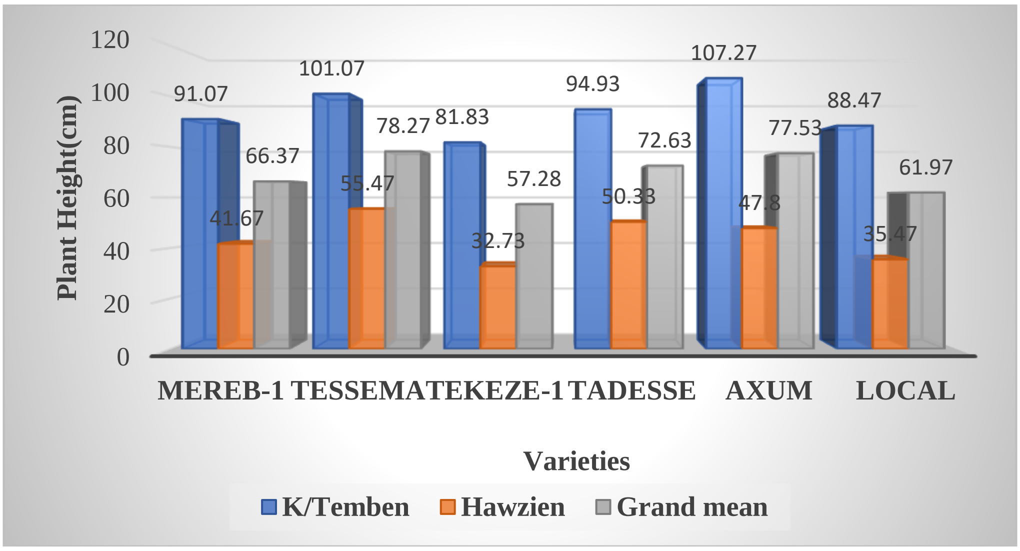

Fig. 2. Mean values of plant height of various finger millet varieties in two locations

Table 4. Disease severity score (levels) and reactions for finger millet (blast) using 1-5 scale during the 2019/20 cropping season

Variety	BSS (1-5)	Reaction
Mereb-1	1.00^{a}	Resistant
Tessema	3.25^{bc}	Moderate susceptible
Tekeze-1	2.75^{b}	Moderate susceptible
Tadesse	3.00^{bc}	Moderate susceptible
Axum	3.20^{bc}	Moderate susceptible
Local	3.83^{c}	Susceptible
Grand mean	2.83	
CV (%)	12.4	
LSD (5%)	1.0	

BSS = blast severity score (1-5), CV (%) = coefficient of percent variation, LSD= least significance differences and values with the same letters in a column are not significantly different at P≤ 0.05

Table 5. Mean squares from combined analysis of variance for yield and other traits of finger millet varieties evaluated at two locations during 2019/20 cropping season

Trait	Mean squares					Mean	CV
	Replication (df=2)	Variety (V) (df=5)	Location (L) (df=1)	VxL (df=5)	Error (df=20)		
DM		342.13**	900**	47.13**	2.83	132.83	1.3
PH		438.69**	22675.34**	44.42*	26.49	69.01	7.5
GY		345114**	6219482**	168113**	19146	1566	8.8
BSS		5.62**	0.25ns	2.47**	0.123	2.83	12.4

**, ** = significant at P≤ 0.05 and P≤ 0.01, respectively. Where: DF= degree of freedom; DM = days to maturity, PH = plant height (cm), GY= grain yield (kg ha -1), BSS = blast severity score (1-5), CV = coefficient of variation and values with the same letters in a column are not significantly different P≤ 0.05*

4. DISCUSSION

Genotype (G), environment (E), and genotype × environment interaction effects (GEI) were significant based on the combined mean grain yield outcome (Table 3). Although the genotypic grand mean yield was exceeded by the Mereb-1 (2034 kg ha $^{-1}$) and Axum (1574 kg ha $^{-1}$) varieties, the genotypic mean yield (1566 kg ha $^{-1}$) was below the scores of the Local (1388 kg ha -1), Tessema (1397 kg ha $^{-1}$), Tadesse (1484 kg ha $^{-1}$), and Tekeze-1 (1522 kg ha -1) varieties. While Mereb-1 had the best variety across all locations, Kola Temben (1982 kg ha $^{-1}$) had a higher mean grain production than Hawzen (1152 kg ha $^{-1}$) based on the overall grand mean (1566 kg ha $^{-1}$).

Finger millet varieties at multiple locations exhibited distinct genotype responses to environmental variation, as indicated by the substantial interaction effects. Similar to the current study, a number of publications [15-17] revealed substantial interaction effects for Ethiopian finger millet grain production. The current study's findings also showed that the Mereb-1 variety had shorter days to maturity and medium plants Fig. (1). As a result, Mereb-1 is more adaptable in the target areas and is a better variety for the moisture-stress areas of Kola Temben and Hawzen districts than the other types.

Furthermore, the research result revealed that the tested finger millet varieties varied in reaction to head blast disease. One improved variety out of six genotypes tested, viz., Mereb-1, was released for yield, but in this study, the variety was found to be resistant to head blast disease. The phenomenon might be due to the fact that the variety was perhaps developed from resistant genes (parents). Similar studies were conducted in Ethiopia by [16-18], who identified resistant or tolerant reactions of finger millet varieties to head blast disease in their planting materials studied. This implies that the success of genetic improvement in any character depends on the nature of the variability present for that trait.

5. CONCLUSION AND RECOMMENDATION

Finger millet is an important indigenous crop mainly grown in dryland areas, where the climate and interaction varieties considerably. The combined analysis of variance revealed significant (P<0.01) for locations, varieties and varieties by location interaction. The result of this study showed a significant difference among finger millet varieties for days to physiological maturity, plant height, grain yield, and disease severity score. The Mereb-1 variety scored a special merit over the other varieties in terms of earliness, high yielding, adaptability, and resistance to blast disease; therefore, this variety is very important for further studies and breeding program especially for drought prone areas. So, it is recommended for dry land areas of central and eastern zones and similar agro-ecological zones in the Tigray region of Northern Ethiopia and further study also needed to confirm stability of the variety across multi locations with additional genotypes.

SIGNIFICANCE STATEMENT

This research finds that better types of finger millet can raise yields. The results of this study will assist the researcher in identifying the crucial regions for increasing agricultural output through variety selection. Thus, in order to raise the productivity and production of finger millet crops, this research's progress must be put into practice.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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