Acta Scientific Biotechnology

Volume 4 Issue 1 January 2023

Research Article

Performance Evaluation of Finger Millet (*Eleusine coracana* L. Gaertn) Varieties in Dry Land Areas of Northern Ethiopia

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Received: November 17, 2022

Published: December 08, 2022

Abstract

Background and Objective: Shortage of widely adapted, high yielding and disease resistant variety is one of the major bottlenecks for production and productivity of Finger millet (*Eleusine coracana* L.) in dry lands of Kola Temben and Hawzen districts, Northern Ethiopia*.* A field experiment was conducted to evaluate and select early matured, high yielded and disease resistant finger millet varieties for the target areas.

Materials and Methods: Six finger millet varieties were evaluated at farmers' training center (FTC) under rainfed conditions during the 2019 cropping season using a randomized complete block design with three replications. Data were collected and analyzed variance for the traits' days to maturity, plant height, grain yield and blast disease severity score.

Results: The combined analysis of variance exhibited highly significant differences among the varieties for the traits studied. The highest grain yield, shortest days to maturity and lowest disease severity score (resistant to blast) were recorded from Mereb-1.

Conclusion: The present finding provides, Mereb-1 is considered as high yielder, early matured and resistant to blast disease than the other varieties. Therefore, this variety could be recommended for the study areas and similar agro-ecologies in Tigray region, Northern Ethiopia.

Keywords: Blast Disease; Dry Land; *Eleusine coracana*; FTC; Grain Yield

Introduction

Finger millet (*Eleusine coracana* L. Gaertn., 2n = 4x = 36) belongs to the family Poaceae is one of the staple food cereal crops in the drought-prone areas of Ethiopia in general, and the Northern region in particular though presently considered relatively as a minor crop in the country [1]. Its cultivation is mainly concentrated in lowland and mid-altitude regions of Tigray, Gojam, Gondar and Wellega. It is also very likely that finger millet is native to the Ethiopian highlands. Thus, Ethiopia is one of the center of origin for finger millet [2] and many other crops due to its wide range of altitudes, temperature extremes, huge amounts of rainfall and different soil characteristics.

Finger millet is the sixth important crop in Ethiopia after teff, wheat, maize, sorghum, and barley. It accounts for 4.5% of the total cultivated land covered by cereals; however, the national average grain yield of finger millet is low, 2.01 ton/ha, although it has a potential to yield up to 3 ton/ha[1]. The grain of the crop is used for the preparation of "Tela" and "Areki" (local drinks), as well as for "injera" making quality as human food and the crop residue (straw) makes good animal feeds. It is also nutritionally rich containing high ash, calcium and iron content, which is essential for strengthening bone and teeth and reduce the incidence of anemia [3,4]. So, it helps many poor farmers withstand times of famine. That is why finger millet is often called a famine crop.

The production and productivity of finger millet in Ethiopia is, however low due to numerous production constraints including: a shortage of improved varieties, poor agronomic managements, little research emphasis given to the crop, non-adoption of improved technologies, poor attitude to the crop, disease like blast which is the most serious disease and weeds, lodging and moisture stress in dry areas, threshing and milling problems [5].

Developing improved varieties with high yield and wide adaptation is one of the major objectives of the national finger millet improvement program in Ethiopia. So far, more than 20 improved varieties in the country have been released. However, these improved varieties have not been tested for their adaptability potential under Kola Temben and Hawzen districts and did not reach the smallholder farmers living in that areas.

Hence, this study was initiated with the objectives to select early matured, high yielded and disease resistant finger millet varieties.

Material and Methods

Study areas

Field experiment was conducted at two locations namely; Kola Temben and Hawzen on farmers' training center (FTC) during the 2019/2020 cropping season. Kola Temben and Hawzen are found in the central and eastern zones of Tigray regional state, northern Ethiopia. The detailed description of the study area is listed in table 1 below.

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	500	800
Maximum	450	650

Table 1: Description of the study areas.

Experimental materials, 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).

Genotype	Adaptation masl	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	SARC
Mereb-1	1300-2100	2016	AxARC/TARI
Local	-	-	Local landrace

Table 2: Description of finger millet varieties.

Masl = 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.

The experiment was laid out in Randomized Complete Block Design (RCBD). Each entry was planted in a plot having 5 rows of 3-meter length. Three middle rows were harvested and two border rows were left to exclude border effect. The row and plant spacing was kept at 40 cm and 10 cm, respectively. The net harvested plot size was 1.2 m x 3m =3.6 m^2 and 1.5m between each block. Each experimental plot was fertilized uniformly with NPSZnB (100 kg/ha) and Urea (50 kg/ha) fertilizer. Weeding and other management practices were applied uniformly in all experimental plots as per recommendation for the crop.

Data collected

Some important agronomic traits were recorded following the finger millet descriptor (IBPGR, 1985).

Days to physiological maturity: This was recorded as the number of days from emergence to the stage when the plants in a plot have reached physiologically matured.

Plant height (PH) (cm): It was recorded by measuring the height of plants from ground level to the tip of inflorescence (ear), at the hard dough stage from 5 plants randomly.

Grain yield: The central three rows were threshed from each plot and seeds obtained from them were adjusted to standard moisture level (12%) per plot in grams and converted 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 = moderate resistant, 3 = moderate susceptible, 4 = susceptible; 5= highly susceptible.

Data analysis

Homogeneity of error variance was tested before combined analysis for each trait using the method based on the ratio of the larger mean square of error (MSe) from the separate analysis of variance to the smaller mean square of error using Bartlett's test [6] and statistical analyses were done using Genstat statistical program version 16th edition software program [7]. The mean separation was performed using Fisher's least significant difference (LSD) test at 5% level of probability.

Results

Analysis of variance (ANOVA) for agronomic traits

The mean squares from combined analysis of variance (ANOVA) is presented in table 6. The results revealed highly significant ($P \leq 0.01$) differences for most of the characters which indicated the presence of considerable genetic variation among the varieties for all the traits. This shows that the tested genotypes were variable, this provides opportunities for genetic improvement of finger millet crop. Most of the genotypes were significantly different on genotype x location interactions this implies that there were differential responses of genotype under two locations for those traits.

Grain yield

The separate and combined analysis of variance for grain yield showed very highly significant ($P < 0.001$) difference among finger millet varieties as presented in table 3. Since yield is the final result of many plant characters, which are interacting with numerous external factors during the life span of the plants, ranking of genotypes based on grain yield may be considered as a reliable measure for genotypic performance. Thus, the highest grain yield from over locations was obtained from Mereb-1 (2034 kg ha^{-1}) while the lowest was recorded from local (1388 kg ha^{-1}) and the average grain yield of varieties was 1566 kg ha^{-1}.

Variety	Kola Temben	Hawzen	GM
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

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

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 $P \leq 0.05$.

Days to maturity

The mean values of days to maturity of the varieties ranged from 118.8 to 141 days and the mean days to maturity obtained was 132.83 days as shown in Table 4. The shortest days to maturity (118.8) was recorded by Mereb-1, whereas, the longest days to maturity (141) was recorded for the variety Axum.

Plant height

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 table 4.

Variety	DM			PH		
	KT	HZ	GM	KT	HZ	GM
Mereb-1	110^{d}	127.7^{d}	118.8^{d}	91.07^{c}	41.67^{cd}	66.37^{b}
Tessema	132^{b}	143.7^{a}	137.8^{ab}	101.07^{ab}	55.47^{a}	78.27^{a}
Tekeze-1	135^{b}	137.3^{b}	136.2^{ab}	81.83^{d}	32.73^{c}	57.28^{c}

Tadesse	128[c]	143.0[a]	135.5[ab]	94.93[bc]	50.33[ab]	72.63[a]
Axum	140[a]	142.0[a]	141.0[a]	107.27[a]	47.80[bc]	77.53[a]
Local	127[c]	133.0[c]	130.0[c]	88.47[cd]	35.47[dc]	61.97[bc]
EM	127.84	137.83	132.83	94.1	43.91	69.01
CV	1.3	0.8	1.3	5.3	9.3	7.5
LSD (5%)	3.13	1.94	2.85	8.99	7.46	8.72

Table 4: Mean values of days to physiological maturity and plant height (cm) of six finger millet varieties evaluated at two locations in the 2019 cropping season.

Where: DM = Days to Maturity, PH = Plant Height, GM = Genotypic Means, EM = Environment Means; KT = Kola Temben, HZ= Hawzen, 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.

Disease severity score and reactions for finger millet blast

The combined analysis of variance over locations revealed that there was significant (P ≤ 0.01) difference among the finger millet varieties for blast severity score as shown in table 5. The result displayed that the variety Mereb-1 was resistant (blast score = 1) to the most devastating blast (foot rot, neck and head blast) disease while the rest five varieties were susceptible (blast score = 2.75 - 3.83) to blast disease.

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	

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

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.

Discussion

Based on the combined mean grain yield result (Table 3), genotype (G), environment (E) and genotype × environment interaction effects (GEI) were significant. Mereb-1 (2034 kg ha^{-1}) and Axum (1574 kg ha^{-1}) varieties scored above the genotypic grand mean yield; however, Local (1388 kg ha^{-1}), Tessema (1397 kg ha^{-1}),

Trait	Mean squares					Mean	CV
	Replication (df = 2)	Variety (V) (df = 5)	Location (L) (df = 1)	V*L (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**	0.25[ns]	2.47**	0.123	2.83	12.4

Table 6: Mean squares from combined analysis of variance for yield and other traits of finger millet varieties evaluated at two locations during 2019 cropping season.

*, ** = 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.

Tadesse (1484 kg ha^{-1}) and Tekeze-1 (1522 kg ha^{-1}) varieties had scored below genotypic mean yield (1566 kg ha^{-1}). In comparison from overall grand mean (1566 kg ha^{-1}), Kola Temben (1982 kg ha^{-1}) had higher mean grain yield than Hawzen (1152 kg ha^{-1}) location, while the best variety over locations was Mereb-1.

The significant interaction effects showed that genotypes responded differently to the variation in environmental conditions for finger millet varieties at multi-locations. In line with the current study, many authors [8-11] reported significant interaction effects for grain yield in finger millet in Ethiopia. The results of the present study also exhibited that Mereb-1 variety had recorded shorter days to maturity and medium plant (Table 4). This shows that Mereb-1 is appropriate variety for the moisture stress areas of Kola Temben and Hawzen districts than the other varieties, thus, making it more adaptable in the target areas.

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 though it was released for yield, 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 [9,12] who identified resistant/ 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 variability present for that trait.

Conclusion

The result of this study revealed a significant difference among finger millet varieties for days to physiological maturity, plant height, grain yield and disease severity score. Mereb-1 variety had scored a special merit over the other varieties in terms of earliness, high yielding, well adaptability and resistance to blast disease, therefore, recommended for dry land areas of central and eastern zones and similar agro-ecological zones of Tigray region, Northern Ethiopia.

Significance Statement

This study discovers the yield of finger millet can be increased through improved varieties. This study will help the researcher to uncover the critical areas of crop yield improvement through genetic enhancement. Thus, the development of this research is needed to be implemented to increase finger millet crop production and productivity.

Conflict of Interest

The authors have not declared any conflict of interest.

Acknowledgements

The authors would like to thank Abergelle Agricultural Research Center for financing and providing working facility and crop staff members for their commitment during this study.

Author’s Contribution

FB designed the study, data collected, analyzed and wrote the manuscript. HM and KF collect data and gave comments for the manuscript. All authors read and approved the final manuscript.

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