American Journal of BioScience
2024, Vol. 12, No. 4, pp. 127-132
https://doi.org/10.11648/j.ajbio.20241204.14

Research Article

Evaluation of Recently Released Finger Millet Varieties for Their Adaptability in West Haraghe Zone, Eastern Ethiopia

Desu Assegid[1, *], Abubeker Terbush[1], Gebeyehu Chala[2], Gabbisa Bekela[1]

[1]Oromia Agricultural Research Institute, Mechara Agricultural Research Center, Mechara, Ethiopia
[2]Oromia Agricultural Research Institute, Bedele Agricultural Research Center, Bedele, Ethiopia

Abstract

Finger millet is a major grain crop in the west hararghe zone. However, due to major constraints like lack of improved varieties and drought, the productivity is by far lower than the genetic potential of a crop in the study areas. Thus, current study initiated to obtain high-yielding and stable varieties. The study was conducted in districts of Habro, Mechara, and Gamachis of the west hararghe zone, using eight improved and one standard check finger millet varieties at 2020 main cropping seasons. The experiment was laid down in a randomized completely block design with three replications. Analysis of variance for grain yield across locations showed significant differences at $p< 0.05$. Further analysis of AMMI indicated that environments, varieties, and their interaction effects were significantly different. Even if, tested materials showed a significantly different grain yield across locations nevertheless, the GGE bi-plot analyses implied relatively high yielding and consistent across environments for varieties Bako-09, Gudetu, and Addis-01. Therefore, these varieties of finger millet were recommended for further evaluation at the farmer's field.

Keywords

ANOVA, AMMI, GGEI, IPCA

1. Introduction

Finger millet (Eleusine coracana) is a small seed cereal that grows in semi-arid regions of low rainfall areas. It widely grows in the semi-arid areas of East and South Africa as well as South Asia [2]. It has a wide adaptability to drought-prone areas and then it is a stable food security crop for regions vulnerable to drought. Moreover, it has a significant nutritional value and excellent storage capability [5]. As a result, finger millet is a critical crop for poor farmers who inhabit arid, infertile, and marginal lands.

In Ethiopia, finger millet is the sixth most important cereal crop in total area and production after teff, maize, sorghum, wheat, and barley [11]. It accounts for 5% of the total area allocated to cereal production [1]. Despite Ethiopia being the second largest producer of finger millet in the world after India [6]. Its productivity is lower than the genetic potential of crop 6tha^{-1}. This low yield is mainly due to the major biotic and abiotic factors such as; shortage of improved varieties, little research emphasis given, non-adoption of improved technologies, disease, lodging, and moisture stress [3, 9]. The national average productivity of a crop is 2.5tha^{-1} [4]. Which is low relative to its potential 6 tha^{-1} [1]. However, in west Hararghe by far lower it is 1.4tha^{-1} [4]. This is due to major

*Corresponding author: desuassegid@gmail.com (Desu Assegid)

Received: 16 July 2024; **Accepted:** 13 August 2024; **Published:** 30 August 2024

production constraints like drought, a lack of improved varieties, limited access to seed, and a lack of access to fertilizers [1]. Therefore, this study was initiated to select the best adaptive finger millet varieties with high yield and good agronomic performance for the study area.

2. Materials and Methods

2.1. Description of the Study Area

The field experiment was conducted at three locations namely; Mechara, Gemechis, and Habro districts during at 2020 main cropping season. These districts are found in the west Hararghe Zone of Oromia National Regional State, Eastern part of Ethiopia. A detailed description of the study area is presented in the following Table 1.

Table 1. *Description of Experimental Sites.*

Variables	Study area		
	Daro Labu	**Gamachis**	**Habro**
Soil type	sandy loam with a reddish colour	black, brown, and red soils	Black sandy and loam soil
Altitude (m.a.s.l.)	1780	2400	1739
Annual Temperature (℃)	21℃	20℃	20℃
Minimum	15℃	20℃	13℃
Maximum	28℃	30℃	27℃
Annual rainfall (mm)	1120 mm	1280 mm	967 mm
Minimum	737.3 mm	850 mm	650 mm
Maximum	1134 mm	1000 mm	1000 mm

2.2. Experimental Treatments and Design

In this study, eight recently released finger millet varieties (Bareda, Wama, Gute, Addis 01, Digaa01, Digaa02, Gudatu, and Bako 09) along with one standard check (Tesema) were evaluated as experimental materials. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The spacing between blocks and plots was 1.5 m and 1 m, respectively. The gross size of each plot was 8 m^2 (2 m x 4 m) having five rows with a row-to-row spacing of 40 cm. Two external rows from both sides of each plot were considered, as border making and the three net plot areas is 4.8 m^2 (1.2 m x 4 m). The total area of the experimental field was 306 m^2 (34 m x 9 m). Fertilizer was applied with the rate of 100 kg ha^{-1} NPS during planting and 50 kg ha^{-1} Urea after 35 days of emergence.

2.3. Data Collected

The relevant data were collected from randomly selected five plants of central three of each plot. The following are the major parameters were recorded:

1. Days to 50% emergence (days), Number of fingers per plant
2. Days to 50% flowering (days), Finger length (cm)
3. Days to 75% maturity (days), Plant height (cm)
4. Grain yields ($qtha^{-1}$)

2.4. Data Analyses

The collected data from individual locations and the combined data over locations were analyzed by Genstat 16th Edition. Various statistical models such as analysis of variance (ANOVA), principal component analysis (PCA), and the additive main effects and multiplicative interaction (AMMI) and GGE bi-plot were used. Mean separations were carried out using the least significant difference (LSD) at a 5% probability level.

3. Results and Discussion

Analysis of Variance

The analysis of variance for agronomic traits across locations revealed significant differences for most traits except days to maturity Table 2. In the current result varieties, environments and their interaction show highly significant at (P < 0.01). The result revealed that the tested finger millet varieties had genetic variability and that the testing locations were heterogeneous. Additionally, the GxE interaction shows that different varieties respond differently to these environments for these traits. In line to these, significant differences among tested varieties for most yield-related traits across locations reported by [12]. In addition, [11] reported highly significant differences in finger length and plant height. The variability of yield across a location could be due to distribution variation in rainfall amount, temperature, and soil type [8].

In the current finding mean of days to flower and maturity ranged from moderate to high (Table 2). The farmers of the study areas faced commonly short durations of rainfall and low moisture stress among production constraints. Earliness could be as an escape approach and resilient adaptation under drought stress [10]. Thus, should have considered a variety that has moderate days to maturity and high yielding for the study area and similar environments.

Analysis of the mean for finger length, number of fingers per plant, and plant height showed significant differences for most varieties (Table 2). These could be due to the genetics of the varieties and the variability in the rainfall distribution in the study areas. The numbers of fingers per plant and finger length are important features of the crop in determining the yield potential. This is in agreement with the findings of [12]. The presence of variability of varieties to these traits provides ample chance for the selection of high-yielding varieties.

Table 2. *Agronomic mean performance of varieties across environments.*

Varieties (Genotypes)	**DF**	**DM**	**PH**	**FL**	**NFPP**
Gudetu	91.33^{bc}	145.4^{a}	95^{c}	4.46^{c}	8.37^{a}
Addis-01	99.33^{ab}	152.6^{a}	112.9^{a-c}	4.65^{bc}	7.22^{b-d}
Bako-09	86.67^{c}	143.1^{a}	110.4^{bc}	5.40^{a-c}	8.04^{ab}
Diga-01	98.22^{a-c}	145.3^{a}	121.4^{ab}	7.45^{a}	8.46^{a}
Bareda	99^{ab}	153.4^{a}	112.6^{a-c}	6.40^{a-c}	7.04^{cd}
Wama	88.33^{bc}	145.8^{a}	120.9^{ab}	5.91^{a-c}	6.68^{d}
Gute	97.78^{a-c}	148.9^{a}	122.1^{ab}	6.20^{a-c}	6.6^{d}
Tesema	93.22^{bc}	150.6^{a}	126.1^{ab}	5.55^{a-c}	8.53^{a}
Diga-02	107.44^{a}	153.7^{a}	135.2^{a}	6.75^{ab}	7.73^{a-c}
Mean	96	149	117.4	5.87	8
G	**	ns	**	**	**
E	**	**	**	**	**
G*E	*	ns	*	**	**
CV%	13.1	13.7	7.5	9.1	12.3
LSD (0.05)	11.8	19.1	23.43	2.15	0.9

Key = *, ** significant at 5% and 1% respectively, DF= Days to Flowers, DM= Days to Maturity, PH =Plant Height, FL = Finger Length, NFPP= Number of Finger per Plant, G = Genotypes, E= Environments, G*E== Genotype Environment interaction.

Analysis of variance for grain yield revealed significant differences among varieties, environments, and their interactions Table 3. The results demonstrated the presence of genetic variability among varieties and respond differently to these environments. In harmony with this result, the contribution of environment and Genotype to the observed variation of grain yield was large [8]. This justifies the importance of testing varieties in different environments before recommendations for large-scale production.

Table 3. Combined analysis of variance for grain yield of finger millet Varieties.

Source of variation	DF	SS	MS	p. value
Environment	2	264.93	132.46	<.001
Blocks (Environment)	6	10084.86	1260.61	
Genotype (varieties)	8	6603.29	3301.65	<.001
Genotype* Environment	16	3296.21	206.01	0.018
Error	52	4940.46	95.01	
Total	80	25189.75		

DF = Degree Freedom, SS = sum of square, MS= Mean of square.

Further, the mean grain ranged from 30.25 to 67.26 q tha^{-1} Table 4. The performance of varieties is relatively better at Habro, whereas poor at Gamachis. Among tested varieties, Bako-09, Gudetu, and Addis-01 are relatively better at Habro, Mechara, and Gamachis respectively. Additionally, these varieties across locations are considerably stable and their yield Advantage is higher than ten percent. The difference in yields of varieties across locations exhibited the high cross-over type of GxE interaction [13]. Therefore, the AMMI model is appropriate for the analysis of interaction [15].

Table 4. Mean of grain yield performance for varieties across locations.

Varieties	Mecharaa	Habroo	Gamchis	Combined Mean	Yield Advantage
Gudetu	75.42^{a}	75.4^{a}	41.25^{ab}	65.69^{ab}	16.4
Addis-01	70.83^{ab}	69.17^{ab}	55.88^{a}	65.29^{ab}	14.6
Bako-09	69^{a-c}	80.83^{a}	54.12^{a}	67.99^{a}	23.6
Diga-01	67.92^{a-c}	51.25^{c}	43.67^{a}	43.67^{ab}	
Bareda	60.12^{b-d}	50^{c}	23.92^{c}	44.68^{d}	
Wama	55.42^{cd}	67.92^{b}	50.12^{a}	50.12^{ab}	
Gute	53.75^{d}	69.17^{ab}	35.92^{bc}	52.94^{cd}	
Tesema	50.62^{d}	61.25^{bc}	52.83^{a}	54.90^{c}	
Diga-02	52.83^{a}	32.50^{d}	22.00^{c}	30.25^{e}	
Mean	59.9	62.5	42		
CV%	13.4	11	22		
LSD(0.05)	13.88	11.89	21.09		

CV= coefficient of variation &LSD =least significant difference.

Analysis of variance AMMI for grain yield across environments revealed that highly significant difference due to genotypes and environments at ($P \leq 0.001$) whereas significant for their interaction Table 5. Moreover, the variation attributed to treatments (40%), environments (26.2%), and their interactions (13%). The AMMI model, based on partitioning the GEI indicated that the first two IPCA explained 99.8% of the GEI variance. Specifically, the first and second principal component axes of the interaction explained 56.2% and 43.7% of the GEI sum of squares; respectively. The finding demonstrated the presence of genetic variability and heterogeneity of environments. Further, a significant G*E interaction indicates a differential response of genotypes in varying environments for this trait. In such moments, stability analysis is relevant to determine consistently performed varieties across environments.

Table 5. *AMMI analysis of variance for grain yield.*

Source	DF	SS	MS	SS%	F cal.	F pr
Total	80	25190	314.9			
Trt (at each loc)	26	19984	768.6	79.3	11.42	<0.001
Genotypes	8	10085	1260.6	40	18.73	<0.001
Environments	2	6603	3301.6	26.2	10.03	<0.001
Block	6	1975	329.2		4.89	<0.001
Interactions	16	3296	206.0	13.0	3.06	0.0014
IPCA 1	9	1855	206.1	56.2	3.06	0.0056
IPCA 2	7	1441	205.9	43.7	3.06	0.0096
Error	48	32300	67.3			

DF=Degree of freedom, SS= Sum of squares, MS= Mean of squares, SS%= percentage of sum of squares, IPCA= Interaction principal component analysis, AMMI= Additive mean and Multiplicative Interactions.

The discriminating ability of environments and genotypes stability.

An environment, which has a small angle with the average environment coordinate, is ideal [15]. Accordingly, Habro is an ideal environment it has both the discriminating ability of the varieties and is representative of the other test environments (figure 1). Therefore, Habro could be used to effectively select superior finger millet varieties that can perform consistently across environments. An ideal genotype has the highest yield and is the most stable [13]. Further, it was located in the center of the concentric circles and used as a reference for comparisons of the rest varieties [14]. Thus, the Bako-09 variety is a high yielder and consistent across locations. A desirable genotype is located closer to the ideal ones [7] therefore, Gudetu and Addis-01 are desirable varieties (Figure 1).

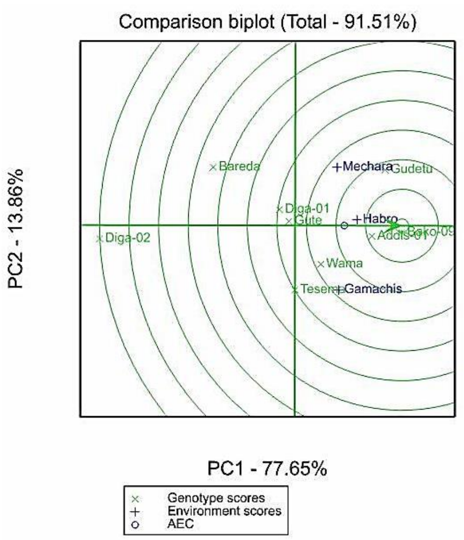

Figure 1. *Ranking environments and varieties relative to the ideal environment and Variety.*

4. Conclusion and Recommendation

Studying varietal responses to different environments is crucial for plant breeding programs since there is diverse natural and environmental variability exists. Accordingly, a total of nine finger millet varieties were studied at three locations Gamachis (segeria FTC), Habro (Biso FTC), and Mechara during the 2020 main cropping season to select the best adaptive finger millet varieties with high grain yield and consistent for the study areas. Despite the finding of grain yield is significantly different across a locations, however varieties; Bako-09, Gudetu, and Addias-01 had relatively higher and stable grain yield across locations as well as it possess higher yield advantage over the standard check. Therefore, these varieties of finger millet were recommended for further evaluation in the farmer's field.

Abbreviations

AMMI	Additive Mean and Multiplicative Interactions
GEI	Genotype Environment Interaction
IPCA	Interaction Principal Component Analysis

Acknowledgments

The author gratefully acknowledged the Oromia Agricultural Research Institute (OARI) and Mechara Agricultural Research Center (McARC) for their financial support.

Author Contributions

Desu Assegid: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Abubeker Terbush: Data curation, Investigation, Methodology, Supervision, Visualization, Writing – original draft

Gebeyehu Chala: Data curation, Investigation, Methodology, Supervision, Visualization

Gabbisa Bekela: Methodology, Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Adane Gebreyohannes, Hussein Shimelis, Mark, L., Isack, M., Damaris, A. O. and Henry, O. 2021. Finger millet production in Ethiopia: Opportunities, problem diagnosis, key challenges and recommendations for breeding. *Sustainability,* 13: 1–23. https://doi.org/10.3390/su132313463

[2] Babu, T. K., Sharma, R., Upadhyaya, H. D., Reddy, P. N., Deshpande, S. P., Senthilvel, S.,... & Thakur, R. P. 2013. Evaluation of genetic diversity in Magnaporthe grisea populations adapted to finger millet using simple sequence repeats (SSRs) markers. *Physiological and molecular plant pathology*, *84*, 10-18. https://doi.org/10.1016/j.pmpp.2013.06.001

[3] Bekele, M., & Debara, M. 2022. Popularization of Medium Maturing Orange Fleshed Sweet Potato (OFSP) Variety (Alamura) and on Farm Evaluation of Its Root Yield Performance at Halaba Zone, Weira District, SNNPR, Ethiopia. *Asian Journal of Advances in Agricultural Research*, *20*(3), 31-39. https://doi.org/10.9734/ajaar/2022/v20i3401

[4] CSA (Central Statistics Agency). 2021. Agricultural sample survey 2020/21. Report on area and production of major crops.

[5] Dida M. M., Srinivasachary, S. Ramakrishnan, J. L. Bennetzen, M. D. Gale and K. M. Devos 2007. The genetic map of finger millet (Eleusine coracana). Theo App. Genet 114: 321-332. https://doi.org/10.1007/s00122-006-0435-7

[6] Food and Agriculture Organization of the United Nations STAT. 2019. Available online: http://www.fao.org/faostat/en/#data/QC (accessed on 20 June 2019)

[7] Kaya, Y., Akçura, M., & Taner, S. 2006. GGE-biplot analysis of multi-environment yield trials in bread wheat. *Turkish journal of agriculture and forestry*, *30*(5), 325-337.

[8] Kinfe, H., Yiergalem, T., Alem, R., Redae, W., Desalegn, Y., & Welegerima, G. 2017. Yield performance and adaptability of finger millet landrace in North Western Tigray, Ethiopia. World News of Natural Sciences, (15), 98-111.

[9] Semahegn, Z., Teressa, T., & Bejiga, T. 2021. Finger millet [Eleusinecoracana (L.) Gaertn] breeding in Ethiopia: A review article. *Int. J. Res. Stud. Agric. Sci*, *7*, 38-42. https://doi.org/10.20431/2454-6224.0703005

[10] Shavrukov, Y., Kurishbayev, A., Jatayev, S., Shvidchenko, V., Zotova, L., Koekemoer, F., de Groot, S., Soole, K. and Langridge, P. 2017. Early flowering as a drought escape mechanism in plants: how can it aid wheat production? *Frontier in* plantsci. 8 (1950): 1-8. https://doi.org/10.3389/fpls.2017.01950

[11] Simion, T., Markos, S., & Samuel, T. 2020. Evaluation of finger millet (Eleusine coracana (L). Gaertn.) varieties for grain yield in lowland areas of southern Ethiopia. *Cogent Food & Agriculture*, *6*(1), 1788895.

[12] Wossen Tarekegne, Firew Mekbib and Yigzaw Dessalegn. 2019. Performance and participa tory variety evaluation of finger millet [Eleusine coracana (L.) Gaertn] varieties in West Gojam Zone, Northwest Ethiopia. East African Journal of Sciences, 13(1): 27–38.

[13] Yan WeiKai, Y. W., & Kang, M. S. 2003. GGE biplot analysis: a graphical tool for breeders, geneticists, and agronomists.

[14] Yan, W. 2001. GGE bi-plot, a Windows application for graphical analysis of multi-environment trial data and other types of two-way data. *Agronomy Journal*, 93: 1111–1118.

[15] Zobel, R. W., Wright, M. J. & Gauch, H. G. 1988. Statistical analysis of a yield trial. Agronomy Journal, 80, 388-393.