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Research Article

GGE biplot analysis of genotype by environment interaction and yield stability of some accessions of mung bean (*Vigna radiata*)

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Abstract - Understanding genotype-by-environment interaction (GEI) is essential for sustainable agricultural production and food security. This study assessed GEI and yield stability in 21 mung bean (*Vigna radiata*) accessions across seven Nigerian locations during the 2023 rainy season using genotype plus genotype by environment (GGE) biplot analysis. A randomized complete block design with three replicates was employed to evaluate agro-morphological traits such as grain yield, plant height, flowering, and pod characteristics. Environmental factors significantly influenced grain yield, accounting for 28.75% of the variation, while genotype and GEI effects explained 4.31% and 17.88%, respectively. Principal component analysis revealed that the first two axes explained 72.25% of total variation, with PC1 and PC2 accounting for 60.20% and 12.05% of the variation, respectively. Ballah was identified as the most favorable environment due to high-yielding potential in mung bean accessions, and Tvr-5 emerged as the most stable and high-yielding genotype, particularly excelling in the southern guinea savanna. Variability in plant height, pod number, and grain yield across environments highlighted the need for breeding strategies targeting both broad and specific adaptability. Tvr-58, Tvr-5, and Tvr-8 were identified to exhibit stability with high yield and are therefore recommended for cultivation and breeding programs.

Keywords: Adaptability, biplot analysis, mung bean, grain yield and stability, *Vigna radiata*

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1. Introduction

The evaluation of genotype by environment interaction (GEI) and yield stability in crop yield is crucial for sustainable agricultural production, particularly in the context of global food security challenges. The mung bean (*Vigna radiata*), widely cultivated across Asia and Africa, serves as a significant source of income for smallholder farmers in these regions (Nair et al., 2012). It is cultivated across diverse environments, ranging from tropical to subtropical regions, with its productivity significantly influenced by genotype-environment (G×E) interactions (Baraki et al., 2020a). Genotype by environment interaction refers to the differential response of genotypes across varying environmental conditions. Improving mung bean production's resilience and productivity requires an understanding of how genotypes and environments interact as well as an assessment of yield stability. This interaction plays a pivotal role in determining the performance and adaptability of mung bean accessions across different agro-ecological zones. The factors such as temperature, soil types, moisture availability and agronomic practices significantly influence the expression of genetic potential in crops (Annicchiarico, 2003). Therefore, measuring GEI becomes crucial for finding superior genotypes that perform consistently across diverse environments.

Yield stability is another crucial trait that agricultural researchers focus on to ensure consistent and predictable crop production. A genotype with high yield stability maintains its performance across varying environmental conditions, thereby reducing production risks and increasing farmers profitability (Daemo et al., 2024). Achieving yield stability involves identifying genotypes that does not only yield high under optimal conditions but also exhibit resilience to stress and sub-optimal environments. In recent years, the use of advanced statistical tools such as GGE biplot analysis has revolutionized the study of GEI and yield stability in crop plants, including mung bean. The GGE biplot provides a graphical and quantitative approach to analyze multi-environment trial (MET) data, aiding at visualizing GEI patterns and identifying mega-environments where specific genotypes perform best (Yan & Tinker, 2006). This approach combines genetic information and environmental factors into a unified framework, allowing researchers to make informed decisions regarding genotype selection and breeding strategies.

In recent years, several studies have applied GGE biplot analysis to investigate GEI and yield stability in various crops, including mung bean. For instance, Mohiddin and Mujeebur Rahman (2018) examined the performance of mung bean genotypes across multiple environments in Pakistan using GGE biplot analysis. Their findings underscored the importance of considering GEI dynamics when selecting genotypes for specific regions or production systems. Moreover, advancements in molecular biology and genomics have enriched our understanding of the genetic basis of traits related to yield and stress tolerance in mung bean. Integrating genomic information with phenotypic data from GGE biplot analysis holds promise for accelerating breeding progress towards developing climate-resilient and high-yielding mung bean varieties.

Despite these advancements, challenges remain in applying GGE biplot analysis effectively in mung bean research. Differences in environmental conditions, interactions between genotype and environment, and the requirement for consistent experimental methods create challenges for robust data interpretation. Addressing these challenges requires interdisciplinary collaboration among agronomists, breeders, statisticians, and molecular biologists to refine methodologies and enhance the reliability of research outcomes. The exploration of genotype by environment interaction and yield stability through GGE biplot analysis represents a pivotal advancement in mung bean research. This approach helps in grasping the complicated relationships among genotypes and their environments, while also guiding breeding plans that seek to enhance the productivity and improvement of mung beans. As global challenges such as climate change and population growth intensify, the application of GGE biplot analysis becomes increasingly indispensable for sustainable agricultural development and food security.

This research aims to (i) conducting a comprehensive GGE biplot analysis of selected mung bean accessions to provide substantial information on the genotypes performances and (ii) assessing yield stability across diverse environments towards development of resilient mung bean varieties.

2. Materials and methods

2.1 Plant material

A collection of 21 mung bean (*Vigna radiata*) accessions was used in this study. Accessions were obtained from the International Institute of Tropical Agriculture (IITA), Nigeria (Table 1).

Table 1. Accessions and seed coat color of twenty-one mung bean collections used in this study.

Accession number	Accession code	Seed color
1	Tvr-58	Green
2	Tvr-89	Green
3	Tvr-98	Green
4	Tvr-45	Green
5	Tvr-65	Green
6	Tvr-5	Green
7	Tvr-52	Green
8	Tvr-93	Green
9	Tvr-40	Orange
10	Tvr-84	Light brown
11	Tvr-8	Green
12	Tvr-42	Green
13	Tvr-78	Orange
14	Tvr-70	Green
15	Tvr-43	Green
16	Tvr-62	Green
17	Tvr-50	Orange
18	Tvr-95	Orange
19	Tvr-83	Green
20	Tvm-11	Green
21	Tvm-12	Brown

2.2 Experimental design

The experiment followed a randomized complete block design (RCBD) with three replications. Each accession was planted in seven different environments to assess GEI. The plot size was 2.4 m x 2.4 m with plant spacing of 0.6 m between and within rows. Seeds were sown at 2 seeds per hole to give a total of 50 plant stands per plot.

2.3 Field Trials

The field trials were conducted on the research farms of seven out-stations of the Institute of Agricultural Research and Training located in Ibadan (transition zone), Ballah and Kabba (southern guinea savannah), Ilora (derived savanna), Ikenne and Ile-Ife (rain forest), Kishi (northern guinea savannah) during the rainy season (June–August) in 2023. Each location varied in agro-ecological conditions and soil types and is referred to as an "environment" in this study. The experimental sites were mechanically prepared to achieve weed-free and loose soil. Pre-emergence herbicide (Metolachlor 960 gE.C. at 1.44 kg a.i./ha) was applied at planting. Manual weeding was carried out on the field as necessary. Field insect pests were controlled using Magic Force (Lambdacyhalothrin 15 % + Dimethoate 300 g/L) both at the vegetative and reproductive stages.

2.4 Data collection

The data collected in each location included plant height, days to first and 50% flowering, days to 50% podding, number of pods per peduncle, number of pods per plant, pod length, number of grains per pod, and grain yield. These parameters were measured according to methods highlighted in the International Board for Plant Genetic Resources (IBPGR) descriptor for mung bean (International Board for Plant Genetic Resources, 1980).

2.5 Data analysis

Analysis of variance (ANOVA) was conducted to assess the impact of genotype, environment and GEI on the agronomic traits. Additionally, Tukey's significant difference (HSD) test was employed for mean comparisons among accessions and environments, seeking a deeper understanding of the variations between them. Furthermore, GGE biplot analysis was performed using Plant Breeding Tools software (Version 1.4, 2014) to analyze the multi-environment trial (MET) data, seeking valuable insights into the complex relationships between the accessions and their performance in different environments.

3. Result and discussion

The grain yield of mung bean accessions exhibited remarkable variability, ranging from a low value of 20.31 g to as high as 3195 g. The average of grain yield was 816.7 g, with a substantial standard deviation of 765.7 g (Table 2). This aligns with the report of Nalajala et al. (2022) and it suggests that certain genotypes or environments were considerably more productive than others, potentially indicating of diverse environmental adaptations or genetic differences in yield potential. Similarly, plant height demonstrated substantial variation, ranging from 20.5 cm to 193.4 cm, with a mean of 54.39 cm and a standard deviation of 26.74 cm. This concurs with the findings by Baraki et al. (2020b), who also reported that plant height is significantly influenced by genotype and environment. This variability could influence harvesting efficiency and may reflect adaptability to different environmental conditions or genetic factors affecting plant architecture. In contrast, days to first flowering, 50% flowering and days to 50% podding displayed relatively lower variability, fluctuating between 40-64, 44-67, and 47-72 days after planting, respectively, across the seven environments. This suggests most of the genotypes are medium-maturing. Similar variability was observed by Salman et al. (2021) on green gram recombinant inbred lines. Notably, the observed variability highlights significant differences in agronomic traits among the mung bean genotypes, particularly in grain yield, plant height, and pod number. This variability presents valuable opportunities for breeding programs to identify high-yielding genotypes or those adaptable to diverse environments. Ultimately, these findings provide a vital foundation for selecting genotypes with desirable traits, enhancing yield, growth performance and flowering in mung bean cultivation. (Table 2).

Table 2. Mean, standard error (SE), minimum and maximum values of agronomic traits of the twenty-one genotypes of mung bean, evaluated in the seven locations in Nigeria in 2023.

Traits	Minimum	Maximum	Mean	StdDev	SE (0.05)
Grain yield/plot (g)	20.31	3195	816.7	765.7	40.02
Plant height (cm)	20.5	193.4	54.39	26.74	1.52
Days to first flower	39.67	64.0	45.11	4.64	0.22
Days to 50% Flowering	44.26	67.33	50.62	4.72	0.23
Days to 50% Podding	47.0	71.67	53.92	4.596	0.23
Number of pods per peduncle	2.96	11.1	5.09	1.56	0.08
Number of pods per plant	2.72	105.5	40.55	29.36	1.55
Pod length (cm)	4.12	9.28	8.11	1.28	0.07
Number of grains per pod	5.37	14.82	12.67	2.05	0.10

Note: StdDev.: Standard deviation; SE: Standard error.

Table 3 shows the genetic variation and environmental performance of each mung bean accession evaluated. Considerable variability was observed across traits, underscoring the importance of both genetic potential and environmental factors. Grain yield per plot ranged from 500.1 g for Tvr-83 to 1202.8 g for Tvr-5, with significant environmental differences. It was observed that the highest-yielding accession (Tvr-5) demonstrated strong genetic potential in specific environments. Tvr-83 with lowest grain yield per plot (500 g) had the lowest pod length (6.12 cm) and grain number per pod (9.84), in contrast with Tvr-5 with highest yield. This may be responsible for the low yield of Tvr-5 as yield is a function of number and weight. Plant height varied widely (45.58 - 73.4 cm), with significant genotype, environment, and genotype-by-environment (GxE) effects. This highlights the need for environment-specific selection to stabilize plant height. Days to first flower, 50% flowering, and 50% podding exhibited significant genetic, environmental, and GxE effects. This emphasizes the complex interactions between genetic background and environmental conditions on flowering time.

There was significant genetic and environmental variation for the number of pods per peduncle. This implies that the trait might be controlled by both additive and non-additive genetic effects. Pod length and number of grains per pod exhibited significant GxE effects, indicating sensitivity to environmental conditions.

This corroborates the findings of Giang et al. (2024), who reported significant differences among grain yield per pod for genotypes of mung bean. Breeding strategies should prioritize environmental stability for these traits. The findings suggest that traits with lower GxE effects, such as grain yield and pods per plant, offer greater stability across diverse locations and traits with high GxE effects require careful selection towards specific environments. This study shows the importance of considering both genetic and environmental factors in mung bean breeding programs, particularly for traits that are usually affected by environmental factors.

Table 3. Mean performance of the agronomic traits of twenty-one accessions of mung bean, evaluated across seven locations in 2023, in Nigeria.

Accessions	Grain yield/ plot (g)	Plant height (cm)	Days to first flower	Days to 50% flowering	Days to 50% podding	Number of pods per peduncle	Number of pods per plant	Pod length (cm)	Number of grains per pod
Tvr-58	1056.9	45.58	44.2	49.1	52.7	5.8	44.1	8.29	13.5
Tvr-89	757.1	51.4	44.7	49.7	53.1	5.2	44.7	8.44	13.1
Tvr-98	812.2	47.32	44.1	49.6	52.8	5.3	45.4	8.44	13.4
Tvr-45	948.8	50.74	44.9	50.5	54.0	5.4	48.4	8.31	12.7
Tvr-65	1026.0	64.97	51.0	58.3	6077	5.4	38.1	8.41	13.3
Tvr-5	1202.8	53.39	42.2	48.2	51.5	5.1	44.5	8.47	13.2
Tvr-52	655.6	54.98	42.2	48.4	52.4	5.2	29.0	8.36	12.9
Tvr-93	911.7	63.52	46.5	52.8	56.1	5.6	43.0	8.48	13.1
Tvr-40	758.0	53.44	43.9	49.1	52.5	5.0	41.2	8.51	13.1
Tvr-84	541.6	67.56	46.7	51.9	53.5	4.5	32.7	5.82	9.6
Tvr-8	919.7	55.23	45.3	50.3	53.6	5.3	48.3	8.45	13.0
Tvr-42	668.8	50.42	45.2	51.1	53.6	5.2	44.2	8.10	13.0
Tvr-78	726.4	50.93	45.4	50.1	53.6	5.1	32.0	8.66	13.5
Tvr-70	678.2	52.52	44.0	50.0	53.2	5.0	39.7	8.33	13.2
Tvr-43	883.5	52.18	46.7	51.6	54.9	5.0	40.0	8.52	12.7
Tvr-62	863.6	48.8	43.6	49.4	53.0	4.5	39.9	8.21	13.2
Tvr-50	670.9	50.58	43.3	48.9	52.2	4.7	31.1	8.53	12.8
Tvr-95	905.3	49.64	47.0	49.62	53.3	4.8	39.8	8.72	13.1
Tvr-83	500.1	73.4	49.3	57.88	61.4	3.9	41.1	6.12	9.8
Tvm-11	844.4	52.26	44.1	49.65	52.7	5.8	39.3	8.40	13.1
Tvm-12	631.6	57.73	44.1	49.47	53.8	4.8	45.0	5.56	8.7
Gen	ns	**	**	**	**	**	ns	**	**
Env	**	**	**	**	**	**	**	**	**
GxE	ns	**	**	**	*	ns	ns	**	**
CV (%)	68.98	16.92	4.59	3.84	3.27	15.25	54.72	13.97	11.73

Note: * significant at P = 0.05, ** significant at P = 0.01 level of significance, ns: not significant, gen: genotypic variance, env: environmental variance, GxE: genotype by environment variance.

Table 4 shows the mean yield performance across locations. Ballah had the highest average grain yield (1691.0 g), indicating optimal growing conditions, while Ilora had the lowest average grain yield (219.3 g), suggesting less favorable conditions. Ballah's favorable conditions make it an ideal location for testing high-yielding potential in mung bean genotypes. Intermediate yield performances were observed in Kabbah (972.1 g) and Kishi (929.3 g), which indicates the significant influence of environmental conditions of the locations on yield performance. Similar results were reported by Gebremariam and Baraki (2018), who attributed the differences observed in the yield of mung bean to soil and climatic conditions. Some accessions exhibited exceptional performance in specific environments. For instance, Tvr-58 yielded 2106.03 g in Ballah and 26.54 g in Ilora, indicating sensitivity to environmental variation and highlighting strong GxE interactions. These results are consistent with the findings of Asfaw et al. (2012), who identified similar environmental influences on mung bean yield in their multi-environment trials.

Table 4. Average of grain yield (g/plot) of the twenty-one mung bean accessions in seven environments, in Nigeria.

Accessions	Ibadan	Ballah	Ilora	Kishi	Kabbah	Ikenne	Ile-Ife
Tvr-58	1449.9	2106.0	26.5	-	1218.9	565.7	376.9
Tvr-89	823.8	1342.0	89.2	810.4	908.8	493.5	806.1
Tvr-98	1150.3	1262.9	231.7	766.4	538.8	893.5	436.4
Tvr-45	1605.2	1519.1	291.4	994.3	838.3	495.4	1106.7
Tvr-65	743.2	1723.2	220.6	1519.2	2416.9	103.4	285.7
Tvr-5	1272.9	3195.3	303.1	1019.5	1459.7	844.2	700.1
Tvr-52	309.4	1931.7	201.7	627.3	671.6	709.6	272.6
Tvr-93	1042.1	1572.8	315.9	999.6	1346.2	301.3	662.4
Tvr-40	795.3	1483.3	181.0	1097.8	711.2	591.9	178.8
Tvr-84	185.1	64.2	325.9	329.6	881.7	90.7	1265.9
Tvr-8	687.2	2369.4	390.6	1060.6	1085.3	455.6	264.3
Tvr-42	745.9	1195.8	253.0	972.2	801.2	555.9	80.8
Tvr-78	974.4	1266.0	189.6	735.8	686.1	821.1	295.1
Tvr-70	690.8	1389.1	169.5	612.7	902.9	762.5	173.8
Tvr-43	961.7	1613.5	236.4	1157.5	1051.1	719.2	266.6
Tvr-62	808.0	1674.1	350.9	837.3	798.8	1006.0	447.7
Tvr-50	217.8	1735.7	127.3	613.6	591.0	769.0	433.6
Tvr-95	486.9	2820.3	107.7	797.1	611.7	792.10	534.2
Tvr-83	218.3	-	183.7	325.7	921.5	883.61	602.8
Tvm-11	982.9	1210.5	20.3	851.1	1193.2	448.27	350.9
Tvm-12	765.6	-	213.9	934.2	761.6	-	376.9
Mean	805.6bc	1691.0a	219.3e	929.3b	972.1b	612.4cd	521.6d

Note: Means with the same alphabet are not significantly different at 5% level of probability.

Analysis of variance of grain yield (Table 5) revealed that significant environmental effects, accounting for 28.75% of the total variation (P < 0.01) observed for grain yield. These findings are consistent with the study of Asfaw et al. (2012), emphasizing the dominance of environmental factors over genetic ones in mung bean yield variability. This emphasizes the critical role of environmental conditions, such as climate and soil, in determining yield. In contrast, replication within environments had no significant impact, indicating consistent results and minimal random error within each of the environments. The GxE interaction explained 17.88% of the variation but was non-significant. Residual variation accounted for the largest portion (45.16%) of the total variation, capturing unexplained or random sources of variation. Reducing residual variation in future studies could help isolate specific genotype and environmental effects. These findings explained the dominant role of environment in mung bean yield variation and breeding programs could be channeled towards environmental adaptability and stability across diverse conditions to maximize yield.

Table 5. Analysis of variance and variation of the grain yield of twenty-one accessions of mung bean evaluated in seven environments in Nigeria.

Source	DF	Sum of square (10^6)	Mean square (10^6)	Variation explained (%)
Environment (E)	6	59.25	9.87**	28.75
Rep (Env.)	14	8.03	0.57	3.90
Genotype (G)	20	8.88	0.44	4.31
GxE	115	36.84	0.32	17.88
Residual	210	93.07	0.44	45.16
Total	**365**	**206.07**		

Note: ** significant at P = 0.01 level of significance.

Figure 1 shows the "which–won–where" biplot analysis for grain yield in the seven environments to identify the best-performing accessions in specific environments. GGE biplot makes it possible to assess the environment using the representativeness of the GGE view and discriminating power (Sharma et al., 2020). The value of 72.25% of the variation was represented by the principal component axes, with PC1 and PC2 accounting for 60.20% and 12.05% of the variation, respectively. This graphical representation divided the biplot into five sectors, each corresponding to the environments where particular accessions excelled. The presence of multiple sectors highlights the existence of distinct mega-environments, confirming the importance of environment-specific genotypes (Yan & Tinker, 2006). Sector one (mega environments) comprises of three environments, which are Ibadan (transition zone), Ballah (southern guinea savanna), and Ilora (derived savanna) where Tvr-5 excelled with the highest yield. Sector three comprises of Ikenne and Ile-Ife, both of which are in the rain forest agroecology. The sector had Tvr-50 as the best genotype in the two environments indicating its strong adaptability to rainforest conditions. Similarly sector five grouped Kishi (Northern Guinea Savanna) and Kabbah (Southern Guinea Savanna) together. The accession Tvr-65 was identified as the most productive in this sector, demonstrating its suitability for growth in these agroecological zones. Nevertheless, no environment was represented in sectors 2 and 4, implying that the creation of discrete environmental groupings in these areas was not supported by the data that was available. Variations in environmental conditions or the absence of significant genotype-by-environment interactions in particular places could be the cause of this absence.

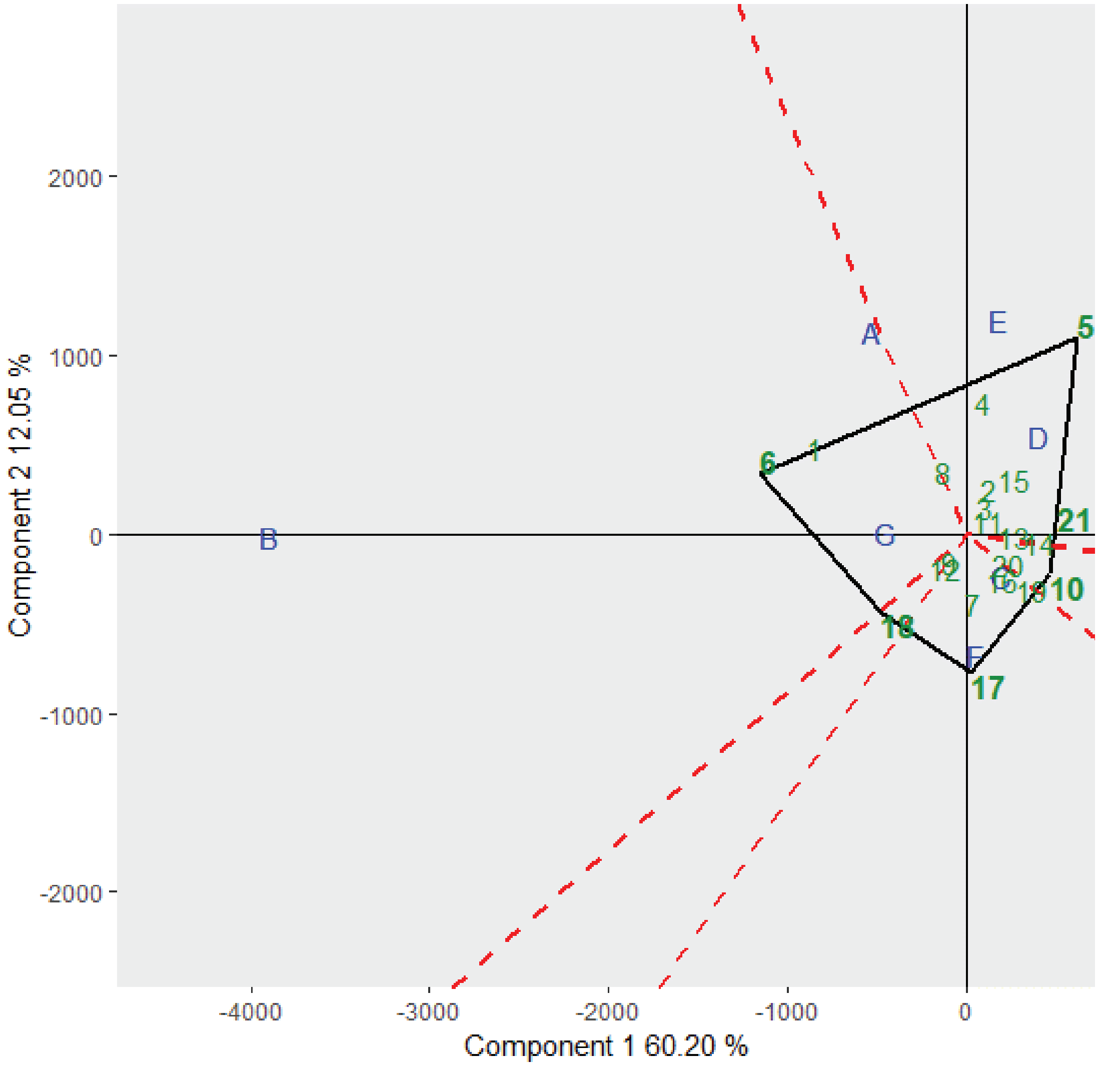

Figure 1. The "which–won–where" view of the GGE biplot for the grain yield of the twenty-one mung bean accessions in seven environments of Nigeria (grain kg/ plot).
(A: Ibadan; B: Ballah; C: Ilora; D: Kishi; E: Kabbah; F: Ikenne and G: Ile-Ife. Accessions 1: Tvr-58; 2: Tvr-89; 3: Tvr-98; 4: Tvr-45; 5: Tvr-65; 6: Tvr-5; 7: Tvr-52; 8: Tvr-93; 9: Tvr-40; 10: Tvr-84; 11: Tvr-8; 12: Tvr-42; 13: Tvr-78; 14: Tvr-70; 15: Tvr-43; 16: Tvr-62; 17: Tvr-50; 18: Tvr-95; 19: Tvr-83; 20: Tvm-11; 21: Tvm-12.)

Figure 2 ranked the seven environments based on the grain yield performance among all the accessions evaluated. The proximity of an environment to the ideal center of the biplot indicates favorable conditions for mung bean production and those far away from the center may represent environments that are prone to stress. Ballah which is in the second concentric circle and has the shortest projection from the Average Environment Axis (AEA), is the most ideal environment for production of mung bean for optimum yield. This was followed by Ibadan in the third concentric circle and ranks second in projection on the direction of AEA. All other environments were clustered in the third concentric circle, with almost similar projections. These rankings can guide breeders in selecting representative environments for multi-location trials, thereby improving the efficiency of varietal evaluation (Yan et al., 2007). Additionally, understanding the variability among environments helps identify breeding targets, such as tolerance to specific abiotic or biotic stresses prevalent in low-performing environments.

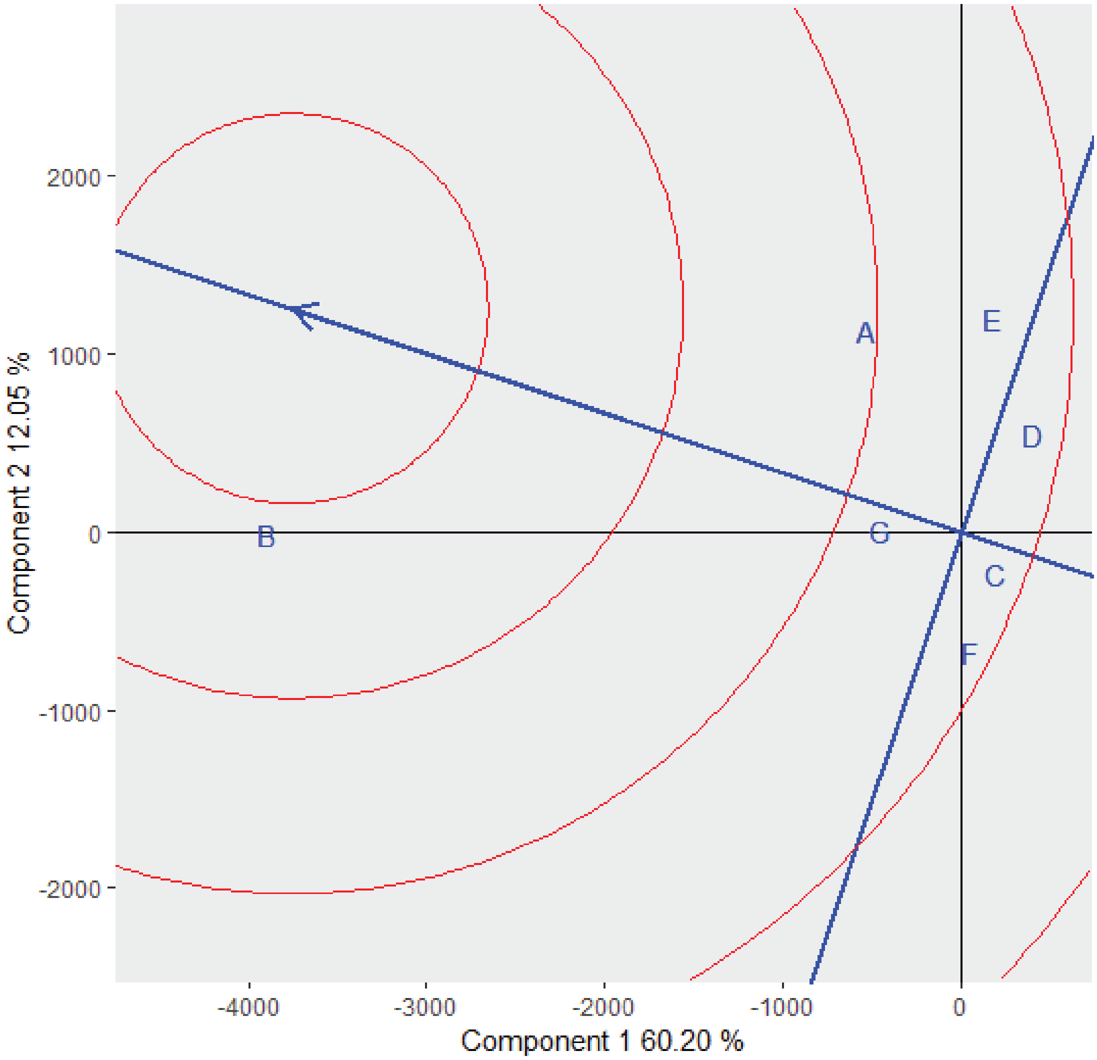

Figure 2. Ranking of the environments of the twenty-one accessions of mung bean based on their yield performance (grain kg/ plot.
(A: Ibadan; B: Ballah; C: Ilora; D: Kishi; E: Kabbah; F: Ikenne and G: Ile-Ife.)

Figure 3 illustrates the "mean vs. stability" analysis of the GGE biplot using principal component axis (PC1 and PC2) scores of the seven environments. This analysis evaluates both the average performance and stability of the accessions across environments. Stable accessions with high mean yields, located near the average environment coordinate (AEC), are ideal candidates for release as widely adapted varieties. Such accessions demonstrate resilience to environmental variability, an important trait for ensuring food security under changing climatic conditions (Kang, 2002; Yan et al., 2007). Tvr-84, Tvr-5, Tvr-70, Tvr-58, Tvr-8, Tvr-78, Tvm-11, Tvr-89, Tvr-83, Tvr-93 were all considered stable in this experiment, whereas only Tvr-58, Tvr-5, Tvr-8 combine the stability with high yield; the others were stable but yielded lower than the average, whereas Tvr-65, Tvr-45, Tvr-50 are quite far from the AEC and are considered not so stable, even though Tvr-65 and Tvr-45 are high yielding. Baraki et al. (2020a) reported similar trends in their mung bean GEI experiment using both GGE biplot and additive main effect and multiplicative interaction (AMMI) models. Furthermore, among the high-yielding genotypes, Tvr-5 was found to be the most stable and the optimal genotype due to its high grain output.

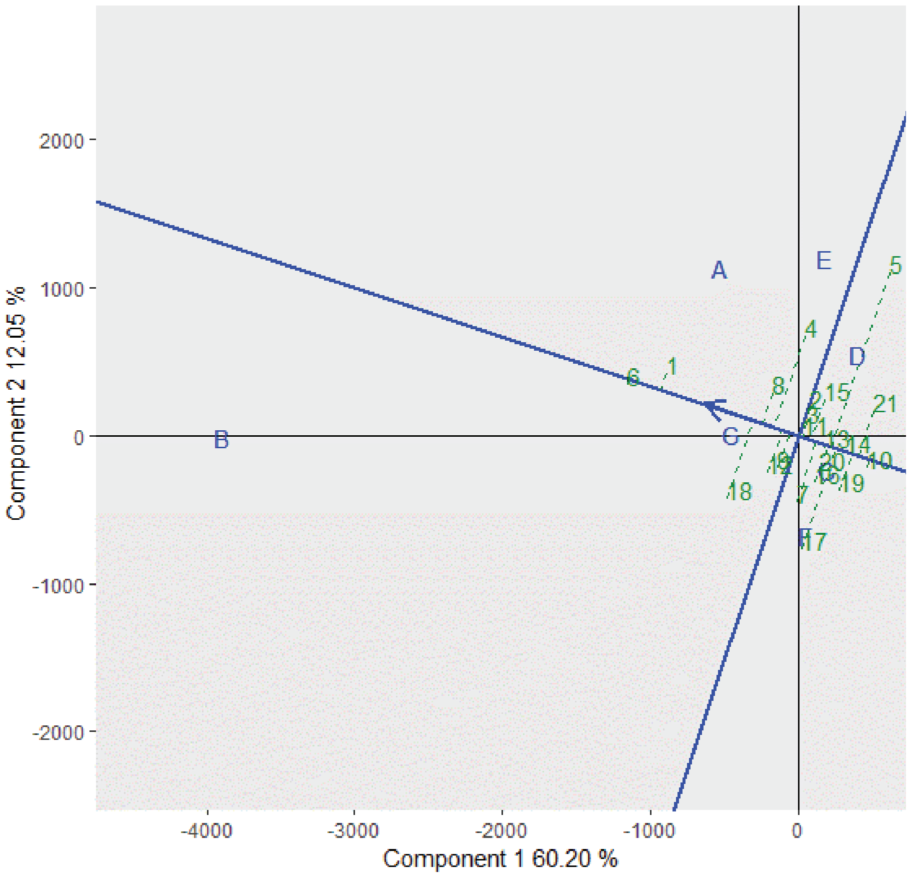

Figure 3. The "mean vs. stability" analysis of the twenty-one mung bean accession for the grain yield in seven environments.
(A: Ibadan; B: Ballah; C: Ilora; D: Kishi; E: Kabbah; F: Ikenne and G: Ile-Ife. Accessions 1: Tvr-58; 2: Tvr-89; 3: Tvr-98; 4: Tvr-45; 5: Tvr-65; 6: Tvr-5; 7: Tvr-52; 8: Tvr-93; 9: Tvr-40; 10: Tvr-84; 11: Tvr-8; 12: Tvr-42; 13: Tvr-78; 14: Tvr-70; 15: Tvr-43; 16: Tvr-62; 17: Tvr-50; 18: Tvr-95; 19: Tvr-83; 20: Tvm-11; 21: Tvm-12.)

4. Conclusion

This study demonstrated the significance of environmental factors and GEI in yield performance and stability of mung bean. Environment accounted for 28.75% of the total variation, while genotype-by-environment interaction explained 17.88% in this study. Using GGE biplot analysis, accessions and environments with optimal performances were identified, emphasizing the importance of environment-specific breeding strategies. Tvr-5 was the most stable and high-yielding genotype, making it a promising candidate. Ballah emerged as the most favorable environment for mung bean cultivation. Therefore, Tvr-5, which has shown wide environmental adaptability, is recommended to farmers in Nigeria and other tropical countries for commercial cultivation to enhance productivity and for further breeding work for resilience. Moreover, the high-yielding accessions are also recommended as promising parental lines to improve grain yield as a way of contributing to sustainable agricultural practices and food security.

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