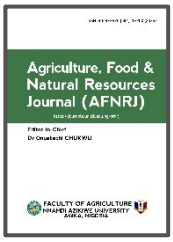
Agr. Foo. Nat. Res. J. Volume 5, Issue 2, Page: 85-92

e-ISSN: 1597-7153 | p-ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj



Original Article

Performance of nine maize (*Zea mays*) varieties in guinea savannah agro-ecological zone of Taraba State, Nigeria

OPEN ACCESS

Ahmed ISHAKA[1]*, Yakubu Ali GARJILA[1], Isa Umar KYARI[2], Nuruddeen Bakari ABBA[3], & Lynda HAMZA[1]

[1]*Department of Agricultural Technology, College of Agriculture Science and Technology, Jalingo, Taraba State, Nigeria*
[2]*Department of Agricultural Economics and Extension, College of Agriculture Science and Technology, Jalingo, Taraba State, Nigeria.*
[3]*Department of Statistics, College of Agriculture Science and Technology, Jalingo, Taraba State, Nigeria.*

DOI: https://doi.org/10.5281/zenodo.23055325

Editor: *Onyekachi CHUKWU, Nnamdi Azikiwe University, NIGERIA*

Received: *August 1, 2026*
Accepted: *September 19, 2026*
Available online: *September 30, 2026*

Peer-review: *Externally peer-reviewed*

Copyright: © 2026 Author(s)
This is an open access article licensed under Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Conflict of Interest: *The authors have no conflicts of interest to declare*

Financial Disclosure: *The authors declare that this study received financial support from the Tertiary Education Trust Fund Institution Based Research.TETF/IBR/COAST/2026/016*

ABSTRACT

This study evaluated the agronomic performance, yield potential, and adaptability of nine maize varieties across three agro-ecological locations (Jalingo, Bali, and Wukari) in Taraba State during the 2025 cropping season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on vegetative growth, flowering, ear characteristics, yield components, and grain yield. Data subjected to Pearson correlation, analysis of variance, and Duncan's Multiple Range Test was used to separate significant means ($p<0.05$). The result revealed significant effects of genotype, location, and genotype-location interaction for most traits, indicating substantial genetic variability among the varieties. Broad-sense heritability ranged from 35.74% for days to 50% tasselling to 99.20% for fresh cob weight, while grain yield exhibited high heritability (97.69%), confirming strong genetic control. Plant height, leaf number, fresh cob weight, and dry cob weight were positively correlated with grain yield, indicating their usefulness as indirect selection criteria. Across environments, LW1701-10 consistently produced the tallest plants, highest fresh and dry cob weights, and superior grain yield per plant in Jalingo and Wukari. Conversely, SAMMAZ 24 recorded the best ear characteristics and highest grain yield in Bali. Consequently, LW1701-10 is recommended for cultivation in Jalingo and Wukari, whereas SAMMAZ 24 is recommended for Bali based on site-specific superiority. However, due to significant genotype-location interactions, further multi-environment trials and formal stability analyses are recommended to confirm broader regional adaptation.

KEYWORDS: *Adaptability, Environment interaction, Genotype, Grain yield, Phenotypic variability*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops globally, serving as a major source of food, livestock feed and industrial raw materials. It contributes substantially to food security, household income, and economic development, particularly in sub-Saharan Africa where millions of smallholder farmers depend on its production. In Nigeria, maize is cultivated across diverse agro-ecological zones and is consumed in various forms, while also supplying the feed, brewing, starch, and biofuel industries. Consequently, the crop plays a significant role in national food systems and agricultural development (International Institute of Tropical Agriculture [IITA], 2022; Food and Agriculture Organization [FAO], 2023;). Despite Nigeria being the largest producer of maize in Africa (FAO, 2024), national average grain yield remains considerably below the attainable yield of improved varieties. Although modern maize cultivars can produce between 4 and 6

*Corresponding author: ahmedishaka360@gmail.com

t ha^{-1} under good agronomic management, yields obtained by most smallholder farmers are often below 2 t ha^{-1}. This yield gap has been attributed to declining soil fertility, erratic rainfall associated with climate variability, poor crop management practices, pest and disease infestations, and the cultivation of varieties that are poorly adapted to local environmental conditions (Manyong *et al.,* 2021; FAO, 2023).

Taraba State is one of the major maize-producing states in northeastern Nigeria because of its favourable climate and extensive agricultural land. However, the state encompasses diverse agro-ecological environments characterized by differences in rainfall distribution, temperature, soil properties, and growing-season length. Major maize-producing areas such as Jalingo, Bali, and Wukari differ in these environmental conditions, which can significantly influence crop growth, grain yield, and overall varietal performance (Akanbi *et al.,* 2022). Such environmental variability often results in significant genotype × environment (G × E) interactions, whereby the performance of a maize variety differs across locations. Consequently, a variety that performs well in one environment may not necessarily maintain similar performance under different agro-ecological conditions (Prasanna *et al.,* 2021; Bänziger *et al.,* 2022; Adewale *et al.,* 2023). Several improved maize varieties have been developed through breeding programmes of the International Institute of Tropical Agriculture (IITA), the Institute for Agricultural Research (IAR), and other national research institutions to enhance productivity, resilience, and adaptation to diverse production environments. However, information on the adaptability and yield stability of these varieties under the specific agro-ecological conditions of Jalingo, Bali, and Wukari remains limited. Most available studies have focused on varietal evaluation in other ecological zones of Nigeria, while location-specific comparative evaluations for these important maize-growing areas of Taraba State are scarce. This lack of empirical information limits evidence-based varietal recommendations, reduces the effectiveness of agricultural extension services, and constrains farmers' ability to select suitable varieties for their production environments. Addressing this knowledge gap is essential for improving maize productivity and ensuring sustainable crop production in Taraba State. Evaluating maize varieties across contrasting agro-ecological locations will provide reliable information on varietal adaptability, yield performance, and stability under different environmental conditions. Such information will support the identification of superior varieties for specific locations, enhance farmers' decision-making, improve the efficiency of extension advisory services, and contribute to increased maize production, food security, and sustainable agricultural development. Therefore, this study evaluated the performance of nine maize (*Zea mays* L.) varieties across three agro-ecological locations of Jalingo, Bali, and Wukari in Taraba State, Nigeria, with the objective of identifying high-yielding, stable, and well-adapted varieties suitable for recommendation to farmers.

MATERIAL AND METHOD

Study Location

The study was conducted in three major maize-producing Local Government Areas (LGAs) of Taraba State, Nigeria, namely Jalingo, Bali, and Wukari, which were selected to represent the diverse agro-ecological conditions and major maize production environments of the state (Bako et al., 2019). Jalingo LGA is located approximately between 8.89°–8.92° N latitude and 11.33°–11.36° E longitude, Bali LGA lies approximately between 7.85°–8.15° N latitude and 10.96°–10.96° E longitude, while Wukari LGA lies approximately between 7.87°–7.96° N latitude and 9.78°–9.85° E longitude (Bako et al., 2019; GeoNames, 2026). Taraba State, located in North-Eastern Nigeria, is characterized by variations in climate, topography, vegetation, and soil types, making it suitable for evaluating the adaptability and performance of maize varieties under contrasting environmental conditions. Jalingo is located in Taraba State, northeastern Nigeria, and lies within the Northern Guinea Savannah ecological zone. The area has a tropical wet-and-dry climate, with a mean annual temperature of approximately 28°C and annual rainfall generally ranging from 1,000 to 1,200 mm. The rainy season usually extends from April to October, while the dry season occurs from November to March. Jalingo is characterised by Northern Guinea Savannah vegetation. Soil studies in the metropolis have reported predominantly loamy sand and sandy loam textures, with variations in physical and chemical properties across different landscape positions. The soils are generally well drained, with variations in fertility-related properties such as organic carbon, total nitrogen, available phosphorus and cation exchange capacity (Osujieke *et al.,* 2018; Kefas *et al.,* 2024). Bali is located in the southern-central part of Taraba State and falls within the Northern Guinea Savannah agro-ecological zone. Long-term climatic analysis indicates an annual rainfall of approximately 1,489.0 mm, with an estimated rainy-season length of about 186 days, extending from April to October. These climatic conditions provide a relatively long growing period and support rain-fed agricultural production. The area is characterised by savanna vegetation and environmental conditions that favour the cultivation of a variety of food crops (Ezra *et al.,* 2023). Wukari is situated in Taraba State and is also classified within the Northern Guinea Savannah agro-ecological zone. Long-term climatic analysis reported an annual rainfall of approximately 1,260.5 mm, with a rainy season lasting about 179 days, from approximately April to October. The climatic conditions are generally suitable for rain-fed agriculture. Wukari's soils show spatial variation in their physical and chemical characteristics, reflecting differences in parent material, topography and land-use conditions. Previous soil research in Wukari has also characterised and evaluated the soils in relation to their properties and susceptibility to erosion (Osujieke *et al.,* 2018; Ezra *et al.,* 2023).

Experimental Design and Field Management

The experiment consisted of nine maize varieties: SAMMAZ 17, SAMMAZ 24, Admiral 'A', LW1701-5, LW1701-4, LW1701-10, TZM 216, TZM 213, and TZM 224, obtained from established maize breeding programmes in Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, which is widely recommended for minimizing experimental error in field trials (Gomez & Gomez, 1984; Petersen, 1994). The experimental field measured 35 m × 10 m and was divided into 27 plots, each measuring 3 m × 3 m. Adjacent plots were separated by 0.5 m unplanted borders, while replications were separated by 1.0 m alleys to minimise border effects and facilitate field operations (FAO, 2023). The experimental field was manually cleared, ploughed and harrowed to obtain a suitable seedbed for planting. Maize seeds were sown at a spacing of 75 cm between rows × 25 cm within rows, at a depth of 3–5 cm, with two seeds per planting hole. Each 3 m × 3 m plot contained 4 rows, with 12 planting stands per row, giving 48 planting stands per plot. Two seeds were initially planted at each stand, resulting in 96 seeds per plot. Thinning was carried out after seedling establishment, retaining one healthy plant per stand, giving a final population of 48 plants per plot. The spacing resulted in an intended plant population of approximately 53,333 plants ha^{-1}, calculated as 10,000 m^2 ÷ (0.75 m × 0.25 m). The same spacing, number of rows, number of planting stands and target plant population were maintained across all experimental locations. Standard agronomic practices recommended for maize production in the Guinea Savannah zone of Nigeria were followed (NAERLS, 2020; IITA, 2022).

Data Collection

Details of data collected are presented in Table 1.

Table 1: Collection of Data on Vegetative and Yield Parameters of Maize

Traits	Measurements
Plant height (cm)	Plant height was measured on five randomly selected plants per plot from the ground level to the tip of the tassel using a measuring tape. The mean plant height was computed and recorded.
Number of leaves per plant	The number of fully expanded leaves was counted on five randomly selected plants per plot, and the mean number of leaves per plant was computed and recorded.
Days to 50% tasselling	The number of days from sowing to the stage when 50% of the plants in each plot had produced tassels was counted and recorded.
Days to 50% silking	The number of days from sowing to the stage when 50% of the plants in each plot had produced silks was counted and recorded.
Days to ear formation	The number of days from planting until the appearance of ears was counted and recorded.
Ear length (cm)	Five ears were randomly selected from each plot, and ear length was measured from the base to the tip using a ruler. The mean ear length was computed and recorded.
Ear diameter (cm)	Ear diameter was measured at the middle portion of five randomly selected ears per plot using a Vernier caliper. The mean ear diameter was computed and recorded.
Number of ears per plant	The number of ears produced by five randomly selected plants per plot was counted, and the mean number of ears per plant was computed and recorded.
Fresh ear weight per plant (g)	Fresh ears harvested from five randomly selected plants per plot were weighed using a sensitive weighing balance, and the mean fresh ear weight was computed and recorded.
100 seed weight (g)	One hundred seeds were randomly selected from each plot, weighed using a sensitive weighing balance, and the weight recorded.
Fresh biomass weight (kg)	The fresh weight of leaves, stems, and roots from the sampled plants was determined using a weighing balance, and the mean fresh biomass weight was recorded in kilograms.
Dry ear weight per plant (kg)	Harvested ears were dried to constant moisture content and weighed using a sensitive weighing balance. The mean dry ear weight per plant was computed and recorded.
Grain yield per plot (kg)	At harvest, ears from each plot were harvested separately, shelled, cleaned and weighed using a sensitive weighing balance. The grain yield from each plot was recorded in kilograms. Grain moisture content was determined at harvest, and the recorded grain weights were adjusted to a standard moisture content of 12% before calculating grain yield. Grain yield was subsequently expressed as kilograms per plot (kg $plot^{-1}$).

Data Analysis

Data collected were first subjected to tests for homogeneity of error variances before the statistical analysis. Analysis of variance (ANOVA) was performed separately for each location and combined across locations using the PROC GLM procedure of SAS version 9.4 (SAS Institute Inc., 2013). The analyses were conducted to determine the effects of genotype (G), location (L), and genotype × location (G × L) interaction. The combined analysis across locations was performed following the procedures described by Gomez & Gomez (1984) and Yan & Kang (2003) for multi-environment trials. In the

combined analysis, genotype was considered a fixed effect, while location and the associated interaction effects were considered random where appropriate for the estimation of variance components.

Estimation of Broad-Sense Heritability

Broad-sense heritability (H^2) was estimated from the variance components obtained from the combined analysis of variance using the following formula:

$$H^2 = \frac{\sigma^2 G}{\sigma^2 G + \frac{\sigma^2 GL}{l} + \frac{\sigma^2 e}{lr}} \quad (1)$$

Where: H^2 = broad-sense heritability, $\sigma^2 G$ = genotypic variance, $\sigma^2 GL$ = genotype × location interaction variance, $\sigma^2 e$ = residual or experimental error variance, l = number of locations; and r = number of replications per location.

The above formula estimates the proportion of the total phenotypic variance attributable to genetic differences among the maize genotypes while accounting for genotype × location interaction and experimental error. The genotype × location interaction variance is divided by the number of locations (l) because the interaction contributes to the variation in genotype performance across locations. Similarly, the residual variance is divided by the product of the number of locations and replications (lr) to account for the increased precision resulting from repeated observations across locations and replications. Heritability values were expressed as proportions and, where required, converted to percentages by multiplying H^2 by 100.

Statistical Model for Combined Analysis

The statistical model used for the combined analysis across locations was expressed as:

$$\mathrm{Y\,ij}k = \mu + Li + \mathrm{R}j(i) + \mathrm{G}k + (LG)\,ik + \varepsilon ij \quad (2)$$

Where: Yijk = observed value of the kth genotype in the jth replication within the ith location, μ = overall mean, Li = effect of the ith location, Rj(i) = effect of the jth replication nested within the ith location, Gk = effect of the kth genotype, (LG)ik = genotype × location interaction effect; and εijk = random experimental error.

The analysis of variance was used to determine whether significant differences existed among genotypes, locations, and genotype × location interactions for the traits evaluated. Where significant differences among treatment means were detected, means were separated using Duncan's Multiple Range Test (DMRT) at the 5% probability level (Duncan, 1955).

RESULTS AND DISCUSSION

Analysis of Variance, Variance Components and Heritability Estimates for Agronomic and Grain Yield Traits of Nine Maize Varieties Evaluated Across Three Locations

Table 2: shows the combined analysis of variance showed significant ($P \leq 0.05$) genotypic differences for most agronomic and grain yield traits, indicating substantial genetic variability among the nine maize varieties and good prospects for genetic improvement (Badu-Apraku *et al.,* 2022; Beyene *et al.,* 2023). Location significantly influenced days to 50% tasselling, days to 50% silking, ear width, ear length, ears per plant, fresh cob weight, dry cob weight, and grain yield, demonstrating the importance of environmental variation across Jalingo, Bali, and Wukari (Prasanna *et al.,* 2021; Tadesse *et al.,* 2022). Significant genotype × location interactions for most yield-related traits further emphasized the need for multi-location evaluation before varietal recommendation (Menkir *et al.,* 2022). The relatively low coefficients of variation for most traits indicated good experimental precision, while higher values for ears per plant reflected greater environmental influence. Phenotypic variance exceeded genotypic variance for all traits, confirming environmental effects on trait expression, although the small differences between the two variances for major yield traits suggested strong genetic control. Similarly, phenotypic coefficients of variation were higher than genotypic coefficients of variation, indicating the presence of exploitable genetic variability despite environmental influences. Broad-sense heritability estimates ranged from 35.74% for days to 50% tasselling to 99.20%for fresh cob weight. High heritability values recorded for fresh cob weight, dry cob weight, grain yield, number of leaves, ear length, ear width, days to 50% silking, and plant height indicate that these traits are predominantly governed by genetic factors and can be effectively improved through selection. Overall, the results demonstrate substantial genetic diversity among the maize varieties and identify key yield-related traits with high heritability as reliable selection criteria for developing high-yielding and stable maize cultivars across the agro-ecological zones of Taraba State.

Mean Performance of Maize Varieties for Agronomic Traits across Jalingo, Bali and Wukari

The nine maize varieties exhibited significant variation in agronomic traits across Jalingo, Bali, and Wukari, indicating substantial genetic diversity and differences in adaptation to the three agro-ecological environments (Table 3a and 3b). Variety LW1701-10 consistently produced the tallest plants and the highest number of leaves, reflecting superior vegetative growth, while SAMMAZ 24 recorded the widest and longest ears, demonstrating excellent reproductive performance and high yield potential. Days to 50% tasselling varied only slightly among the varieties, indicating relatively stable flowering, whereas SAMMAZ 17 attained 50% silking earlier than the other varieties, suggesting better adaptation to moisture-limited conditions. The differences observed among varieties and locations highlight the combined influence of genetic makeup and environmental factors on maize growth and development. Overall, LW1701-10 and SAMMAZ 24 emerged as the best-performing varieties due to their superior vegetative growth, ear characteristics, and broad adaptability across the three

locations, confirming the importance of multi-location evaluation for identifying stable and high-yielding maize varieties (Prasanna *et al.,* 2021; Badu-Apraku *et al.,* 2022; Menkir *et al.,* 2022; Tadesse *et al.,* 2022; Beyene *et al.,* 2023).

Mean Performance of Maize Varieties for Yield and Yield Components across Jalingo, Bali and Wukari

Tables 4a and 4b; indicate significant variation in yield and yield-related traits across Jalingo, Bali, and Wukari, indicating differences in their genetic potential and adaptability to the three agro-ecological environments. SAMMAZ 24 consistently produced the highest number of ears per plant and the heaviest 100-seed weight, particularly in Bali, suggesting superior reproductive efficiency and grain filling ability. In contrast, LW1701-5 and LW1701-4 generally recorded lower values for these traits, indicating comparatively lower yield potential. Similar observations were reported by Badu-Apraku *et al.* (2022), who identified ears per plant and kernel weight as important determinants of grain yield in tropical maize. Significant differences were also observed in fresh cob weight, dry cob weight, and grain yield per plant. LW1701-10 consistently recorded the highest fresh cob weight, dry cob weight, and grain yield in Jalingo and Wukari, while SAMMAZ 24 performed best in Bali. Conversely, Admiral 'A', LW1701-5, and LW1701-4 generally produced lower yields across the study locations. The superior performance of LW1701-10 and SAMMAZ 24 demonstrates their high yield potential and wide adaptation under varying environmental conditions. These findings further confirm the combined influence of genotype and environment on maize productivity and emphasize the importance of multi-location evaluation for identifying stable, high-yielding varieties suitable for recommendation to farmers (Prasanna *et al.,* 2021; Menkir *et al.,* 2022; Tadesse *et al.,* 2022; Beyene *et al.,* 2023).

Table 2: Analysis of Variance, Variance Components and Heritability Estimates for Agronomic and Grain Yield Traits of Nine Maize Varieties Evaluated Across Three Locations

SV	Df	PH	NL	DTASS	DSILK	EAR W	EAR L	EAR/PL	100 Seed	FCW	DCW	GY/PLT
Genotype	8	14.56*	11.16*	1.53ns	17.16*	2.13*	12.96*	0.83*	7.03*	288.25*	231.50*	1095.93*
Replication	2	0.68	0.03	2.74	1.05	0.99	1.36	1.55	6.35	3.17	0.96	4.99
Location	3	0.04ns	0.03ns	10.66*	6.00*	6.72*	58.09*	2.66*	1.85ns	183.52*	4.44*	537.39*
Loc × Gen	24	4.00*	3.34*	0.45ns	2.66*	1.34*	4.36*	0.33ns	4.64*	286.28*	282.69*	1045.61*
Error	16	2.06	0.20	1.66	1.60	0.11	1.16	0.37	3.64	2.31	2.67	25.62
Mean		30.35	10.71	54.37	61.88	12.85	15.09	2.33	25.03	62.11	33.61	102.52
Cv		4.73	4.18	2.37	2.04	2.58	7.13	26.38	7.62	2.44	4.86	4.93
σ^{2p}		15.93	11.38	2.63	18.22	1.20	13.73	1.07	9.45	289.79	233.28	1113.01
$\sigma^{2}g$		13.87	11.09	0.97	16.62	1.09	12.57	0.70	5.81	287.48	230.61	1087.39
PCV		13.15	31.49	2.98	6.89	8.52	27.55	44.39	12.28	27.40	45.44	32.54
GCV		6.56	2.36	2.04	2.58	7.13	26.10	7.62	2.44	4.86	4.93	11.60
Heritability		87.06	97.45	35.74	91.21	90.83	95.73	65.42	61.48	99.20	98.85	97.69

*Key: * = Significant at P ≤ 0.05; ns = Not significant; SV= Source of variation, DF= Degree of freedom, PH = Plant height; NL = Number of leaves; DTASS = Days to 50% tasselling; DSILK = Days to 50% silking; EAR W = Ear width; EAR L = Ear length; EAR/PL = Ears per plant; FCW = Fresh cob weight; DCW = Dry cob weight; GY/PLT = Grain yield per plant; σ^2p = Phenotypic variance; σ^2g = Genotypic variance; PCV = Phenotypic coefficient of variation; GCV = Genotypic coefficient of variation; H^2 = Broad-sense heritability.*

Table 3a: Mean Values for agronomic traits across Jalingo, Bali and Wukari

Varieties	Plant height (cm)			Number of leaves			Days to 50% tassel		
	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari
SAMMAZ 17	31.86^{ab}	30.96^{abc}	31.41^{b}	12.09^{ab}	11.23^{bc}	11.66^{a}	55^{a}	53.66^{a}	54.33^{ab}
SAMMAZ 24	29.46^{c}	32.53^{a}	31.00^{bc}	10.73^{ab}	14.00^{a}	12.36^{b}	54^{a}	53.33^{a}	54.00^{ab}
Admiral 'A'	30.93^{ab}	30.30^{abc}	30.61^{bc}	10.23^{ab}	10.10^{d}	10.16^{c}	55^{a}	54.33^{a}	54.83^{ab}
LW1701-5	30.50^{ab}	30.23^{abc}	30.36^{bcd}	10.73^{ab}	11.06^{c}	10.90^{d}	55^{a}	53.66^{a}	54.33^{ab}
LW1701-4	28.53^{c}	29.36^{c}	28.95^{cd}	9.26^{c}	9.206^{e}	9.26^{f}	54^{a}	54.00^{a}	54.33^{ab}
LW1701-10	35.06^{a}	31.96^{ab}	33.51^{a}	14.16^{a}	11.76^{b}	12.96^{a}	55^{a}	55.00^{a}	55.33^{a}
TZM 216	29.86^{c}	30.00^{bc}	29.93^{bcd}	9.93^{c}	10.6^{d}	10.00^{e}	54^{a}	54.00^{a}	54.33^{ab}
TZM 213	28.46^{c}	29.03^{c}	28.75^{cd}	9.93^{c}	8.66^{f}	9.03^{f}	55^{a}	53.66^{a}	54.33^{ab}
TZM 224	28.53^{c}	28.50^{c}	28.60^{d}	10.10^{ab}	10.03^{d}	10.06^{e}	53^{a}	53.33^{a}	53.50^{b}

Table 3b: Mean Values for Jalingo, Bali and Wukari

Varieties	Days to 50% silk			Ear width (cm)			Ear length (cm)		
	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari
SAMMAZ 17	55^{c}	54.66^{e}	54.50^{d}	12.45^{c}	12.00^{cd}	12.22^{c}	16.14^{abc}	12.73^{cd}	12.43^{b}
SAMMAZ 24	56^{bc}	55.66^{d}	55.00^{c}	13.11^{ab}	14.20^{a}	13.65^{a}	18.27^{a}	19.56^{a}	18.92^{a}
Admiral 'A'	59^{a}	59.00^{a}	57.33^{a}	13.69^{ab}	12.50^{bc}	13.09^{b}	17.10^{ab}	13.23^{bcd}	15.17^{b}
LW1701-5	58^{ab}	57.33^{bc}	56.16^{b}	13.06^{ab}	11.50^{d}	12.28^{c}	15.33^{bc}	14.06^{b}	14.69^{b}
LW1701-4	56^{bc}	56.00^{bcd}	56.66^{ab}	13.95^{a}	12.00^{cd}	12.97^{b}	15.88^{abc}	13.20^{bcd}	14.54^{b}
LW1701-10	57^{abc}	58.00^{ab}	56.00^{b}	12.46^{c}	12.10^{c}	12.78^{b}	15.99^{abc}	12.53^{d}	14.26^{b}
TZM 216	56^{bc}	56.00^{bcd}	56.83^{ab}	12.95^{c}	12.80^{b}	12.87^{b}	14.26^{c}	14.06^{b}	14.16^{b}
TZM 213	55^{c}	55.00^{cd}	55.83^{bc}	12.96^{c}	12.76^{b}	12.73^{c}	15.85^{abc}	13.43^{bcd}	14.64^{b}
TZM 224	57^{abc}	57.33^{bc}	54.50^{d}	13.49^{ab}	12.66^{b}	13.08^{b}	16.35^{abc}	13.70^{bc}	15.02^{d}

Within each parameter, means with the same letter on a column are not significantly different, (p>0.05)

Table 4a: Mean Values for yield and yield-related traits across Jalingo, Bali and Wukari

Varieties	Number of ears per plant			100-seed weight (g)			Fresh cob weight (kg)		
	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari
SAMMAZ 17	2.33^{ab}	2.00^{ab}	2.16^{bc}	24.33^{a}	24.00^{b}	24.16^{b}	70.70^{b}	52.66^{d}	61.68^{d}
SAMMAZ 24	3.00^{a}	3.00^{a}	3.00^{a}	25.33^{a}	28.66^{a}	27.00^{a}	58.01^{e}	78.63^{a}	68.77^{d}
Admiral 'A'	3.33^{a}	2.00^{ab}	2.66^{ab}	26.33^{a}	23.33^{b}	24.83^{ab}	52.63^{f}	52.2^{6d}	52.45^{g}
LW1701-5	2.33^{ab}	1.33^{b}	1.83^{c}	25.00^{a}	25.00^{b}	25.00^{ab}	54.93^{f}	54.13^{d}	54.53^{f}
LW1701-4	2.00^{b}	1.66^{b}	1.83^{c}	23.66^{a}	24.00^{b}	23.83^{b}	62.23^{d}	59.90^{c}	61.06^{d}
LW1701-10	2.66^{ab}	2.33^{ab}	2.50^{abc}	26.00^{a}	25.66^{b}	25.83^{ab}	89.76^{a}	59.30^{c}	74.53^{a}
TZM 216	2.33^{ab}	2.33^{ab}	2.33^{abc}	25.33^{a}	23.66^{b}	24.50^{ab}	60.40^{de}	60.40^{c}	60.40^{be}
TZM 213	2.33^{ab}	2.33^{ab}	2.33^{abc}	24.00^{a}	24.00^{b}	24.00^{b}	66.63^{c}	66.63^{b}	66.63^{c}
TZM 224	2.66^{ab}	2.00^{ab}	2.33^{abc}	27.00^{a}	25.33^{b}	26.16^{ab}	59.36^{e}	58.46^{c}	58.91^{e}

Within each parameter, means with the same letter on a column are not significantly different, (p>0.05)

Table 4a: Mean Values for yield and yield-related traits across Jalingo, Bali and Wukari

Varieties	Dry cob weight (kg)			Grain yield per plant (kg)		
	Jalingo	Bali	Wukari	Jalingo	Bali	Wukari
SAMMAZ 17	37.52^{b}	30.26^{bcd}	33.89^{b}	130.73^{b}	100.40^{b}	115.56^{b}
SAMMAZ 24	30.27^{c}	58.36^{a}	44.31^{a}	83.78^{d}	128.00^{a}	115.89^{b}
Admiral 'A'	28.70^{c}	28.86^{d}	28.78c	85.53^{d}	89.16^{c}	87.35^{d}
LW1701-5	29.13^{c}	30.46^{bc}	29.80^{c}	84.30^{d}	86.60^{c}	85.45^{d}
LW1701-4	30.60^{c}	30.60^{bc}	30.60^{c}	88.73^{d}	88.73^{c}	88.73^{d}
LW1701-10	57.16^{a}	31.36^{b}	44.26^{a}	152.46^{a}	99.46^{b}	125.96^{a}
TZM 216	30.33^{c}	29.70^{cd}	29.86^{c}	112.26^{c}	99.33^{b}	105.80^{c}
TZM 213	31.52^{b}	30.43^{bc}	30.85^{c}	108.93^{c}	101.60^{b}	105.26^{c}
TZM 224	30.43^{c}	29.90^{cd}	30.16^{c}	104.36^{c}	101.60^{b}	102.70^{c}

Within each parameter, means with the same letter on a column are not significantly different, (p>0.05)

Correlation of Agronomic and Yield Traits of Maize Varieties in the Study Area

The Pearson correlation analysis (Table 5), based on pooled data from Jalingo, Bali, and Wukari, revealed significant positive associations among several traits. Plant height was significantly correlated with number of leaves (r = 0.80), fresh cob weight (r = 0.50), dry cob weight (r = 0.65), and grain yield per plant (r = 0.55). Number of leaves was also significantly correlated with fresh cob weight (r = 0.60), dry cob weight (r = 0.82), and grain yield per plant (r = 0.65), highlighting the importance of vegetative growth in maize productivity (Prasanna *et al.,* 2021; Menkir *et al.,* 2022). Ear length was significantly correlated with ear width (r = 0.58), while ear width showed a strong positive correlation with fresh cob weight (r = 0.90). Fresh and dry cob weights were strongly correlated with grain yield per plant (r = 0.87 and 0.81, respectively). These findings suggest that cob-related traits, particularly fresh and dry cob weight, are important components associated with grain yield (Badu-Apraku *et al.,* 2022; Tadesse *et al.,* 2022; Beyene *et al.,* 2023). Overall, fresh cob weight, dry cob weight, plant height, and number of leaves showed significant positive associations with grain yield and may be useful for indirect selection in maize breeding. The correlations represent overall relationships across the three locations and should not be interpreted as location-specific effects.

Table 5: Correlation coefficients of agronomic and yield traits of maize varieties in the study area

	PH	NL	DTASS	DSILK	EAR W	EAR L	EAR/PL	100 SEED	FCW	DCW	YPP
PH	1.00										
NL	0.80*	1.00									
DTASS	0.03	0.11	1.00								
DSILK	0.07	-0.06	0.07	1.00							
EAR W	0.09	0.18	0.07	0.15	1.00						
EAR L	0.13	0.36	0.08	0.02	0.58*	1.00					
EAR/PL	0.27	0.19	0.12	0.13	0.33	0.008	1.00				
100 SEED	0.28	0.41	-0.10	0.24	0.32	0.46	0.27	1.00			
FCW	0.50*	0.60*	0.09	-0.09	0.90*	0.37	0.21	0.25	1.00		
DCW	0.65*	0.82*	0.01	-0.07	0.40	0.45	0.24	0.39	0.87*	1.00	
YPP	0.55*	0.65*	0.65*	-0.16	0.22	0.23	0.16	0.26	0.87*	0.81*	1.00

*PH: Plant height; NL: Number of leaves; DTASS: Days to 50% tasselling; DSILK: Days to 50% silking; EAR W: Ear width; EAR L: Ear length; EAR/PL: Ears per plant; 100 SW: 100-seed weight; FCW: Fresh cob weight; DCW: Dry cob weight; YPP: Grain yield per plant. * indicates significant correlation at the 5% probability level.*

CONCLUSION AND RECOMMENDATIONS

The study revealed significant genetic variability among the nine maize (Zea mays L.) varieties evaluated across Jalingo, Bali, and Wukari. Genotype, location, and genotype × environment interaction significantly influenced most agronomic and yield traits, indicating differential varietal responses across environments. High broad-sense heritability estimates for important traits, particularly plant height, number of leaves, fresh cob weight, dry cob weight, and grain yield per plant, indicate substantial genetic influence and potential usefulness in maize improvement programmes. Varietal performance varied across locations. LW1701-10 recorded superior performance in Jalingo and Wukari, whereas SAMMAZ 24 performed best in Bali, demonstrating that varietal suitability was influenced by the test environment. These varieties therefore showed promising yield potential within their respective locations.

Based on the findings, LW1701-10 is recommended for cultivation in Jalingo and Wukari, while SAMMAZ 24 is recommended for Bali. Agricultural extension services should promote the location-appropriate varieties among farmers. Breeders should also exploit the highly heritable traits, particularly plant height, number of leaves, fresh cob weight, dry cob weight, and grain yield per plant, in selection and development of improved maize varieties. Because a significant genotype × environment interaction was observed, further multi-location and multi-season testing should be conducted to assess yield stability, adaptability, and consistency of performance across additional environments and seasons before making broader recommendations for large-scale cultivation.

Acknowledgements

The authors sincerely acknowledge the support of the College of Agriculture, Science and Technology, Jalingo, for providing the facilities and enabling environment for this research. We also express our profound gratitude to the Tertiary Education Trust Fund (TETFund), Abuja, Nigeria, for the financial sponsorship that made this study possible.

Authors' Contributions

AI conceived the study, conducted the field experiments, collected and analyzed the data, and drafted the manuscript. YAG supervised the study, contributed to the methodology, and reviewed the manuscript. IUK assisted with the experimental design, field supervision, data analysis, and manuscript review. NBA contributed to data interpretation, literature review, and manuscript editing. LH assisted with data collection, manuscript formatting, proofreading, and final editing. All authors reviewed, approved, and accepted responsibility for the final manuscript.

REFERENCES

Adewale, S. A., Badu-Apraku, B., & Akinwale, R. O. (2023). Assessing the suitability of stress tolerant early-maturing maize (*Zea mays*) inbred lines for hybrid development using combining ability effects and DArTseq markers. *Plant Breeding, 142*(2), 223–237. https://doi.org/10.1111/pbr.13077

Badu-Apraku, B., Garcia-Oliveira, A. L., Petroli, C. D., Hearne, S., & Adewale, S. A. (2021). Genetic diversity and population structure of early and extra-early maturing maize germplasm adapted to sub-Saharan Africa. *BMC Plant Biology*, 21, 96. https://doi.org/10.1186/s12870-021-02829-6.

Badu-Apraku, B., Menkir, A., Fakorede, M. A. B., Meseka, S., Gedil, M., & Garcia-Oliveira, A. L. (2022). Genetic improvement of tropical maize for enhanced grain yield, stress tolerance and nutritional quality in sub-Saharan Africa. *Plant Breeding Reviews, 46*, 1–45.

Bänziger, M., Setimela, P. S., Hodson, D., & Vivek, B. (2022). Breeding maize for adaptation to diverse environments in sub-Saharan Africa: Progress, challenges and opportunities. *Plant Breeding Reviews, 46*, 121–162. https://doi.org/10.1002/9781119828235.ch4

Bako T., Oparaku L.A & Flayin J.M (2019). The environmental issues at Taraba State *International Journal of Science and Engineering Research*, 7(2): 286 – 294

Beyene, Y., Semagn, K., Mugo, S., Prasanna, B. M., Tarekegne, A., Olsen, M., & Crossa, J. (2023). Genotype × environment interaction and stability analysis of tropical maize hybrids under diverse African environments. *Frontiers in Plant Science, 14*, 1190843. https://doi.org/10.3389/fpls.2023.1190843

Duncan, D. B. (1955). Multiple range and multiple *F* tests. *Biometrics,11*(1), 1–42. https://doi.org/10.2307/3001478

Ezra, A., Chesumada, E., Thabbal, M. L., Zemba, A. A., & Ikusemoran, M. (2023). Spatio- temporal variation of precipitation effectiveness indices across the agro-ecological zones of Taraba State and its implication on crop cultivation. *Confluence Journal of Environmental Studies,* 17(1), 1–12.

Food and Agriculture Organization of the United Nations. (2023). *FAOSTAT: Crops and livestock products*. https://www.fao.org/faostat/

Food and Agriculture Organization of the United Nations. (2024). *Hand-in-Hand Investment Forum 2024: Nigeria*. FAO.

GeoNames. (2026). GeoNames geographical database. https://www.geonames.org/

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley & Sons.

International Institute of Tropical Agriculture. (2022). *Maize improvement programme: Annual report 2022*. IITA.

Kefas, P. K., Ofem, K. I., Hammanjoda, A., & Garjila, Y. A. (2024). Characterization and classification of three major soils at the College of Agriculture, Jalingo, Taraba State, Nigeria. *Agro-Science, 22*(1), 10–16. https://doi.org/10.4314/as.v22i1.2

Menkir, A., Meseka, S., Gedil, M., & Badu-Apraku, B. (2022). Genetic variability, heritability and selection efficiency for grain yield and agronomic traits in tropical maize. *Agronomy, 12*(11), 2768.

Osujieke, D. N., Obasi, N. S., Imadojemu, P. E., Ekawa, M., & Angyu, M. D. (2018). Characterization and classification of soils of Jalingo Metropolis, North-east, Nigeria. *Nigerian Journal of Soil Science, 28*(2), 72–80. https://doi.org/10.67042/njss.2018.lxhbb7pn

Petersen, R. G. (1994). *Agricultural field experiments: Design and analysis*. Marcel Dekker.

Prasanna, B. M., Cairns, J. E., Zaidi, P. H., Beyene, Y., Makumbi, D., Gowda, M., Magorokosho, C., Zaman-Allah, M., Olsen, M., Das, A., & Worku, M. (2021). Beat the stress: Breeding for climate resilience in maize for tropical rainfed environments. *Theoretical and Applied Genetics, 134*(6), 1729–1752.

SAS Institute Inc. (2013). *SAS/STAT® 9.4 user's guide*. SAS Institute Inc.

Tadesse, W., Cairns, J. E., Sanchez-Garcia, M. & Prasanna, B. M. (2022). Genotype × environment interaction and climate-resilient crop improvement in sub-Saharan Africa. *Frontiers in Plant Science, 13*, 845513.

Yan, W. & Kang, M. S. (2003). *GGE biplot analysis: A graphical tool for breeders, geneticists, and agronomists*. CRC Press.