impact International Journals and Publications

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

GROWTH, YIELD AND GENETIC VARIABILITY OF TEN COWPEA (*Vigna unguiculata* (L.) Walp.) ACCESSIONS IN GUMA AND MAKURDI LOCAL GOVERNMENT AREAS OF BENUE STATE, NIGERIA

Gbashinbo John Oraduen[1], *Mshelmbula Barka Peter[2a] & Ogah Omame Godwin[3]

[1,2,3]*Department of Plant Science and Biotechnology, Faculty of Life Sciences, Federal University of Lafia, Nigeria*

[a]*ORCID: https://orcid.org/0000-0003-0338-8349*

***Corresponding author**: barkapeter5@gmail.com*

ARTICLE INFO

Article No.: 0652

Accepted Date: 11/09/2026

Published Date: 26/10/2026

Type: Research

ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important legume crop, yet information on the comparative agronomic performance of improved accessions across different agro-ecologies in Benue State remains limited. This study was therefore conducted to evaluate the comparative performance of ten cowpea accessions obtained from the International Institute of Tropical Agriculture (IITA) in Guma and Makurdi Local Government Areas of Benue State. A Randomized Complete Block Design (RCBD) with three replications was used at both locations. Germination percentage showed no significant difference among accessions at either location. Accession G recorded the highest plant height (88.98 ± 2.60 cm), leaf area (73.95 ± 1.29), 100-seed weight (10.44 ± 0.21 g) and pod number (32.33 ± 3.06) ($p < 0.05$), with accessions H, I, B and D ranking next for these traits. Plant height and branch number were higher in Guma, while leaf area, flower production and pod formation were higher in Makurdi. Genotypic coefficients of variation were generally lower than phenotypic coefficients of variation, indicating environmental influence on trait expression. Total pod number and 100-seed weight recorded high heritability (91.65% and 94.14%) and high genetic gain (102.50% and 29.43%), making them reliable selection criteria in cowpea improvement programmes. The consistent superiority of accession G across both environments within this single season indicated broad adaptability. Accession G is identified as the most promising genotype for cultivation and future varietal development in Benue State, while accessions B, D and I also show considerable potential for genetic improvement.

Keywords: Cowpea, genotype × environment interaction, heritability, genetic advance

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most important and low-cost legume crops grown in sub-Saharan Africa, especially in West Africa (FAO, 2023). Nigeria is a leading producer and consumer of cowpea, accounting for approximately 45 to 55% of world production (Singh *et al.*, 2022; FAO, 2023). It is a food security crop, which serves as a major source of plant-based protein and an important source of income for smallholder farmers (Manda *et al.*, 2020). It has the advantages of drought resistance, enhancing soil fertility by fixing nitrogen from the atmosphere, and adaptability to low soil fertility, making it a climate-smart and sustainable crop option in low-input farming systems (Mohammed *et al.*, 2021; IITA, 2024).

Despite the recognized importance of cowpea, its productivity in Nigeria remains far below its potential. This is due to several factors such as high frequency of pests and diseases, declining soil fertility, irregular and insufficient rainfall and limited access to improved and suitable varieties (Abberton *et al.*, 2021; Boukar *et al.*, 2019). In addition to these limitations, a major problem is the use of cowpea varieties poorly suited to local environmental conditions. Many cowpea accessions exist with different genetic characters, but these differ in performance across locations because of the interaction between genotype and environment (Odeseye *et al.*, 2018). The use of cowpea genetic diversity, especially through the evaluation of accessions, is of great potential to solve these problems, as growth and yield differentials among genotypes can be utilized for plant improvement and varietal selection (Mshelmbula *et al.*, 2024).

The genotype × environment (G × E) interaction is one of the factors that influences accession performance. The interaction is important for the varying responses of different accessions to different climate, soil and management conditions, and evaluation of accessions at several locations is important for obtaining information on accessions well adapted to specific agro-ecologies (Odeseye *et al.*, 2018). Research on related legumes has also suggested that environmental factors play a major role in the observed differences in growth and yield traits (Mshelmbula *et al.*, 2024).

Several Nigerian and regional studies have examined genotype × environment interaction in cowpea to guide accession selection. Odeseye *et al.* (2018) evaluated twenty cowpea accessions across two locations in Nigeria over two planting seasons and found that G × E interaction significantly altered the relative ranking of accessions between environments. Popoola *et al.* (2024) assessed forty-two elite cowpea lines across five Nigerian agro-ecological environments and confirmed that both genotype and environment strongly influenced grain yield and associated agronomic traits. At a more localized scale, Mshelmbula *et al.* (2024) evaluated growth and yield performance of legume accessions in Lafia, Nasarawa State, and reported significant differences among accessions, reinforcing the need for site-specific evaluation before recommending varieties to farmers. However, these studies have concentrated mainly on yield stability and G × E ranking at a broader regional or national scale, with limited attention given to the combined assessment of growth parameters, yield parameters, and genetic variability estimates (heritability, genetic advance) specifically for cowpea accessions within Guma and Makurdi Local Government Areas of Benue State.

In Guma and Makurdi, where there are variations in soil, rainfall and farming practices, farmers find it difficult to choose appropriate varieties without location-specific data, and tend to stick to traditional or general varieties, resulting in low productivity. Moreover, despite ongoing breeding efforts and the development of improved cowpea varieties, adoption among farmers remains limited, information dissemination systems remain weak, and there is limited information on locally evaluation of accessions especially in Benue state. This represents a gap

that the present study addresses. This study therefore aimed to assess the growth, yield and genetic variability of ten cowpea accessions in Guma and Makurdi Local Government Areas of Benue State, Nigeria.

Materials and Methods

Study Area

The study was carried out in Guma and Makurdi Local Government Areas (LGAs) of Benue State, North-Central geopolitical zone of Nigeria. Benue State is located between latitudes 6°25'N and 8°8'N and longitudes 7°47'E and 10°E, it belongs to the Southern Guinea Savannah agro-ecological zone. Benue is well endowed with fertile soils, deciduous vegetation and a tropical wet-and-dry climate conducive to growing major crops such as yam, maize, cassava, rice and cowpea (FMARD, 2020; NIMET, 2023). Guma LGA is mainly rural area, with agriculture as the primary source of livelihood. The trial site in Guma was located in Daudu area, at Latitude 7.91846°N (7°55'7"N) and Longitude 8.59469°E (8°35'41"E). The LGA had a unimodal rainfall pattern and received an annual rainfall of between 1,200 mm and 1,500 mm. The soil is loamy and well drained, suitable for legume production. Farming methods practice in Guma are mostly traditional, with mixed farming, and a minimal use of external inputs, and dependence on family labour (Adeyemi *et al.*, 2022).

Makurdi LGA is a more urbanized and semi-commercial agricultural activity than Guma. The trial site in Makurdi was located in Federal Low-Cost area, at Latitude 7.73375°N (7°44'01"N) and Longitude 8.52139°E (8°31'17"E). Makurdi has a slightly higher annual rainfall of 1,300 mm to 1,600 mm and higher humidity, due to its location along the River Benue, which also moderated the local climate and supported dry-season irrigation practices (NIMET, 2023). Guma and Makurdi differed ecologically in soil type, rainfall pattern and intensity of land use, which favored the evaluation of cowpea accessions under contrasting field conditions. This selection enabled a thorough understanding of genotype × environment interaction within the same regional context.

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

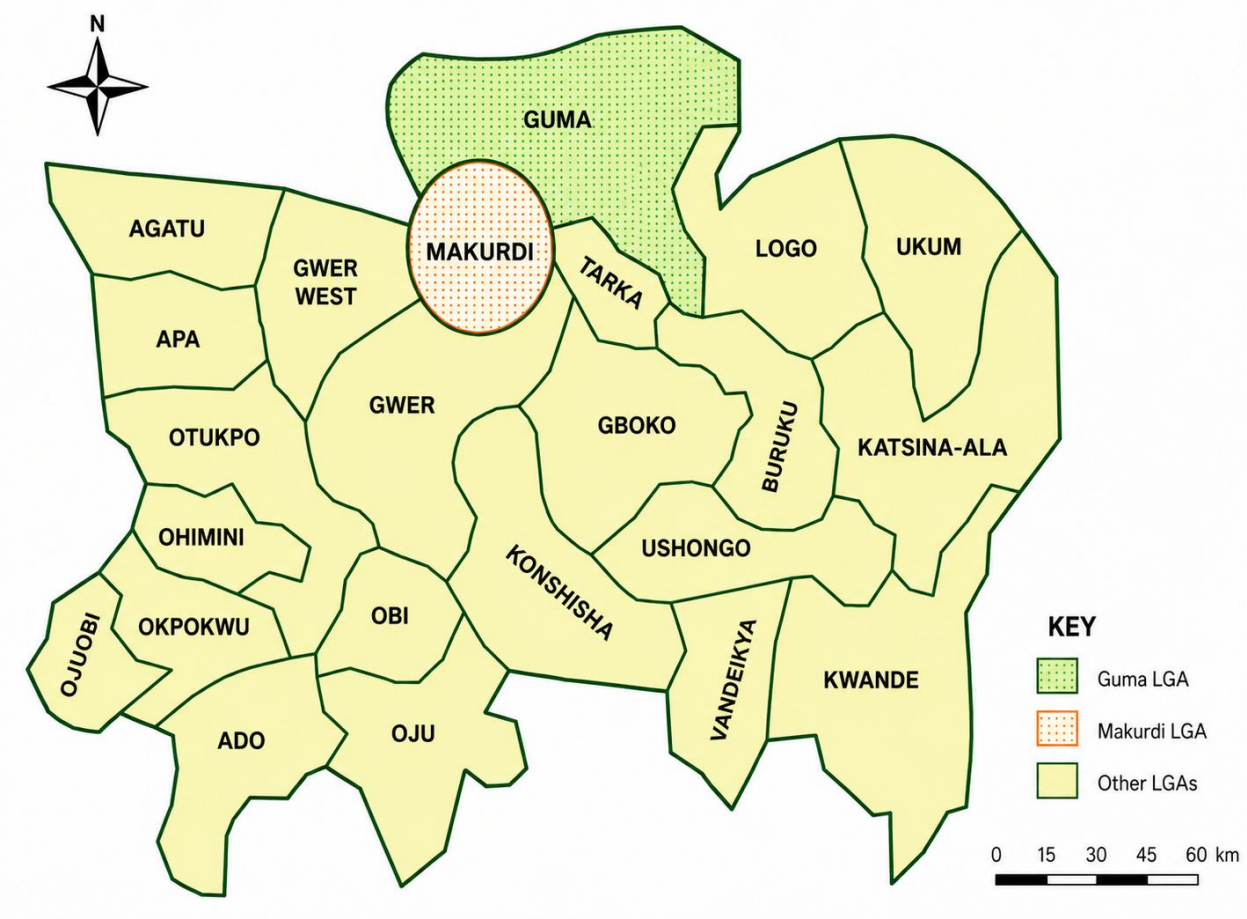


Figure 1: Map of Benue State Showing the Study Areas (Guma and Makurdi LGAs)

Soil Physical and Chemical Properties of the Experimental Sites

Soil samples were collected from the experimental sites in Guma and Makurdi Local Government Areas of Benue State to determine their physical and chemical properties before the field experiment. The soil samples were analyzed using standard soil analytical procedures. Soil pH was determined using a pH meter in soil-water and soil-KCl suspensions, while electrical conductivity was measured using an EC meter in a soil-water extract. Available phosphorus was determined using the Bray-1 method. Organic carbon was determined using the Walkley–Black method, organic matter was estimated from organic carbon, total nitrogen was determined using the Kjeldahl method, and available phosphorus was analysed using the Bray-1 method. Exchangeable potassium, sodium, calcium and magnesium were measured to assess the nutrient status of the soils, while exchangeable acidity and cation exchange capacity were used to evaluate their exchange properties. Particle-size distribution was determined by separating the sand, silt and clay fractions, and the textural class was assigned based on their proportions. Copper, iron and zinc were also determined to assess the micronutrient status of the soils. The results of the physical and chemical analyses are presented in Table 1, while the micronutrient contents are shown in Table 2.

The results in Table A showed that the soils from the two experimental sites had slightly different physical and chemical properties. Soil pH in water was 6.72 in Guma and 6.75 in Makurdi, indicating slightly acidic to near-neutral conditions. The corresponding pH values in KCl were 6.88 and 6.73, respectively. Makurdi recorded higher electrical conductivity (386

µS/cm), nitrogen (0.42%) and available phosphorus (8.61 ppm) than Guma, which had values of 128 µS/cm, 0.35% and 8.36 ppm, respectively. Organic carbon contents were similar at the two sites, with values of 2.40% in Guma and 2.42% in Makurdi. The corresponding organic matter contents were 4.13% and 4.16%, respectively. This similarity suggests that the soils had comparable organic matter levels. Differences were also observed in the exchangeable nutrients and physical properties. Guma had higher exchangeable magnesium, while Makurdi recorded higher potassium, sodium, calcium and cation exchange capacity. The Guma soil contained 60% sand, 13.4% silt and 26.6% clay and was classified as loam. Makurdi had 68% sand, 9.4% silt and 22.6% clay, giving it a sandy clay loam texture. These differences may affect soil moisture retention, drainage and nutrient availability, which are important for cowpea growth.

The micronutrient results showed higher iron (0.418 mg/L) and zinc (1.616 mg/L) concentrations in Guma than in Makurdi, where the respective values were 0.195 and 0.962 mg/L. Copper was slightly higher in Makurdi (1.045 mg/L) than in Guma (0.941 mg/L). Overall, the results show that although the sites had similar pH and organic matter contents, they differed in soil texture, nutrient composition and micronutrient levels. These differences provide useful background information for evaluating cowpea performance across the two locations.

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

Table A: Physical and chemical properties of the soils of the experimental sites

S/N	Sample Code	pH H_2O	pH KCL	EC µs/cm	% O.C	% O.M	% N	Avail P(ppm)	Cmole/kg						% B.S	PARTICLE SIZE DIST.			
									K	Na	Ca	Mg	E.A	CEC		% Sand	% Silt	% Clay	Tex.
1	Guma	6.72	6.88	128	2.40	4.13	0.35	8.36	0.24	0.11	0.140	0.157	0.50	1.147	56	60	13.4	26.6	Loam
2	Makurdi	6.75	6.73	386	2.42	4.16	0.42	8.61	0.27	0.13	0.213	0.071	0.67	1.354	51	68	9.4	22.6	SCL

Table B: micronutrient contents of the soils of the experimental sites

S/N	Sample Code	Cu (mg/l)	Fe (mg/l)	Zn (mg/l)
1	Guma	0.941	0.418	1.616
2	Makurdi	1.045	0.195	0.962

Note: *EC = electrical conductivity; OC = organic carbon; OM = organic matter; N = total nitrogen; P = available phosphorus; K = potassium; Na = sodium; Ca = calcium; Mg = magnesium; EA = exchangeable acidity; BS = base saturation; CEC = cation exchange capacity.*

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD), with ten cowpea accessions replicated three times at each location. Each plot measured 5 m × 5 m, with a spacing of 75 cm between rows and 20 cm between plants within a row. Sowing was carried out on 14 July 2025 at both sites. No fertilizer was applied, and no pest or disease control measures were used during the trial period.

Collection of Planting Materials

Ten cowpea seeds used in this study were supplied by the International Institute of Tropical Agriculture (IITA).

Table 1: Cowpea accession used in the study

Accession	Source
TVU-8863	IITA
TVU-8846	IITA
TVU-93	IITA
TVU-8834	IITA
TVU-8940	IITA
TVU-987	IITA
TVU-8867	IITA
TVU-8864	IITA
TVU-9967	IITA
TVU-8950	IITA

Parameters Measured

On the field, growth and yield parameters were measured every week during the growing season. The following growth and yield parameters were measured:

Germination percentage: This was recorded as the percentage of replicates that had germinated within 7 days after sowing, calculated as (number of germinated replicates / total replicates sown) × 100.

Plant height (cm): This was measured from the base of the plant to the tip of the tallest leaf using a measuring tape.

Leaf area (cm²): It was estimated non-destructively using the linear measurement method: leaf area = leaf length × leaf width × correction factor (K = 0.75), following Musa and Hassan (2016).

Number of branches per plant: This was obtained by counting all branches on each tagged plant.

Number of leaves per plant: This was obtained by counting all fully expanded leaves on each tagged plant.

Number of flowers per plant: This was obtained by counting all open flowers on each tagged plant.

Total pods harvested per plant: This was obtained by counting all pods harvested at maturity.

100-seed weight (g): This obtained by weighing 100 randomly selected seeds per accession using a sensitive electronic balance.

Data analysis

Data were analyzed using the linear mixed-effects model in IBM SPSS Statistics version 20. Environment, variety, week, and their interactions were considered fixed effects, while block nested within environment was included as a random effect. Week was treated as the repeated-

measures factor, with an autoregressive first-order [AR (1)] covariance structure used to account for the correlation among repeated observations over time. Estimated marginal means were obtained for the main effects and interactions, and pairwise comparisons were performed using Bonferroni adjustment at the 5 % significance level. Results were presented as estimated marginal means ± standard error (SE), with statistical significance declared at $P < 0.05$.

Genotypic ($\sigma^2 g$), genotype × environment ($\sigma^2 ge$), and environmental/error ($\sigma^2 e$) variance components were estimated from the combined ANOVA mean squares following Burton and Devane (1953):

$$\sigma_e^2 = MS_e$$

$$\sigma_{ge}^2 = \frac{(MS_{ge} - MS_e)}{r}$$

$$\sigma_g^2 = \frac{(MS_g - MS_{ge})}{(r \times e)}$$

where MSg, MSge, and MSe are the mean squares for accession, accession × environment, and error respectively, r is the number of replications, and e is the number of environments. Phenotypic variance ($\sigma^2 p$) was calculated as:

$$\sigma_p^2 = \sigma_g^2 + \left(\frac{\sigma_{ge}^2}{e}\right) + \left(\frac{\sigma_e^2}{(r \times e)}\right)$$

Genotypic and phenotypic coefficients of variation were calculated following Burton and Devane (1953) as:

$$GCV\ (\%) = \frac{\sqrt{\sigma_g^2}}{X} \times 100$$

$$PCV\ (\%) = \frac{\sqrt{\sigma_p^2}}{X} \times 100$$

where $\bar{X}$ is the trait mean. Broad-sense heritability (H^2) was calculated following Allard (1960) as:

$$H^2\ (\%) = \left(\frac{\sigma_g^2}{\sigma_p^2}\right) \times 100$$

Genetic advance (GA) and genetic advance as a percentage of the mean (GAM) were calculated following Johnson, Robinson, and Comstock (1955) as:

$$GA = K \times H^2 \times \sqrt{\sigma_p^2}$$

$$GAM\ (\%) = \frac{GA}{X} \times 100$$

where K is the selection differential constant, taken as 2.06 at 5% selection intensity. Heritability, GCV, and GAM were interpreted following Panse and Sukhatme (1957): traits combining high heritability with high genetic advance were considered to be under predominantly additive gene control and therefore responsive to direct phenotypic selection.

Results

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

Table 1: Type III tests of fixed effects for growth parameters of the studied varieties across environments and weeks

Source	Plant height		Number of leaves		Leaf area		Number of branches		Number of flowers	
	Df	F-value	df	F-value	df	F-value	df	F	df	F-value
Block	4, 46.91	0.692ns	4, 38.754	0.488^{ns}	4, 98.890	2.786*	4, 39.821	0.332ns	4, 55.457	0.96^{ns}
Environment (E)	1, 48.30	13.342*	1, 41.255	0.447^{ns}	1, 91.958	224.269*	1, 42.408	6.755*	1, 53.917	37.867*
Accession (A)	9, 48.30	68.408*	9, 41.255	8.125*	9, 91.958	363.132*	9, 42.408	2.87*	9, 53.917	9.531*
Week (W)	13, 468.33	221.069*	13, 509.789	207.525*	13, 357.350	330.776*	13, 510.294	98.57*	13, 427.348	226.97*
E × V	9, 48.30	15.929*	9, 41.255	1.376^{ns}	9, 91.958	9.643*	9, 42.408	1.486^{ns}	9, 53.917	1.768^{ns}
E × W	13, 468.33	11.641*	13, 509.789	12.461*	13, 357.350	25.202*	13, 510.294	27.561*	13, 427.348	20.035*
V × W	117, 468.33	6.95*	117, 509.789	4.068*	117, 357.350	11.116*	117, 510.294	4.179*	117, 427.348	11.712*
E × V × W	117, 468.33	3.52*	117, 509.789	1.347*	117, 357.350	3.66*	117, 510.294	3.633*	117, 427.348	3.538*

Values are presented as F-values with numerator and denominator df. ns = not significant ($P \geq 0.05$); * = significant ($P < 0.05$).

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

Table 2: Covariance parameter estimates for growth parameters across environments and weeks

Parameter	Plant Height	Number of leaves	Leaf area	Number of branches	Number of flowers
AR (1) diagonal	66.45	669.78	28.459	4.548	2.396
AR (1) rho	0.889	0.964	0.533	0.963	0.81

Values are covariance parameter estimates obtained from the autoregressive [AR (1)] covariance structure fitted to repeated measurements.

Table 3: Estimated marginal means for growth parameters across environments

Environment	Plant height	Number of leaves	Leaf area	Number of branches	Number of flowers
Environment 1	43.05 ± 1.17^{a}	76.23 ± 4.36^{a}	44.427 ± 0.446^{b}	3.320 ± 0.358^{a}	4.144 ± 0.192^{b}
Environment 2	49.11 ± 1.17^{b}	80.35 ± 4.36^{a}	34.990 ± 0.446^{a}	4.637 ± 0.358^{b}	2.469 ± 0.192^{a}

Values are presented as estimated marginal means ± standard error (SE). Means sharing the same superscript letter are not significantly different according to Bonferroni-adjusted pairwise comparisons at $P < 0.05$. Environment 1 = Makurdi; Environment 2 = Guma

Table 4: Estimated marginal means for growth parameters across varieties

Variety	Plant eight	Number of leaves	Leaf area	Number of branches	Number of flowers
TVU-8863	8.34 ± 2.63^{a}	16.77 ± 9.75^{ae}	9.091 ± 0.996^{a}	0.983 ± 0.801^{ab}	0.00 ± 0.43^{a}
TVU-8846	71.00 ± 2.63^{b}	111.07 ± 9.75^{bcd}	33.738 ± 0.996^{bcd}	4.857 ± 0.801^{ab}	3.33 ± 0.43^{b}
TVU-93	48.98 ± 2.63^{ce}	69.05 ± 9.75^{bcde}	32.758 ± 0.996^{bcd}	3.196 ± 0.801^{ab}	2.82 ± 0.43^{b}
TVU-8834	32.76 ± 2.63^{de}	99.58 ± 9.75^{bcde}	31.001 ± 0.996^{bcd}	4.226 ± 0.801^{ab}	3.32 ± 0.43^{b}
TVU-8940	33.98 ± 2.63^{de}	76.45 ± 9.75^{bcde}	32.995 ± 0.996^{b}	4.601 ± 0.801^{ab}	3.30 ± 0.43^{b}
TVU-987	44.71 ± 2.63^{cde}	73.11 ± 9.75^{bcde}	69.380 ± 0.996^{e}	3.417 ± 0.801^{ab}	4.16 ± 0.43^{b}
TVU-8867	88.98 ± 2.63^{f}	73.87 ± 9.75^{bcde}	73.952 ± 0.996^{e}	3.869 ± 0.801^{ab}	3.74 ± 0.43^{b}

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

TVU-8864	45.52 ± 2.63^{cde}	101.63 ± 9.75^{bcde}	42.995 ± 0.996^{f}	5.583 ± 0.801^{b}	4.57 ± 0.43^{b}
TVU-9967	41.65 ± 2.63^{cde}	102.38 ± 9.75^{bcde}	37.051 ± 0.996^{b}	5.589 ± 0.801^{b}	4.77 ± 0.43^{b}
TVU-8950	44.85 ± 2.63^{cde}	58.99 ± 9.75^{acde}	34.124 ± 0.996^{bcd}	3.464 ± 0.801^{ab}	3.06 ± 0.43^{b}

Values are presented as estimated marginal means ± standard error (SE). Means sharing the same superscript letter are not significantly different according to Bonferroni-adjusted pairwise comparisons at $P < 0.05$.

Table 5: Estimated marginal means for growth parameters across weeks

Week	Plant height	Number of leaves	Leaf area	Number of branches	Number of flowers
1	8.33 ± 1.05^{a}	1.90 ± 3.34^{a}	8.061 ± 0.689^{a}	0.000 ± 0.275^{a}	0.00 ± 0.20^{a}
2	12.39 ± 1.05^{b}	8.25 ± 3.34^{b}	10.433 ± 0.689^{b}	0.000 ± 0.275^{a}	0.00 ± 0.20^{a}
3	17.29 ± 1.05^{c}	17.19 ± 3.34^{c}	15.036 ± 0.689^{c}	1.598 ± 0.275^{b}	0.00 ± 0.20^{a}
4	24.89 ± 1.05^{d}	29.83 ± 3.34^{d}	26.231 ± 0.689^{d}	2.122 ± 0.275^{c}	0.00 ± 0.20^{a}
5	34.58 ± 1.05^{e}	46.87 ± 3.34^{e}	39.126 ± 0.689^{e}	3.098 ± 0.275^{d}	0.00 ± 0.20^{a}
6	42.76 ± 1.05^{f}	64.60 ± 3.34^{f}	42.220 ± 0.689^{f}	4.106 ± 0.275^{e}	0.00 ± 0.20^{a}
7	49.12 ± 1.05^{g}	87.55 ± 3.34^{g}	43.083 ± 0.689^{f}	5.135 ± 0.275^{f}	0.87 ± 0.20^{b}
8	55.79 ± 1.05^{h}	98.18 ± 3.34^{h}	45.841 ± 0.689^{g}	5.208 ± 0.275^{f}	0.55 ± 0.20^{ab}
9	58.62 ± 1.05^{i}	112.32 ± 3.34^{i}	47.557 ± 0.689^{g}	5.648 ± 0.275^{g}	4.68 ± 0.20^{c}
10	61.68 ± 1.05^{j}	116.59 ± 3.34^{j}	50.177 ± 0.689^{h}	5.661 ± 0.275^{g}	5.13 ± 0.20^{d}
11	64.88 ± 1.05^{k}	121.16 ± 3.34^{k}	52.877 ± 0.689^{i}	5.672 ± 0.275^{g}	6.45 ± 0.20^{e}
12	68.17 ± 1.05^{l}	125.86 ± 3.34^{l}	55.701 ± 0.689^{j}	5.902 ± 0.275^{g}	7.73 ± 0.20^{f}
13	71.52 ± 1.05^{m}	130.55 ± 3.34^{m}	58.455 ± 0.689^{k}	5.918 ± 0.275^{g}	9.78 ± 0.20^{g}
14	75.05 ± 1.05^{n}	135.21 ± 3.34^{n}	61.122 ± 0.689^{l}	5.954 ± 0.275^{g}	11.10 ± 0.20^{h}

Values are presented as estimated marginal means ± standard error (SE). Means sharing the same superscript letter are not significantly different according to Bonferroni-adjusted pairwise comparisons at $P < 0.05$.

Table 6: Comparative Analysis of Yield Components of Accessions Under Two Environments

© IIJP 2026 | Volume 2, Issue 4, pp. 364-379 | ISSN: 2636-4484

Accession	E1		E2	
	100 Seed Weight (g)	Total Number of Pods Harvested	100 Seed Weight (g)	Total Number of Pods Harvested
TVU-8863	7.95 ± 0.10^{b}	28.65 ± 1.20^{a}	8.06 ± 0.27^{b}	6.34 ± 0.10^{a}
TVU-8846	8.90 ± 0.19^{cd}	28.33 ± 3.06^{b}	8.78 ± 0.05^{cd}	23.00 ± 2.00^{cd}
TVU-93	7.81 ± 0.18^{b}	28.00 ± 1.00^{b}	7.90 ± 0.04^{b}	23.67 ± 0.58^{cde}
TVU-8834	9.84 ± 0.33^{e}	29.67 ± 2.08^{b}	8.99 ± 0.22^{d}	28.67 ± 0.58^{ef}
TVU-8940	6.98 ± 0.20^{a}	26.67 ± 1.53^{b}	7.11 ± 0.10^{a}	22.00 ± 1.00^{c}
TVU-987	8.34 ± 0.17^{bc}	27.67 ± 3.06^{b}	8.27 ± 0.21^{bc}	20.33 ± 2.31^{bc}
TVU-8867	10.44 ± 0.21^{f}	32.33 ± 3.06^{b}	9.78 ± 0.28^{e}	25.33 ± 0.58^{cdef}
TVU-8864	9.71 ± 0.24^{e}	28.67 ± 2.08^{b}	8.96 ± 0.25^{d}	28.33 ± 2.52^{def}
TVU-9967	7.91 ± 0.19^{b}	32.00 ± 6.00^{b}	8.44 ± 0.04^{bcd}	29.33 ± 0.58^{f}
TVU-8950	9.32 ± 0.19^{de}	26.00 ± 3.61^{b}	8.93 ± 0.31^{d}	15.33 ± 4.51^{b}
P value	0.00	0.00	0.00	0.00

Data are shown as mean ± standard deviation (N = 3). P values of $p < 0.05$ were considered to be statistically significant; different superscript letters in the same column indicate significant differences.

Table 6: Estimation of coefficient of variability, heritability, genetic advance and genetic gain of yield components of 10 different accessions planted in two locations

Genetic Parameters	Number of flowers	100 Seed Weight (g)	Total Number of Pods Harvested
PCV	148.61	15.17	54.29
GCV	36.36	14.72	51.98
Heritability (%)	6.00	94.14	91.65
GA	0.61	2.54	24.36
GG	18.33	29.43	102.5

Note: PCV = Phenotypic Coefficient of Variation, GCV = Genotypic Coefficient of Variation, GA = Genetic Advance, GG = Genetic Gain

Discussion

Results from the work showing Environment significantly affected plant height, leaf area, number of branches, and number of flowers, while accession significantly affected all measured growth parameters. Week had a significant effect on all parameters, and significant environment × week, variety × week, and environment × variety × week interactions were observed across all

parameters. This observation is consistent with the results of Boukar *et al.* (2021) on significant variation in cowpea growth attributes found under different environments, which are driven by soil and climatic conditions, and also with those of Adeyanju *et al.* (2020) who reported that cowpea genotypic performance varied greatly in response to G×E interaction, especially for plant height and canopy-related traits.

Most of the morphological features like the number of flowers and number of leaves favors Environment 2 (Guma). This could be due to the richer micronutrient contents of the soils found there. These findings are in accordance with the observations of Herniter *et al.* (2020) who observed that characteristics of cowpea are less sensitive to environmental factors than subsequent growth phases. similarly, Fatokun *et al.* (2021) pointed out that early establishment traits are more consistent across environments compared to vegetative and reproductive traits.

There were variable morphological traits among the various accessions considered in this study. This is due to varietal differences. This is consistent with work by Mshelmbula et al., 2024 working on groundnut where varietal differences show various characters in terms of morphological characters. For instance, when considering leaves for fodder in the feeding of animals, TVU-8867 should be considered as it has the largest leaf area.

The results showed that cowpea grain yield as well as yield related traits were highly significantly ($p < 0.05$) affected by environment, genotype, and genotype-environment interaction. These findings are in agreement with those of Kusi et al., 2024 who evaluated Twenty early maturing advance cowpea breeding lines and 3 checks (release varieties) and reported that cowpea grain yield as well as yield related traits were highly significantly affected by environment, genotype, and genotype-environment interaction. This is also consistent with work done by Kindie et al., 2022 who evaluated 25 cowpea landraces in six environments and observed that environment, genotype and genotype x environment interaction had significant effects on cowpea grain yield. Similarly, Santos et al., 2025; Ishiyaku et al., 2017 also reported that cowpea grain yield and yield related traits were significantly affected by genotype, environment, and genotype by environment interaction. Environment and interaction contributed slightly to the total variation than genotype. This indicates that the genotypes did not perform consistently across the test environments. It could be hypothesized that reasons for the differences in the potentials of the accessions across the test environments might be attributed to differences in such abiotic factors as soil, vegetation and rainfall; climatic differences across years may be a contributory factor.

The study has shown that in the current study, environments had different effects on the yield potentials of the 10 cowpea accessions. This would therefore call for the need to do a further study on genotype-environment interaction to understand the nature of interaction and also to identify and select for stable genotypes.

The results showed that the seed weight and total number of pods were highly responsive to selection, whereas the number of flowers was less responsive to selection and highly susceptible to environmental influence, which makes it difficult to improve. This is in agreement with Mshelmbula et al 2024 who working on Bambara groundnut opined that most favorable conditions for selection can be found in the high genetic advance and high heritability estimations observed in the number of pods for each plot as well as the number of seeds in a plot.

Conclusion

There were variable morphological traits among the various accessions considered in this study. The phenotypic coefficient of variation (PCV) with the highest overall variability occurring with number of flowers. The genotypic coefficient of variation (GCV) values was

lower than PCV for all the traits with range of 14.72 % for 100-seed weight to 51.98 % for total number of pods harvested, indicating the relative proportion of variation due to genetic factors.

In environment 1, TVU-8867 should be considered in terms of highest yield recorded while TVU-9967 for environment 2.

References

Abberton, M. T., Diop, N. N., Fatokun, C. A., Boukar, O., & Odeny, D. A. (2021). Accelerated breeding of cowpea for Africa. *Plant Breeding, 140*(3), 329–337.

Adeyemi, O. R., Olanrewaju, R. M., & Akinyemi, O. D. (2022). Agro-ecological characterization of Benue State, Nigeria. *Journal of Environmental Studies, 18*(2), 45–58.

Ajeigbe, H. A., Singh, B. B., & Emechebe, A. M. (2021). Improving cowpea productivity in West Africa. *International Journal of Agricultural Sustainability, 19*(3), 210–222.

Allard, R. W. (1960). *Principles of Plant Breeding*. John Wiley & Sons, New York.

Boukar, O., Belko, N., Chamarthi, S., Togola, A., Batieno, J., Owusu, E., Haruna, M., Diallo, S., Umar, M. L., Olufajo, O., & Fatokun, C. (2019). Cowpea (*Vigna unguiculata*): Genetics, genomics, and breeding. *Plant Breeding, 138*(4), 415–424.

Burton, G. W., & DeVane, E. H. (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal, 45*(10), 478–481.

FAO (2023). *FAOSTAT statistical database on crop production*. https://www.fao.org/faostat

Fatokun, C. A., Boukar, O., & Muranaka, S. (2018). Evaluation of cowpea germplasm for multiple traits. *Crop Science, 58*(5), 2087–2097.

FMARD (2020). *Agriculture Promotion Policy*. Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

Herniter, I. A., Muñoz-Amatriaín, M., & Close, T. J. (2020). Genetic, textual, and archeological evidence of the historical global spread of cowpea (Vigna unguiculata [L.] Walp.). *Legume Science, 2(3), Article e57*.

IITA (2024). *Cowpea*. International Institute of Tropical Agriculture. https://www.iita.org

Johnson, H. W., Robinson, H. F., & Comstock, R. E. (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy Journal, 47*(7), 314–318.

Manda, J., Alene, A. D., Tufa, A. H., Feleke, S., Abdoulaye, T., Omoigui, L. O., & Manyong, V. (2020). Market participation, household food security, and income: The case of cowpea producers in northern Nigeria. *Food and Energy Security, 9*(3), e211.

Mohammed, S. B., Dzidzienyo, D. K., Umar, M. L., Ishiyaku, M. F., Tongoona, P. B., & Gracen, V. (2021). Appraisal of cowpea cropping systems and farmers' perceptions of production constraints and preferences in the dry savannah areas of Nigeria. *CABI Agriculture and Bioscience, 2*(1), 25.

Mshelmbula, B., Daniya, U., Ogah, G., Akomolafe, F., Tsaku Amadu, N., & Ikhajiagbe, B. (2024). Growth and yield variance and heritability estimates among some local and improved varieties of Bambara groundnut (*Vigna subterranean* L. Verdc). *Gazi University Journal of Science, 37*(3), 1084–1092.

Musa, U. T., & Hassan, U. T. (2016). Leaf area determination for maize (*Zea mays* L.), okra (*Abelmoschus esculentus* L.) and cowpea (*Vigna unguiculata* L.) crops using linear measurements. *Journal of Biology, Agriculture and Healthcare, 6*(4), 103–111.

NIMET (2023). *Annual climate report for Nigeria*. Nigerian Meteorological Agency. https://www.nimet.gov.ng

Odeseye, A. O., Amusa, N. A., Ijagbone, I. F., Aladele, S. E., & Ogunkanmi, L. A. (2018). Genotype by environment interactions of twenty accessions of cowpea [*Vigna unguiculata* (L.) Walp.] across two locations in Nigeria. *Annals of Agrarian Science, 16*(4), 481–489.

Olaniyi, J. O., Adewale, B. D., & Adekunle, A. A. (2020). Cowpea production and its economic importance in Nigeria. *Journal of Agricultural Extension, 24*(2), 45–56.

Panse, V. G., & Sukhatme, P. V. (1957). *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Popoola, B. O., Ongom, P. O., Mohammed, S. B., Togola, A., Ishaya, D. J., Bala, G., Fatokun, C., & Boukar, O. (2024). Assessing the impact of genotype-by-environment interactions on agronomic traits in elite cowpea lines across agro-ecologies in Nigeria. *Agronomy, 14*(2), 263.

Singh, B. B., Ajeigbe, H. A., Tarawali, S. A., Fernandez-Rivera, S., & Musa, A. (2020). Improving cowpea productivity and utilization. *Crop Science, 60*(2), 467–481.

Singh, B. B., Ehlers, J. D., Sharma, B., & Freire Filho, F. R. (2022). Recent progress in cowpea breeding. *Journal of Food Legumes, 35*(1), 1–10.

Tamba, M. R., Musa, Y., & Abdullahi, A. (2021). Climate variability and cowpea production in Nigeria. *African Journal of Agricultural Research, 16*(3), 412–420.

Kindie Y, Tesso B, Amsalu B. AMMI and GGE biplot analysis of genotype by environment interaction and yield stability in early maturing cowpea [Vigna unguiculata (L) Walp] landraces in Ethiopia. Plant. Env. Interact. 2022 Feb; 3(1):1–9. https://doi.org/10.1002/pei3.10068 PMID: 37283694 17.

Santos A, Ceccon G, Rodrigues EV, Teodoro PE, Makimo PA, Alves VB, et al. Adaptability and stability of cowpea genotypes to Brazilian Midwest. Afr. J. Agric. Res. 2015 Nov 11; 10 (41):3901–8. https://doi. org/10.5897/AJAR2015.10165 18.

Ishiyaku MF, Yilwa VM, Singh BB, Olufajo OO, Zaria AA. Phenotypic stability for selected traits of some cowpea lines in Nigerian agro-ecologies. Plant Breed. Biotechnol J. 2017 Jun 1; 5 (2):67–77. https://doi. org/10.9787/PBB.2017.5.2.67