

Phenological Diversity and Yield-Component Variation among Early-Maturing Cowpea (*Vigna unguiculata* [L.] Walp.) Accessions in the Southern Guinea Savanna of Nigeria

¹Dangana Mohammed Chata, ²Dickson Junior Nwosu, ¹Aishatu Adamu Gado, ^{*1,3}Jiya Mohammed, ⁴Mohammed Dokodza Abdullahi and ¹Muhammad Alhaji

¹Department of Plant Biology, School of Life Sciences, Federal University of Technology, Minna, P.M.B. 65, Minna, Niger State, Nigeria.

²National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, P.M.B. 5382, Ibadan, Oyo State, Nigeria.

³Department of Forestry, Ministry of Environment, Ilorin, Kwara State.

⁴National Cereals Research Institute, Badeggi, P.M.B. 8, Bida, Niger State, Nigeria

*Corresponding authors' email: mjiya0811308016@gmail.com

ABSTRACT

Cowpea (*Vigna unguiculata* [L.] Walp.) is an important grain legume in sub-Saharan Africa. However, the value of improved germplasm depends on the fit between crop duration, reproductive architecture and the target production environment. This study evaluated 20 early-maturing cowpea accessions at the National Cereals Research Institute (NCRI), Badeggi, Niger State, Nigeria, using a randomised complete block design with three replications. Data were collected on branch number, flowering and maturity, pod number, pod length, seed number and 100-seed weight. Accessions differed significantly for the principal phenological and reproductive traits, whereas branch number and pods per ten plants did not differ significantly. Days to 50% flowering ranged from 47.67 to 58.33 days, while 95% pod maturity ranged from 83.00 to 96.33 days. IT16K-2556-1 was earliest to 50% flowering, and IAR-24R-156-5 was earliest to 95% pod maturity. IT17K-850-1-1 produced the highest pod number (234.33 pods per ten plants), whereas IT17K-1589-3-1 combined the longest pods (18.19 cm) with the highest 100-seed weight (25.44 g). Days to first flowering were strongly correlated with days to 50% flowering ($r = 0.905$, $P < 0.001$) and first pod maturity ($r = 0.960$, $P < 0.001$). Pod length was positively associated with seeds per ten pods ($r = 0.500$, $P < 0.05$) and 100-seed weight ($r = 0.445$, $P < 0.05$). The accessions showed distinct phenological and reproductive strategies useful for parent selection and subsequent multi-environment testing. Grain-yield and stability trials are required before recommending any accession for broad cultivation.

Received: 21 Sept. 2026

Accepted: 05 Oct. 2026

Published: 06 Oct. 2026

Keywords: Cowpea, Earliness, Germplasm, Phenology, Yield components

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is a major food and forage legume in sub-Saharan Africa. The crop provides protein-rich grain for human diets, nutritious haulm for livestock feed, and biological nitrogen inputs to low-fertility soils. Its importance is greatest in savanna production systems where rainfall is seasonal, temperatures are high, and access to external inputs is often limited (Omomowo & Babalola, 2021; Mekonnen et al., 2022).

Nigeria is among the leading cowpea-producing countries, yet farm productivity remains constrained by insect pests, parasitic weeds, low soil fertility, heat and intermittent or terminal drought. These constraints vary across environments, making genotype-by-environment interaction a central issue in cowpea improvement and varietal deployment (Popoola et al., 2024; Omoigui et al., 2025). Selection based on performance in one environment therefore provides useful preliminary information but cannot substitute for multi-environment validation.

Phenology is particularly important in seasonal savanna environments. Early flowering and maturity can reduce exposure of reproductive structures to late-season soil-water deficits, a mechanism commonly described as drought escape (Hall, 2004; Moreira et al., 2023). However, earliness alone is not a sufficient breeding objective because final productivity also depends on pod number, pod capacity, seed

number and individual seed mass. These components can differ substantially among genotypes and may provide contrasting pathways to reproductive performance (Edematie et al., 2021).

The Southern Guinea Savanna of Nigeria is characterised by marked seasonal rainfall and variable end-of-season moisture availability. Identifying germplasm that combines appropriate crop duration with useful reproductive traits is therefore important for breeding and subsequent regional testing. This study evaluated 20 cowpea accessions obtained from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, for agromorphological, phenological and reproductive variation. The objectives were to quantify variation among the accessions, identify contrasting phenological and yield-component strategies, and determine trait associations of potential value for selection.

MATERIALS AND METHODS

Experimental Site and Plant Materials

We conducted the field experiment at the National Cereals Research Institute (NCRI) research field in Badeggi, Niger State, Nigeria, within the Southern Guinea Savanna agroecological zone. The Badeggi research area is located at approximately 9.06°N and 6.14°E. We obtained seeds of the 20 cowpea accessions from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria.

The accessions were IAR-24R-156-5, IAR-24R-29-2, IAR-24R-57-3, IT07K-318-33, IT08K-150-12, IT13K-1308-5, IT16K-2316-4, IT16K-2556-1, IT16K-2602-1, IT17K-1589-3-1, IT17K-2856-1, IT17K-846-1-2, IT17K-850-1-1, IT18K-703-1, IT19K-226-2-3, IT19K-227-4, IT19K-230-2-3, IT19K-670-1-4, IT19K-703-1-1 and UAM14-126-L27.

Experimental Design and Crop Management

The experiment followed a randomised complete block design with three replications. Each accession constituted a treatment. Individual plots measured 2.0 × 4.0 m, with 1 m between plots and 2 m between blocks. We cleared, ploughed, and harrowed the field before laying out the plots. We manually sowed seeds at 75 cm between rows and 20 cm within rows, placing two seeds per hill at approximately 3–5 cm depth. We carried out manual weeding at 3 and 6 weeks after sowing. We managed insect pests with cypermethrin from flower-bud initiation, followed by applications at approximately 10-day intervals during reproductive development, as required. We harvested mature pods manually, then dried and threshed them before measuring seed.

Data Collection

We randomly selected and tagged ten plants in each plot. We recorded the number of branches at six weeks after sowing. We counted days to first flowering from sowing to the first open flower in a plot, and recorded days to 50% flowering when 50% of plants in the net plot had produced at least one open flower. We recorded days to first pod maturity when the first pod lost its green colour and reached physiological maturity, and days to 95% pod maturity when approximately 95% of pods were mature. We counted all pods from the ten tagged plants. Ten pods were sampled per plot for pod-length measurement and seed counting. We randomly sampled 100 clean seeds from each plot and weighed them to determine 100-seed weight.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 20. Analysis of variance appropriate for a randomised complete block design was used to test accession effects. Where the F-test was significant, treatment means were separated using Duncan's Multiple Range Test at the 5% probability level. We calculated Pearson correlation coefficients to determine associations among phenological and reproductive traits. We interpreted statistical significance at $P \leq 0.05$ and, where indicated, $P \leq 0.001$.

RESULTS AND DISCUSSION

Variation in Vegetative and Phenological Traits

Accessions differed significantly in the principal phenological traits, whereas branch number did not differ significantly. Mean branch number was 3.08 and ranged from 2.55 in IT16K-2602-1 and IT17K-846-1-2 to 3.55 in IT17K-850-1-1. Days to first flowering ranged from 40.00 days in IT16K-2556-1 to 50.00 days in IT17K-846-1-2. A similar pattern was observed for days to 50% flowering, with IT16K-2556-1 flowering earliest (47.67 days) and IT17K-846-1-2 latest (58.33 days). For 95% pod maturity, IAR-24R-156-5 was earliest (83.00 days), whereas IT19K-226-2-3 was latest (96.33 days) (Table 1).

The more than ten-day difference in flowering and thirteen days in final pod maturity shows that the germplasm cannot be treated as a uniform early-maturing group. Crop duration is an important adaptive trait in environments where the end of the rainy season is variable. The very early reproductive development of IT16K-2556-1 and IT17K-2856-1 is consistent with a drought-escape phenotype because reproductive development can be completed earlier when terminal soil-water deficit develops (Hall, 2004; Moreira et al., 2023).

Table 1: Vegetative and Phenological Traits of 20 Cowpea Accessions (mean ± SE)

Accession	NOB	DFF (d)	DF50 (d)	D1PM (d)	D95PM (d)
IAR-24R-156-5	3.11±0.49	45.33±2.96	53.67±0.67	54.00±2.52	83.00±0.00
IAR-24R-29-2	3.44±0.56	44.33±0.33	51.67±0.67	53.00±0.58	87.67±2.33
IAR-24R-57-3	3.11±0.62	47.33±0.33	52.67±0.33	55.33±0.33	90.00±1.15
IT07K-318-33	3.00±0.69	47.00±1.00	52.67±0.88	55.33±0.67	85.67±2.67
IT08K-150-12	2.99±0.33	42.33±1.45	50.00±1.53	51.00±1.00	91.33±0.67
IT13K-1308-5	3.44±0.62	49.33±2.40	56.33±1.33	58.00±2.00	90.33±0.33
IT16K-2316-4	3.33±0.19	44.33±2.19	50.00±2.08	52.33±2.19	87.00±2.08
IT16K-2556-1	2.89±0.29	40.00±1.73	47.67±0.67	51.00±2.00	90.00±0.00
IT16K-2602-1	2.55±0.22	48.67±2.73	55.33±1.45	56.67±2.73	89.00±3.79
IT17K-1589-3-1	3.11±0.49	44.67±1.45	52.33±2.03	52.67±1.45	85.33±2.33
IT17K-2856-1	3.44±0.29	40.33±0.33	49.00±1.00	49.00±0.58	85.33±2.33
IT17K-846-1-2	2.55±0.40	50.00±1.00	58.33±0.88	58.67±0.33	93.33±2.40
IT17K-850-1-1	3.55±0.49	47.00±1.73	56.33±0.88	56.00±1.53	90.33±0.88
IT18K-703-1	3.11±0.95	47.00±0.58	55.33±1.45	57.33±0.88	92.00±3.06
IT19K-226-2-3	2.78±0.22	48.67±0.33	55.00±0.58	56.67±0.33	96.33±2.19
IT19K-227-4	3.11±0.59	48.00±2.08	56.33±1.20	56.67±1.45	88.00±2.52
IT19K-230-2-3	2.77±0.29	48.00±1.73	55.67±1.86	56.67±1.86	90.33±0.33
IT19K-670-1-4	3.22±0.40	46.00±1.00	50.67±0.33	54.00±1.00	85.33±2.33
IT19K-703-1-1	3.44±0.11	47.67±1.45	56.00±1.53	56.67±1.33	86.67±3.67
UAM14-126-L27	2.66±0.00	47.00±0.00	54.67±0.88	55.00±0.00	88.67±3.84
Mean	3.08	46.15	53.48	54.55	88.78

NOB = number of branches; DFF = days to first flowering; DF50 = days to 50% flowering; D1PM = days to first pod maturity; D95PM = days to 95% pod maturity.

Variation in Reproductive and Seed Traits

Reproductive traits also differed among accessions (Table 2). Pods per ten plants averaged 152.62 and ranged from 96.67 in

IT17K-846-1-2 to 234.33 in IT17K-850-1-1, although the accession effect for pod number was not significant in the original analysis. Pod length averaged 15.34 cm and was

greatest in IT17K-1589-3-1 (18.19 cm). Seeds per ten pods were highest in IAR-24R-156-5 (140.00), IT19K-227-4 (136.33) and IT19K-226-2-3 (135.67). The widest proportional variation occurred in 100-seed weight, which ranged from 7.33 g in IT16K-2316-4 to 25.44 g in IT17K-1589-3-1, with an overall mean of 15.74 g.

The accessions therefore expressed different reproductive strategies. IT17K-850-1-1 was characterised by high pod number, whereas IT17K-1589-3-1 invested strongly in pod length and individual seed mass. IT19K-227-4 combined

relatively high pod number, high seed number and moderate-to-high seed mass. Such contrasts are useful in parent selection because they identify complementary reproductive architectures. The data do not, however, support a strong population-wide trade-off between pod number and seed size, as their correlation was weak ($r = -0.112$). Accordingly, the observed differences among extreme accessions should not be interpreted as evidence that increasing pod number necessarily reduces seed mass in this germplasm set.

Table 2: Reproductive and Seed Traits of 20 Cowpea Accessions (Mean $\pm$ SE)

Accession	P10P	PL (cm)	S10P	100SW (g)
IAR-24R-156-5	130.00 $\pm$ 5.13	15.83 $\pm$ 0.53	140.00 $\pm$ 0.00	12.47 $\pm$ 0.19
IAR-24R-29-2	120.33 $\pm$ 20.19	15.36 $\pm$ 1.58	103.33 $\pm$ 4.06	15.23 $\pm$ 0.19
IAR-24R-57-3	134.67 $\pm$ 32.06	14.91 $\pm$ 0.45	84.67 $\pm$ 10.20	14.63 $\pm$ 0.09
IT07K-318-33	197.00 $\pm$ 48.60	14.58 $\pm$ 0.70	101.67 $\pm$ 12.33	16.67 $\pm$ 0.15
IT08K-150-12	199.00 $\pm$ 72.60	14.74 $\pm$ 1.01	93.33 $\pm$ 12.02	11.30 $\pm$ 0.16
IT13K-1308-5	150.67 $\pm$ 13.78	14.74 $\pm$ 0.24	106.33 $\pm$ 3.76	23.27 $\pm$ 0.07
IT16K-2316-4	227.67 $\pm$ 68.52	12.94 $\pm$ 0.59	83.33 $\pm$ 3.33	7.33 $\pm$ 0.20
IT16K-2556-1	171.00 $\pm$ 62.27	13.23 $\pm$ 0.43	76.67 $\pm$ 3.33	8.67 $\pm$ 0.19
IT16K-2602-1	153.33 $\pm$ 26.67	16.53 $\pm$ 0.21	107.00 $\pm$ 7.02	13.10 $\pm$ 0.00
IT17K-1589-3-1	158.00 $\pm$ 15.82	18.19 $\pm$ 0.48	92.33 $\pm$ 1.86	25.44 $\pm$ 0.12
IT17K-2856-1	150.33 $\pm$ 13.59	16.99 $\pm$ 2.59	133.00 $\pm$ 6.81	10.47 $\pm$ 0.24
IT17K-846-1-2	96.67 $\pm$ 2.03	15.25 $\pm$ 0.42	43.67 $\pm$ 6.23	10.53 $\pm$ 0.22
IT17K-850-1-1	234.33 $\pm$ 34.82	14.89 $\pm$ 0.24	115.33 $\pm$ 2.33	19.83 $\pm$ 0.03
IT18K-703-1	109.33 $\pm$ 9.24	13.79 $\pm$ 0.46	81.00 $\pm$ 9.54	17.20 $\pm$ 0.06
IT19K-226-2-3	130.33 $\pm$ 22.88	16.50 $\pm$ 0.33	135.67 $\pm$ 2.96	11.63 $\pm$ 0.03
IT19K-227-4	197.67 $\pm$ 53.37	16.84 $\pm$ 0.12	136.33 $\pm$ 3.76	18.30 $\pm$ 0.10
IT19K-230-2-3	124.67 $\pm$ 24.94	13.75 $\pm$ 0.51	108.67 $\pm$ 16.70	10.77 $\pm$ 0.19
IT19K-670-1-4	132.33 $\pm$ 19.63	17.17 $\pm$ 0.87	110.00 $\pm$ 15.28	24.00 $\pm$ 0.12
IT19K-703-1-1	116.67 $\pm$ 8.82	17.22 $\pm$ 1.47	123.00 $\pm$ 10.79	24.27 $\pm$ 0.12
UAM14-126-L27	118.33 $\pm$ 16.74	14.13 $\pm$ 1.00	76.00 $\pm$ 11.55	19.70 $\pm$ 0.15
Mean	152.62	15.34	102.57	15.74

P10P = pods per ten plants; PL = pod length; S10P = seeds per ten pods; 100SW = 100-seed weight.

Trait Associations and Selection Implications

The strongest associations occurred among early phenological events (Table 3). Days to first flowering were strongly correlated with days to 50% flowering ($r = 0.905$, $P < 0.001$) and days to first pod maturity ($r = 0.960$, $P < 0.001$), while days to 50% flowering was strongly correlated with first pod maturity ($r = 0.926$, $P < 0.001$). In contrast, the association between 50% flowering and 95% pod maturity was moderate ($r = 0.375$) and not significant. This indicates that accessions initiating reproduction at similar times can still differ in pod development duration and crop completion.

Pod length was positively associated with seeds per ten pods ($r = 0.500$, $P < 0.05$) and 100-seed weight ($r = 0.445$, $P < 0.05$). These relationships support using pod dimensions as a secondary selection trait when seed capacity and seed size are breeding targets, although the strength of these associations depends on population and environment (Edematie *et al.*, 2021). Recent cowpea studies similarly show that phenology and yield-related traits are genetically complex and should be selected in combination rather than as isolated characters (Iro Sodo *et al.*, 2025).

Table 3: Pearson Correlation Coefficients among Phenological and Reproductive Traits

Trait	NOB	DFP	DF50	D1PM	D95PM	P10P	S10P	PL	100SW
NOB	1	-0.289	-0.227	-0.280	-0.410	0.324	0.396	0.101	0.365
DFP		1	0.905***	0.960***	0.365	-0.296	-0.025	0.063	0.331
DF50			1	0.926***	0.375	-0.299	0.025	0.088	0.316
D1PM				1	0.446*	-0.326	-0.081	-0.051	0.303
D95PM					1	-0.152	-0.316	-0.323	-0.279
P10P						1	0.154	-0.186	-0.112
S10P							1	0.500*	0.160
PL								1	0.445*
100SW									1

* $P \leq 0.05$; *** $P \leq 0.001$.

From a breeding perspective, IT16K-2556-1 and IT17K-2856-1 are useful sources of earliness; IT17K-1589-3-1 is

notable for pod length and seed size; IT17K-850-1-1 is useful for high pod number; and IT19K-227-4 represents a

comparatively balanced reproductive phenotype. These observations are best regarded as evidence for parent choice and advancement to further trials rather than proof of broad adaptation. Multi-environment studies in Nigeria have demonstrated substantial genotype-by-environment interaction for cowpea performance (Popoola et al., 2024; Omoigui et al., 2025). Grain yield, stability, pest response and farmer-preferred seed traits should therefore be evaluated across locations and seasons before varietal recommendation. Principal component analysis further clarified the pattern of variation among the 20 cowpea accessions. The first two principal components explained 64.3% of the total variation, with PC1 accounting for 38.5% and PC2 for 25.8% (Figure

1). PC1 was mainly influenced by flowering and maturity traits, particularly days to first flowering, days to 50% flowering, and days to first pod maturity, whereas PC2 was more strongly associated with pod length, seed number, and 100-seed weight. Accessions such as IT17K-1589-3-1, IT19K-670-1-4 and IT19K-703-1-1 were positioned toward the region associated with larger pods and heavier seeds, while IT16K-2556-1 and IT17K-2856-1 were separated in the opposite direction, reflecting their relatively early phenology. The dispersion of accessions across the biplot confirms substantial phenotypic diversity and indicates that earliness and reproductive traits can be exploited independently when selecting parents for cowpea improvement.

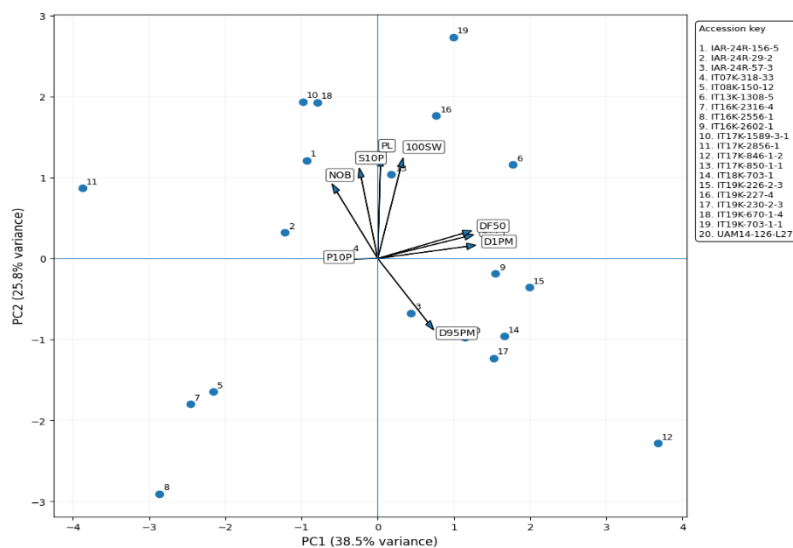


Figure 1: Principal Component Biplot of 20 Cowpea Accessions based on Phenological and Yield-component Traits

CONCLUSION

The 20 cowpea accessions exhibited substantial variation in flowering, maturity, pod architecture, seed number and seed size at NCRI Badeggi. Early reproductive development was strongly coordinated, but final pod maturity was less tightly coupled to flowering, indicating useful differences in reproductive duration. IT16K-2556-1 and IT17K-2856-1 were distinguished by earliness; IT17K-1589-3-1 by pod length and 100-seed weight; IT17K-850-1-1 by pod number; and IT19K-227-4 by a relatively balanced reproductive profile. Pod length was positively related to both seed number and seed mass and may be useful as a supporting selection trait. The identified accessions provide useful material for breeding and further testing, but multi-location and multi-season grain-yield trials are needed before making broad cultivation recommendations.

ACKNOWLEDGEMENT

The authors acknowledge the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, for providing the cowpea germplasm used in this study, and the National Cereals Research Institute (NCRI), Badeggi, Niger State, for access to the field research facilities used for the experiment.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest. All authors read and approved the final version of the manuscript.

REFERENCES

- Edematie, V.E., Fatokun, C., Boukar, O., Adetimirin, V.O. & Kumar, P.L. (2021). Inheritance of pod length and other yield components in two cowpea and yard-long bean crosses. *Agronomy*, 11(4): 682. <https://doi.org/10.3390/agronomy11040682>
- Hall, A.E. (2004). Breeding for adaptation to drought and heat in cowpea. *European Journal of Agronomy*, 21(4): 447–454. <https://doi.org/10.1016/j.eja.2004.07.005>
- Iro Sodo, A.M., Ongom, P.O., Fatokun, C., Olanmi, B., Dieng, I. & Boukar, O. (2025). Quantitative trait loci mapping for yield and related traits in cowpea. *Genes*, 16(3): 247. <https://doi.org/10.3390/genes16030247>
- Kouakou, A.-G., Ogundapo, A., Smale, M., Jamora, N., Manda, J. & Abberton, M. (2022). IITA's genebank, cowpea diversity on farms, and farmers' welfare in Nigeria. *CABI Agriculture and Bioscience*, 3: 14. <https://doi.org/10.1186/s43170-022-00083-w>
- Kusi, F., Padi, F.K., Asante, I.K., et al. (2025). Gains in genetic enhancement of early maturing advanced breeding lines of cowpea [*Vigna unguiculata* (L.) Walp.]. *Ecological Genetics and Genomics*, 35: 100339. <https://doi.org/10.1016/j.egg.2025.100339>
- Mekonnen, T.W., Gerrano, A.S., Mbuma, N.W. & Labuschagne, M.T. (2022). Breeding of vegetable cowpea for

nutrition and climate resilience in sub-Saharan Africa: Progress, opportunities, and challenges. *Plants*, 11(12): 1583. <https://doi.org/10.3390/plants11121583>

Moreira, R., Nunes, C., Pais, I.P., Nobre Semedo, J., Moreira, J., Bagulho, A.S., Pereira, G., Veloso, M.M. & Scotti-Campos, P. (2023). Are Portuguese cowpea genotypes adapted to drought? Phenological development and grain quality evaluation. *Biology*, 12(4): 507. <https://doi.org/10.3390/biology12040507>

Omoigui, L.O., Kamara, A.Y., Shaibu, A.S., Iorlamen, T., Ekeruo, G., Eseigbe, O.B., Solomon, R., Adeleke, M.A., Tofa, A.I. & Ibrahim, E.A. (2025). Agronomic and intercropping performance of newly developed elite cowpea

lines for the West African Savannas. *Agronomy*, 15(11): 2548. <https://doi.org/10.3390/agronomy15112548>

Omomowo, O.I. & Babalola, O.O. (2021). Constraints and prospects of improving cowpea productivity to ensure food, nutritional security and environmental sustainability. *Frontiers in Plant Science*, 12: 751731. <https://doi.org/10.3389/fpls.2021.751731>

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. <https://doi.org/10.3390/agronomy14020263>



©2026 This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license viewed via <https://creativecommons.org/licenses/by/4.0/> which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is cited appropriately.