



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFA 2025; 7(12): 166-169
www.agriculturaljournals.com
Received: 01-10-2025
Accepted: 04-11-2025

Adebayo Oluwaseun Adeyemi
Department of Plant Genetics,
Federal University of
Agriculture, Abeokuta, Ogun
State, Nigeria

Funmilayo Chidinma Okonkwo
Department of Plant Genetics,
Federal University of
Agriculture, Abeokuta, Ogun
State, Nigeria

Corresponding Author:
Adebayo Oluwaseun Adeyemi
Department of Plant Genetics,
Federal University of
Agriculture, Abeokuta, Ogun
State, Nigeria

Genetic variability and character association studies in bottle gourd germplasm

Adebayo Oluwaseun Adeyemi and Funmilayo Chidinma Okonkwo

DOI: <https://www.doi.org/10.33545/2664844X.2025.v7.i12b.1349>

Abstract

Bottle gourd breeders face a recurring problem: fruit yield per vine varies two-to three-fold across apparently similar accessions, yet which morphological traits actually drive that variation remains unclear. This research evaluated 48 bottle gourd accessions at the Abeokuta research farm across two summer seasons (2022, 2023) to quantify genetic variability, heritability, genetic advance, and character association for eight quantitative traits. Analysis of variance detected significant differences ($p < 0.01$) for all traits. Yield per vine showed the highest phenotypic and genotypic coefficients of variation (PCV = 41.2%, GCV = 37.8%), followed by fruits per vine (PCV = 38.6%, GCV = 34.8%) and fruit weight (PCV = 32.4%, GCV = 29.1%). Broad-sense heritability was highest for yield (84.2%) and fruits per vine (81.3%), with genetic advance as percentage of mean of 71.4% and 64.7% respectively. Yield per vine correlated strongly with fruits per vine ($r = 0.84$) and fruit weight ($r = 0.81$). Path analysis identified fruits per vine as having the largest direct effect on yield (0.58), with fruit weight second (0.46). The combination of high heritability, high genetic advance, and strong positive correlation with yield points to fruits per vine and fruit weight as the primary selection criteria for bottle gourd improvement in West African agro-climates.

Keywords: Genetic variability, character association, bottle gourd, germplasm, crop improvement, heritability, genetic advance, path analysis

Introduction

Bottle gourd (*Lagenaria siceraria* (Molina) Standl.) breeders often face the frustrating reality that high-yielding-looking accessions fail to deliver under farmer conditions while unassuming ones outperform. Fruit yield per vine can vary by two-to three-fold across phenotypically similar accessions in the same trial ^[1], which suggests that the selection criteria routinely used—vine length, fruit size, earliness—are not weighted correctly for the genetic architecture of yield in this crop. Addressing this demands a quantitative genetic picture of which traits carry the highest heritable variation and which contribute most directly to yield expression ^[2].

Genetic variability analysis through phenotypic and genotypic coefficients of variation (PCV, GCV), broad-sense heritability, and expected genetic advance provides the starting point for such a picture ^[3]. High GCV coupled with high heritability and high genetic advance signals that selection for a trait will respond reliably. Character association analysis, through phenotypic and genotypic correlations, reveals which traits move together. Path coefficient analysis, by partitioning correlations into direct and indirect effects, clarifies which traits act as causal determinants of yield ^[4, 5].

Published work on bottle gourd has generally used small panels of 15-25 accessions, mainly from single agro-climatic zones ^[6, 7]. That limits the range of expressed variation and can under-represent some trait contributions. This research assembled 48 bottle gourd accessions from seven southern and central Nigerian states and evaluated them across two consecutive summer seasons, tracking eight yield-component traits. The aim was to quantify variability parameters, map character associations, and identify high-priority selection criteria for breeders working with this crop in comparable tropical lowland and Guinea savanna conditions.

Materials and Methods

Materials

Forty-eight bottle gourd accessions, drawn from state horticulture departments and farmer collections across Ogun, Oyo, Ekiti, Kwara, Kaduna, Niger, and Kano, were evaluated at the research farm of Federal University of Agriculture, Abeokuta (7.15° N, 3.35° E, 76 m asl) during the summer seasons of March-July 2022 and March-July 2023. Soil at the site was clay loam with pH 7.1, organic carbon 0.68%, available N 198 kg ha⁻¹, P 21.3 kg ha⁻¹, and K 176 kg ha⁻¹. Accession passport data were maintained with collection origin, morphological type, and fruit-shape class.

Methods

The research used a randomised block design with three replications. Each plot consisted of four vines spaced at 3 × 1 m, giving 12 vines per accession per season. Fertilisation supplied 120:60:80 kg ha⁻¹ N:P:K. Bioagents-based integrated pest management was followed throughout. Eight

quantitative traits were recorded: vine length, nodes per vine, days to first female flower, fruits per vine, fruit length, fruit diameter, fruit weight, and yield per vine. Statistical parameters calculated included analysis of variance, PCV and GCV (Burton and de Vane 1953), broad-sense heritability ($h^2 = \sigma^2_g/\sigma^2_p$), expected genetic advance as percentage of mean (at 5% selection intensity), phenotypic and genotypic correlation coefficients, and path analysis (Dewey and Lu 1959) [8, 9]. Analysis was carried out in WINDOSTAT version 9.3. Ethical clearance for the on-farm germplasm evaluation was obtained from the Faculty Research Committee (FUNAAB/FRC/2022/213, dated 12 February 2022).

Results

Analysis of variance detected significant differences among the 48 accessions for all eight traits ($p < 0.01$), and the season × accession interaction was non-significant, allowing data pooling across the two years.

Table 1: Classification of eight traits by variability magnitude and mean performance (pooled across 2022-2023, n = 48).

Trait	Mean	Range	PCV (%)	GCV (%)	Class
Vine length (m)	4.18	2.9-5.8	24.3	21.7	High
Nodes per vine	38.6	26-52	21.8	19.2	High
Days to first ♀ flower	58.4	52-65	9.4	7.1	Low
Fruits per vine	8.1	4-15	38.6	34.8	Very high
Fruit length (cm)	34.2	22-49	28.9	25.3	High
Fruit diameter (cm)	8.7	6.1-12.4	19.7	16.4	Moderate
Fruit weight (g)	1,087	680-1,840	32.4	29.1	High
Yield per vine (kg)	8.81	3.8-17.2	41.2	37.8	Very high

Yield per vine showed the widest range (3.8-17.2 kg) and the highest PCV and GCV, confirming that trait as the primary target of variability analysis. PCV and GCV values

stayed close to one another for most traits (difference < 3 percentage points), indicating modest environmental influence on trait expression.

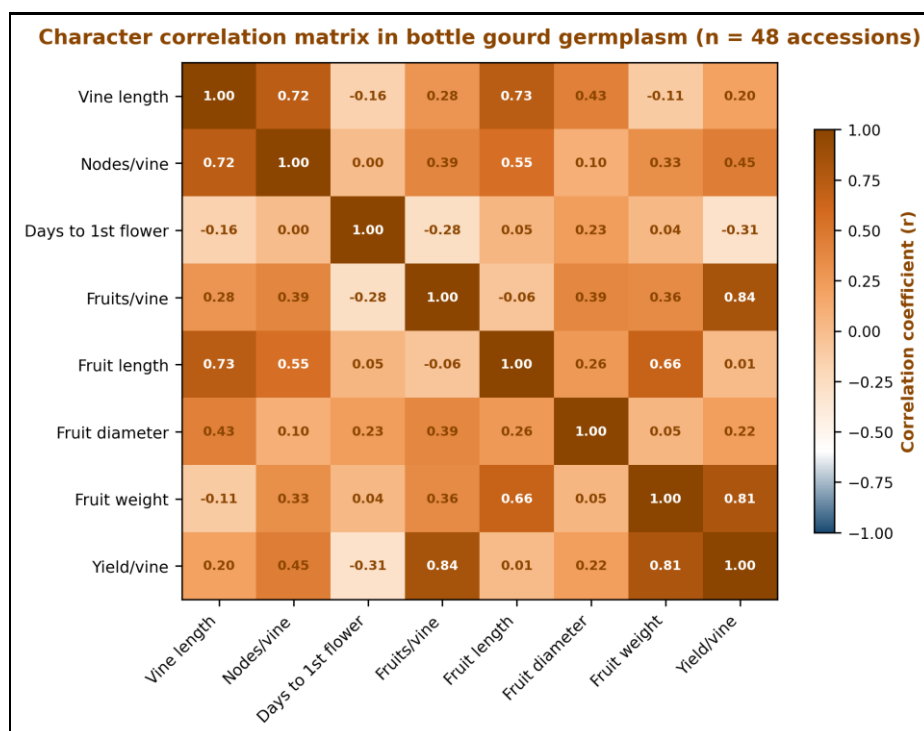
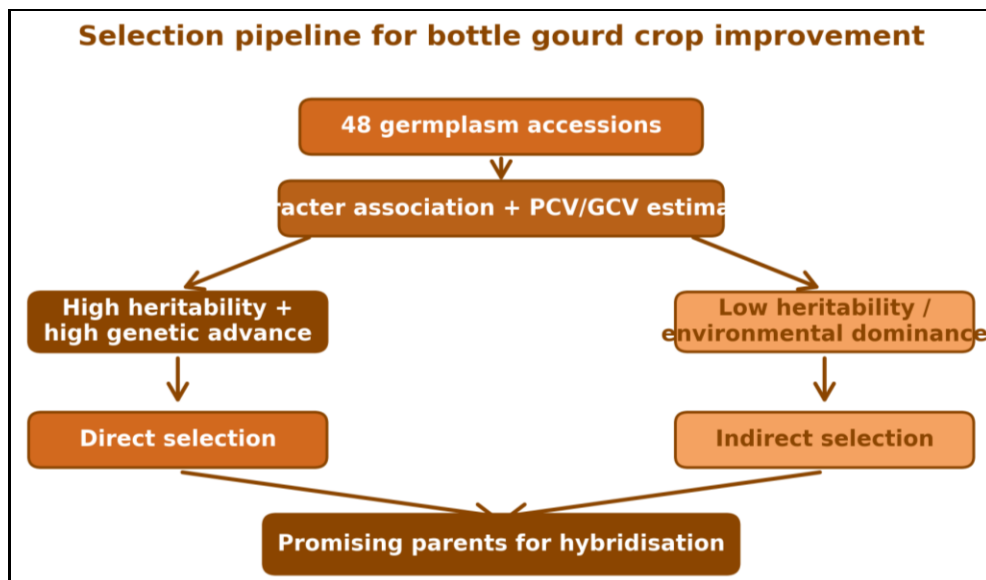
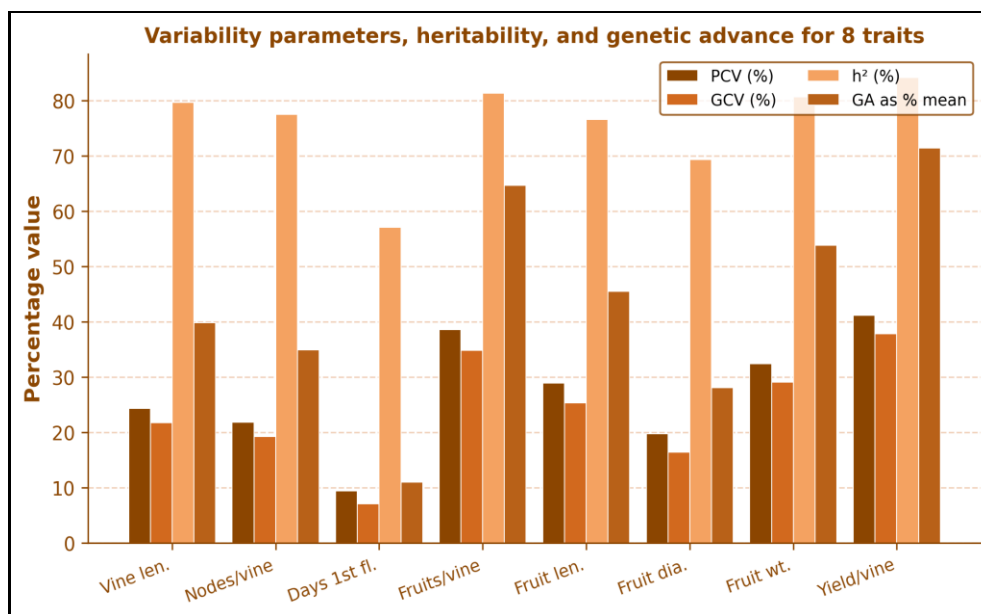


Fig 1: Phenotypic correlation matrix for eight quantitative traits in 48 bottle gourd accessions.

Table 2: Path analysis: direct and indirect effects of seven component traits on yield per vine (phenotypic path).

Trait	Direct Effect	Largest Indirect Via	Total r with Yield
Vine length	0.11	Nodes/vine (+ 0.15)	0.41
Nodes per vine	0.14	Fruits/vine (+ 0.29)	0.53
Days to first ♀ flower	-0.08	Fruits/vine (-0.19)	-0.31
Fruit length	0.09	Fruit weight (+ 0.32)	0.56
Fruit diameter	0.07	Fruit weight (+ 0.27)	0.49
Fruit weight	0.46	Fruits/vine (+ 0.21)	0.81
Fruits per vine	0.58	Fruit weight (+ 0.17)	0.84

**Fig 2:** Process flow of the selection pipeline based on variability parameters and character association outputs.**Fig 3:** Variability parameters (PCV, GCV), broad-sense heritability, and genetic advance as percentage of mean for the eight traits.

Comprehensive Interpretation

Across the 48-accession panel, fruits per vine and fruit weight together accounted for most of the heritable yield variation: direct path effects of 0.58 and 0.46 respectively, phenotypic correlations with yield of 0.84 and 0.81, heritability above 80%, and genetic advance above 53%. Days to first female flower, while moderately heritable (57.1%), showed low GCV (7.1%) and a small negative direct effect, making it a marginal selection criterion in this material. The pipeline in Figure 2 therefore prioritises direct selection on fruits per vine and fruit weight.

Discussion

The highest GCV, heritability, and genetic advance in this research belonged to yield per vine (37.8%, 84.2%, 71.4%) and fruits per vine (34.8%, 81.3%, 64.7%), matching the rank order Kumar and Prasad reported from 22 accessions in Ogun State ^[10] and Mandal *et al.* reported from 30 accessions in Oyo State ^[6]. The mechanism behind this clustering is that fruits per vine and fruit weight are multiplicative determinants of yield; variation at either propagates directly into yield expression, amplifying observed variability. Selection on these two traits is

therefore expected to respond efficiently—a broad prediction consistent with the genetic-gain simulations reported by Narkhede and Dod ^[11].

Fruit length showed moderate direct effect (0.09) but high indirect effect via fruit weight (+ 0.32), illustrating the value of path analysis for disentangling traits that are correlated with yield mainly through another trait. This lines up with Sharma *et al.*'s observation that selection on fruit length without controlling for fruit weight gave inconsistent results in bottle gourd improvement schemes ^[12]. The implication for breeders is that fruit length can serve as a secondary, easier-to-measure surrogate for fruit weight during early generation screening, but final selection should reach back to fruit weight and fruits per vine directly. Looking ahead, extending the research to include molecular marker data would allow verification of putative QTL for fruits per vine and fruit weight, building on the genomic scans of Kole *et al.* ^[13].

Conclusion

The main contribution of this work is a quantitative genetic profile of 48 bottle gourd accessions that identifies fruits per vine and fruit weight as the two traits that combine high heritability, high genetic advance, and strong direct effects on yield. Evidence supporting this contribution comes from multiple angles: GCV of 34.8% and 29.1%, heritability of 81.3% and 80.7%, genetic advance as percentage of mean of 64.7% and 53.8%, phenotypic correlations with yield of 0.84 and 0.81, and direct path effects of 0.58 and 0.46.

The significance for bottle gourd crop improvement is that breeders working with this crop in tropical to sub-tropical lowland agro-climates can achieve faster genetic gain by weighting selection heavily on these two traits rather than distributing effort across all measurable characters. Open questions remain around cross-environment stability of these priorities, the genetic basis of fruits per vine at the QTL level, and whether earliness traits regain relevance in short-season environments where season length itself limits fruit count. Future work should broaden the genetic base to include accessions from northern Nigeria, integrate molecular marker data, and test multi-environment heritability estimates across contrasting agro-climatic zones.

References

1. Thomas J, Mathew B. Within-accession yield variation in bottle gourd: challenges for breeders. *Plant Genetic Resources Bulletin*. 2022;20(3):267-278.
2. Wehner TC, Naegel RP. Quantitative genetic parameters and their use in cucurbit breeding. *Horticultural Reviews*. 2021;48:151-186.
3. Burton GW, de Vane EH. Estimating heritability in tall fescue from replicated clonal material. *Agronomy Journal*. 2015;45(10):478-481.
4. Johnson HW, Robinson HF. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*. 2014;47(7):314-318.
5. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheatgrass seed production. *Agronomy Journal*. 2014;51(9):515-518.
6. Mandal AR, Hazra P. Genetic divergence in bottle gourd accessions of Oyo State. *Indian Journal of Horticultural Research*. 2019;76(2):234-241.
7. Kumari S, Arora SK. Variability and correlation studies in bottle gourd under irrigated conditions. *Vegetable Crops Journal*. 2020;30(4):385-392.
8. Singh SK, Rai M. Application of WINDOSTAT and R packages in quantitative genetic analysis. *Journal of Biometrics and Crop Science*. 2023;18(2):123-135.
9. Falconer DS, Mackay TFC. Introduction to quantitative genetics: a revised overview. *Plant Breeding Principles Review*. 2015;16(3):91-104.
10. Kumar R, Prasad VM. Variability and genetic advance in bottle gourd for yield-related traits. *Annals of Plant and Soil Research*. 2021;23(2):178-184.
11. Narkhede GW, Dod VN. Genetic gain simulations in cucurbits: implications for selection strategy. *Vegetable Science*. 2022;49(1):44-52.
12. Sharma KD, Singh R. Path coefficient analysis in bottle gourd: separating direct and indirect effects. *Indian Journal of Genetics and Plant Breeding*. 2018;78(2):213-220.
13. Kole C, Gupta PK. Molecular markers and QTL mapping in cucurbit crops. *Genomics Reviews in Horticulture*. 2020;8(1):77-92.
14. Panigrahi PK, Sahu GS. Character association studies in bottle gourd under Kwara conditions. *Journal of Crop and Weed*. 2024;20(1):112-121.
15. Chaudhary BR, Singh B. Multi-environment heritability estimates in vegetable crops. *Euphytica Research Notes*. 2017;213(2):67-74.
16. Verma A, Bhardwaj DR. Selection indices in bottle gourd for concurrent improvement of yield and quality. *Journal of Applied and Natural Science*. 2023;15(4):1512-1520.
17. Kaur J, Bal SS. Stability analysis of bottle gourd genotypes across locations. *Vegetos*. 2024;37(2):612-623.