

Growth Performance and Genetic Variation of African Ebony (*Diospyros mespiliformis* Hochst. ex A. DC.) In Bade, Yobe State

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ABSTRACT

Growth performance and genetic variation of *Diospyros mespiliformis* were evaluated across eight locations in Bade Emirate, Yobe State, Nigeria. *Diospyros mespiliformis* is a multipurpose tree species that is mostly found in Sahel ecosystems. Despite the importance of this species, human activities have subjected the species to serious threats; hence, the need to evaluate its growth performance and variation for improvement. The objective of this study was to evaluate the early growth performance and genetic variation of *Diospyros mespiliformis* in the study area. Purposive selection of eight (8) locations with *Diospyros mespiliformis* trees was adopted for the study. Mature and healthy trees were identified for fruits and data collection; fruits collected were measured and processes to seeds and the processed seeds were measured for morphometric traits, and early growth studies. Seed morphometric and seedling traits were assessed. Data collected were subjected to analysis of Variance to identify growth performance and genetic variability. The results of the analysis indicated significant variation ($p < 0.05$) in leaf and fruit morphology among the locations. The highest mean leaf length (15.26cm) was recorded at Matakudukum, while the lowest (3.74cm) was recorded at Takvirvur. The observed variation suggest that the environmental factors may have a greater influence on these morphological traits than the genetic factors. Furthermore, no significant difference was observed in growth traits among the locations. PVC (34.34%) was higher than the GCV (15.56%), suggesting that environmental and other non-genetic factors contributed sustainably to the observed phenotypic variation in the studied traits.

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INTRODUCTION

Trees are the most valuable components of ecosystems, playing a vital role in maintaining and improving environmental stability. In addition, they serve as sensitive indicators of environmental variability, providing valuable insights into ecosystem wellness and changes over time (Wistuba *et al.*, 2013; Szymański *et al.*, 2025). Trees are also major components of agroforestry systems, providing opportunities for farmers to minimize the use of off-site resources, which in turn contributes to the stabilization of upper watersheds (Groninger and Lasko, 2011; Shalizi *et al.*, 2020). African ebony is one of the most important multipurpose tree species which provides humans with numerous benefits such as fruits, medicinal, shade in agroforestry systems, and timber products. The African ebony tree (*Diospyros mespiliformis*) is found throughout tropical Africa, mostly near riverbanks, and is frequently found in low-lying termite mounds. It rarely reaches higher than 200 meters. The species is ubiquitously found in northern Nigeria. Species of *Diospyros* are evergreen and deciduous trees and shrubs. Typically, leaves are coriaceous, simple, and alternating. Cymes make up the inflorescence, actinomorphic flowers, and a prolonged, gamosepalous calyx. (Akagi, *et al.*, 2014). Many species of this genus are commercially important, either for their edible fruit, leaves, or for their timber (Mir-Marqués, 2015). Growth and development in forest trees is identified biomass production be it whether the trees are for pulp and paper, energy or non- timber forest products. Tree improvement and domestication program are achieved through understanding of genetic and environmental factors (FAO, 2009). Wood development results from cellular activities which are dependent of environmental factors

(Barton, 2010). Genetic variation boost adaptability and resilience of living organism and it help them to respond to any changes in environmental conditions and climate variability (Scotti *et al.*, 2016). A selection in tree breeding depends on level of variation within the population which determines the potential for genetic gain (Beaulieu *et al.*, 2022). Therefore efficient uses of genetic diversity are very vital for sustainable management of forest in order to ensure long term productivity (Pérez-Luna & López-Upton, 2026). In tree breeding, identifying a tree as future generation is one of the most crucial tasks of breeding (Roy, *et al.* 2004). Selection process that are based on the detected variations or differences among members of a population, is called selection. Genetic diversity is maximize when breeders are actively involved in selecting parents with diverse genetic profile, as this increases the possibilities of producing offspring with desirable character and a strong hybrid effect. (Wani, 2012). In semi-arid regions, environmental factors and variability in soil may adversely affect the growth and genetic makeup of tree species. Bade Emirates is located in this region. In spite of the economic and ecological importance of *Diospyros mespiliformis*, information on the growth and genetic variation of this species is still limited in this region. Insufficient data have affected effective conservation, domestication, and improvement strategies for the species. It is on this note that this study aims to assess and evaluate the growth performance and genetic variation of *Diospyros mespiliformis* in Bade Emirate, Yobe State. The findings are expected to provide baseline information for selection, breeding, and sustainable management of the species in the study area.

MATERIALS AND METHODS

Study Area

The study was conducted in Bade Emirate, Yobe State, located in the North-East geopolitical zone of Nigeria. The area covers approximately 772 km² and comprises Bade and Jakusko Local Government Areas. The administrative headquarters is situated in Bade town, with a population of 139,782 based on the 2006 national census. The area lies within the Sudan savanna ecological zone and is characterized by a semi-arid climate. Mean maximum temperatures reach 38–40°C in April, while temperatures during the rainy season (June–September) range between 23 and 28°C. Annual rainfall ranges from 500 to 1000 mm, concentrated within a short wet season (Folland *et al.*, 1986; Anyadike, 1993).

Sampling Locations and Plant Material

Fruits of *Diospyros mespiliformis* were collected from eight natural populations (locations) within the study area. Within each location, 500 fruits from 10 mother trees in each location was collected from so as to maintain genetic diversity as described by Ivetiæ *et al.* (2016). Sampled of trees were spaced at distance of 50m apart to minimize the likelihood of sampling related individuals (FAO, 1984). The geographic coordinates and altitudes of the sampling locations are presented in Table 1. Fruits were collected from mature trees with an average diameter at breast height (DBH) of approximately 1.8 m and mean height of about 20m.

Table 1: Geographic Coordinates of Sampled Populations

Population	Latitude (N)	Longitude (E)	Altitude (m)
Kurkushe	12°36'29"	10°38'67"	1146
Matakudukum	12°39'22"	10°47'28"	1125
Iyin	12°43'87"	10°43'28"	1138
Karage	12°47'78"	10°50'01"	1133
Dumbari	12°36'70"	10°43'43"	1103
Bizi	12°15'87"	10°48'28"	1141
Takvirvir	12°40'71"	10°37'91"	1144
Gogaram	12°37'35"	10°42'10"	1124

Source: Field Survey 2025

Seed Processing and Pre-treatment

Fresh fruits were weighed immediately after collection to determine initial mass. The fruits were manually depulped, and seeds were extracted and cleaned. Seed morphological traits, including length and width, were measured using a digital caliper. Seeds were air-dried at room temperature under laboratory conditions. To overcome seed dormancy, seeds were pre-treated by immersion in concentrated sulphuric acid (H₂SO₄) for 30 min, followed by thorough rinsing with distilled water described by Kanmegne *et al.* (2020).

Germination and Seedling Establishment

Five germination trays were prepared for each of the treatment, and twenty treated seeds were sown in each of the polythene bags filled with sterilized river sand as a germination medium. Germination was monitored daily for a period of five weeks. After germination, seedlings were transplanted into individual polythene bags containing a standard nursery substrate (top soil: sand: organic) in ratio of 1:1:1. Seedlings were maintained under uniform nursery conditions throughout the experimental period.

Experimental Design

The experiment was arranged in a Completely Randomized Design (CRD) with eight locations as treatments. Each treatment was replicated five times. Each replicate consisted of 3x5 seedlings making 15 seedlings per location. Randomization was applied to minimize environmental bias. The design enabled comparison of growth performance among locations.

Data Collection

Seed Traits

Seed length and width were measured with the aid of electric weighing scale prior to sowing.

Germination Parameters

Germination was recorded daily for five weeks. Germination percentage was calculated as:

$$\text{Germination Percentage}(\%) = \frac{\text{Number of germinated seeds}}{\text{Total Number of seeds sown}} \times 100$$

Growth Parameters

Seedling growth data were collected at two-week intervals for six months. The following parameters were measured:

- Seedling height (cm), measured from the base to the apical bud
- Collar diameter (mm), measured at the stem base using a veneer caliper
- Number of leaves per seedling

Genetic and phenotypic variability of growth traits indicators assessed

The formulae and reference for computing the genetic and phenotypic variability of growth traits performance indicators is given below:

MSG = Mean Square due to Genotypes (Treatments)

MSE = Mean Square Error (Environmental/Error variance)

r = Number of replications

X = Grand mean of the trait

k = Selection differential constant (2.06 for 5% selection intensity)

Genotypic variance (V_g)

V_g = (Mt – Me)/R (Topwal *et al.* 2024)

Environmental variance (V_e)

V_e = Me (Topwal *et al.* 2024)

Phenotypic variance (V_p)

V_p = V_g + V_e (Topwal *et al.* 2024)

Phenotypic coefficient of variation (PCV %)

$$\text{PCV} = \frac{\sqrt{V_p}}{\bar{X}} \times 100 \quad (\text{Burton and De Vane 1953})$$

Genotypic coefficient of variation (GCV %)

$$\text{GCV} = \frac{\sqrt{V_g}}{\bar{X}} \times 100 \quad (\text{Burton and DeVane 1953})$$

Environmental coefficient of variation (ECV %)

$$ECV = \frac{\sqrt{Ve}}{X} \times 100 \quad (\text{Burton and DeVane 1953})$$

X = mean of the germination performance indicator
Ve = environmental variance.

Heritability in the broad sense (h^2 %)

$$h^2 = \frac{V_g}{V_p} \times 100 \quad (\text{Burton and DeVane 1953, Herbert et al. 1995})$$

V_g = genetic variance

V_p = phenotypic variance.

Genetic advance (GA)

$$GA = K \times \sqrt{V_p} \times h^2 \quad (\text{Herbert et al. 1995})$$

K = selection intensity at 5% (equal to 2.06)

V_p = phenotypic variance

h^2 = broad-sense heritability (%)

Genetic gain (GG %)

$$GG = \frac{GA}{X} \times 100 \quad (\text{Herbert et al. 1995})$$

GA = Genetic advance

RESULTS AND DISCUSSION

Environmental factors, such as temperature and water availability, have a great influence on the growth and development of plants. However, these factors vary from location (geographic source) to location, and location experiments are one of the greatest tools to assess growth performance and adaptation potentials of tree species (Pšidová *et al.*, 2018). These are very important factors that should be considered during tree species selection. Data on growth traits especially the leaves morphological traits were subjected to analysis of variance ($P < 0.05$) and the results revealed significant differences in the leaves, from different locations, even though they are from the same Sahel ecosystem but different locations and this indicates phenotypic variability which could reflect differential

adaptation. Phenotypic variation in leaves trait may be results from environmental influence or genetic variability (Nicotra *et al.*, 2021). However, without common garden it could be difficult to separate these clearly. Furthermore, Morphological variation signifies a presence of genetic variation among the locations. The present study agrees with the findings of (Jingshan *et al.*, 2020) that discovered variations among the leaves of populous clone. Location with the highest leaves length were those collected from Matakudukum, which had the average leaf length (15.26cm), while the location with the lowest average leaf length was Takvuvur (3.74cm). The length and width are among the important morphological attributes because the larger the leaf of tree the better for gas exchange and the better the photosynthesis (Tsukaya, 2006). Leaf size has influence on carbon trade-off between the carbon obtain and the transpiration. This should also be considering during selection process for superior progeny. In furtherance, a highest fruit weight was found in the fruits collected from Gogram Location (330.75 ± 74.50) while the location with the lowest fruits weights was Takvuvur (173.94 ± 45.74). Variation in fruits may be due to differences in resources allocation and environmental conditions which could have impacts on regeneration and overall vigor of seedlings. The study is in line with the findings of Kouyaté (2005), who stated that fruit and leaf dimension variability observed among individuals is probably due to environmental effects. The differences in leaf and fruit dimensions explain phenotypic variation among *D. mespiliformis* from the different locations. The study is in line with the findings of (Mkwezalamba, 2015) regarding the fruits of *Sclerocarya birrea* as seen in figure1 below. The overall variation that was observed in leaves and fruits among the study locations highlighted the presence of phenotypic diversity in *D. mespiliformis* as presented in Figure 1 below.

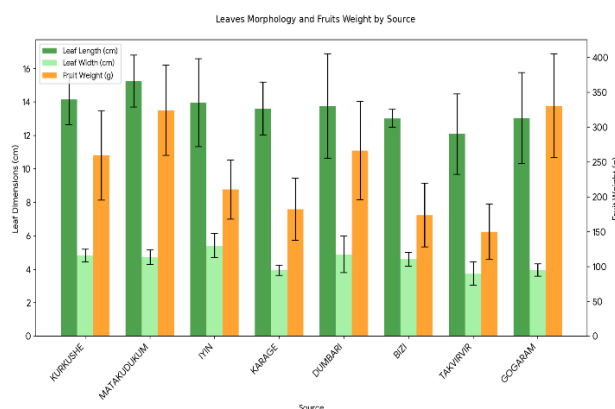


Figure 1: Leaves Morphology and Fruits Weight of *Diospyros mespiliformis* Hochst. ex A. DC

Seed Morphometric Parameters of *Diospyros Mespiliformis* Hochst. ex A. DC

Analysis of variance ($P < 0.05$) results revealed that significant difference exist in the seed morphometric attributes across the eight locations of the study. The number of seeds per fruit ranged from 2 to 6, signifying reasonable variability in reproductive output. This range slightly varies from the findings of (Gnonlonfin *et al.*, 2022) in the Soudanian and Soudano-Guinean transition zones, which could possibly be due to variations in environmental conditions such as rainfall and soil fertility. The identified differences in seed size and morphology may be attributed to both genetic variation

among locations and environmental influences affecting seed development. Similar scenario has been reported in some species, where seed traits are linked to phylogenetic relationships and ecological adaptation strategies (Moles *et al.*, 2005; Westoby *et al.*, 1996; Zanne *et al.*, 2005). Variability in these traits are important for tree improvement programs, as seed size and weight are often related to germination potential, seedling vigor, and early growth performance. The results of this study are consistent with that of (Priya Devi *et al.*, 2022), who reported significant variation in fruit length and seed weight of *Diospyros montana* across different locations as seen below in table 2.

Table 2: Seed Morphometric Parameters of *Diospyros mespiliformis* Hochst. ex A. DC

Source	Length(mm)	Width(mm)	Weight(mm)	Thickness(mm)
Kurkushe	1.18±0.08ab	0.67±0.06	0.41±0.04a	5.33±0.40
Matakudukum	1.24±0.09b	0.67±0.08	0.38±0.04ab	5.01±0.21
Iyin	1.19±0.09ab	0.58±0.09	0.38±0.07ab	5.46±0.23
Karage	1.21±0.10ab	0.62±0.03	0.39±0.05ab	5.14±0.47
Dumbari	1.22±0.05ab	0.61±0.07	0.40±0.05ab	5.42±0.23
Bizi	1.15±0.04ab	0.60±0.07	0.35±0.05ab	5.00±0.24
Takvirvir	1.07±0.05a	0.50±0.09	0.28±0.06b	5.18±0.44
Gogaram	1.18±0.06ab	0.59±0.13	0.36±0.10ab	5.19±0.27

Growth in seedlings is determined by both morphological and physiological traits. The number of leaves, collar diameter, and seedling height are key measurable growth parameters used to assess seedling performance. Over a period of six months, *Diospyros mespiliformis* seedlings from eight different locations were transplanted from germination trays into prepared polyethylene bags for early growth evaluation. The findings obtained from the study indicated no significant differences among the eight locations. However, seedlings from Kurkushe (7.44 ± 0.80) recorded the highest mean number of leaves, while the lowest mean number of leaves was observed in Matakudukum (3.67 ± 1.45). Leaves are one of the most important plant traits, as they play a central role in photosynthesis process. A higher number of leaves

generally support better growth and development of seedlings. Additionally, leaf characteristics are important morphological traits used in plant description (Dobrescu *et al.*, 2017). Furthermore there were no significant differences found in collar diameter and seedling height among the study locations. Although the number of leaves varied, but it did not results to significant variation in other growth parameters, indicating that these traits may be influenced by similar genetic or environmental factors across the locations. The findings of this study are consistent with (Iroko *et al.*, 2020), who also reported no significant differences in the growth performance of *Diospyros mespiliformis* seedlings from different locations table 3 below.

Table 3: Growth Parameters of *Diospyros mespiliformis* Hochst. ex A. DC. Seedlings

Source	No. of Leaves	Collar Diameter(mm)	Stem Height(cm)
Bizi	7.28±1.36	1.55±0.17	7.50±1.19
Dumbari	5.82±2.26	1.55±0.26	7.04±2.35
Gogaram	5.25±1.81	1.42±0.16	5.76±0.91
Iyin	6.19±1.92	1.48±0.60	6.54±2.71
Kurkushe	7.44±0.80	1.55±0.27	6.23±1.49
Karage	4.32±2.30	1.31±0.08	5.25±1.07
Matakudukum	3.67±1.45	1.56±0.10	6.05±0.82
Takvirvir	5.66±1.59	1.60±0.51	4.88±0.66

Variability of genetic and phenotypic in *Diospyros mespiliformis* Seedlings were evaluated using growth traits such as the leaves, collar diameter and stem height. The results of the findings indicated that PVC (34%) was higher than GCV (10.09%) in terms of the number of leaves and stem height as seen in table 4 below. The large gap that was found between PCV and GCV indicated that environmental factors have more influence than the gene in the study area. Similar scenario was recorded by (Mehak *et al.*, 2025) in forest trees

such as *Azadiracta indica*, where phenotypic coefficients of variation were generally higher than genotypic coefficients, expressing environmental influence on seedlings traits (Malakar & Sinha, 2024). Heritability was found to be very minimal which indicates that the species from this location are largely controlled by the environment hence may not be suitable for genetic improvement. The study contradicts the finding of (Balkrishna *et al.*, 2025) that discovered high heritability of about 60% in *Dalbergia sissoo*.

Table 4: Genetic and Phenotypic Variability in *Diospyros mespiliformis* Seedlings

Genetic and phenotypic variability	Number of leaves	Collar diameter	Stem Height
Genotypic variance (Vg)	0.81	0.00	0.14
Environmental variance (Ve)	3.10	0.11	2.53
Phenotypic variance (Vp)	3.92	0.10	2.66
Phenotypic coefficient of variation (PCV %)	34.34	0.00	10.09
Genotypic coefficient of variation (GCV %)	15.56	0.00	2.28
Environmental coefficient of variation (ECV %)	30.55	0.00	9.81
Heritability in the broad sense (h ² %)	20.79	0.00	5.14
Genetic advance (GA)%	14.74	0.00	1.05
Genetic gain (GG %)	14.74	0.00	1.05

CONCLUSION

This study evaluated the genetic and morphological variation of *Diospyros mespiliformis* across different locations in the Bade Emirate. The study identified significant difference in in

morphological traits, particularly in leaf and fruit characteristics, signifying the impacts of environmental factors. Given the important role play by the leaf in physiological process, selection process should take this into

cognizance. However there was no significant difference in seedlings growth parameters and this implies limited genetic variation at the early growth stage of seedlings or it could be the influence of environmental factors. Considering the importance of *D. mespiliformis*, including its nutritional and medicinal value, the conservation and sustainable utilization of this species remain critical. However, the need for targeted conservation effort is needed to conserve these genetic resources. Although this study did not detect clear genetic differentiation among populations but based on morphological and growth traits, it establishes an important baseline for future research in the region. Further studies employing molecular markers are therefore recommended to provide a more robust assessment of genetic diversity and population structure, which will better inform conservation and improvement strategies.

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