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Breeding of Elite Parent Trees of "Néré" or African Locust Bean (*Parkia biglobosa* (Jacq.) R.Br. ex G. Don) Based on the Agromorphological Characteristics of Mother Trees and Their Progeny in the Poro Region

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ABSTRACT

This study aims at selecting néré trees based on their agromorphological characteristics. Data were collected from 90 mother trees distributed across four cities (Korhogo, M'Bengué, Dikodougou, and Sinématiali), as well as their progeny evaluated in a nursery. The data collection focused on 21 quantitative traits related to the trunk, fruits, and seeds for the characterization of the mother trees, and 9 quantitative traits for the characterization of the progeny in the nursery. The collected data were subjected to multivariate statistical analyses. The study revealed a high variability in traits such as trunk circumference, height, number of fruits per cluster, and seed weight. Hierarchical Ascending Classification (HAC) identified three distinct classes of trees and nursery plants. Trees in Class II, consisting of genotypes DN12, DN16, KN11, KN20, SN13, and SN24, along with their progeny, recorded the best performances. These trees stood out with higher values for the number of fruits per peduncle (7 to 8), seed weight per cluster (28.658 g), and number of seeds per cluster (117 to 118). In the nursery, their progeny exhibited the highest germination rates (89.95%), greater plant height (10.339 cm), a higher number of internodes (4 to 5), and a higher number of leaves (5 to 6). The parent trees from Class II should be selected for plant breeding or vegetative propagation.

Keywords: *Parkia biglobosa*, Agromorphological-Characterization, Selection, Côte-d'Ivoire

INTRODUCTION

The Néré tree (*Parkia biglobosa* (Jacq.) R.Br. ex G. Don), a woody species belonging to the Mimosaceae family, is commonly found in the Sudanian-Guinean savannas, extending from the West African coast to Sudan, including Côte d'Ivoire (Lompo *et al.,* 2017; Lompo *et al.,* 2018). Néré plays a significant role in the lives of many people across various African countries (Touré, 2018; Appia *et al.,* 2023). It provides essential resources for survival, including medicinal substances, timber, firewood, fodder, and food (Parkouda *et al.,* 2021; Komolafe *et al.,* 2024). Environmentally, the tree contributes significantly to climate regulation due to its carbon storage capacity, making it a valuable ally in reducing greenhouse gas emissions (Dimobe *et al.,* 2018; Akintunde-Alo *et al.,* 2024).

Today, human activities such as agriculture, mining, and the exploitation of woody species exert increasing pressure on savanna trees, which lack effective protection measures. As a result, néré is now considered a vulnerable species (Houndonougbo *et al.,* 2020; Nodza *et al.,* 2024).

Preserving and conserving the genetic diversity of néré populations is essential in the current context of climate change and biodiversity loss. This study aims at contributing to the domestication of the néré tree. To achieve this, assessing its existing diversity in Côte d'Ivoire is crucial for identifying high-performing plant material for agroforestry park restoration and the establishment of dedicated plantations.

MATERIALS & METHODS

Survey area for mother trees

Data collection on trees and fruits was carried out in four cities of the Poro region (Korhogo, M'Bengué, Dikodougou, and Sinématiali) in northern Côte d'Ivoire. The climate of this region is Sudanian-Guinean, characterized by two major seasons: a dry season from November to April and a rainy season from May to October (Boko-Koiadia *et al.,* 2016). The average annual rainfall is approximately 1200 mm.

Study site for mother tree progeny

The evaluation of the progeny from the mother trees was conducted at the vegetable garden of Peleforo GON COULIBALY University in Korhogo, located in northern Côte d'Ivoire (9°27'28"N, 5°37'46"W).

Plant Material

The plant material for the morphological diversity study of mother trees consisted of 90 *Parkia biglobosa* trees collected in situ. These included 25 trees from Korhogo, 25 from Sinématiali, 20 from Dikodougou, and 20 from M'Bengué. Each sampled tree was assigned a code (Table 1). Seeds from the 90 mother trees were used as plant material for the nursery study.

Table 1. Number of trees and tree codes by city

City (number of trees)	Tree codes
Korhogo (25 trees)	KN01, KN02, KN03, KN04, KN05, KN06, KN07, KN08, KN09, KN10, KN11, KN12, KN13, KN14, KN15, KN16, KN17, KN18, KN19, KN20, KN21, KN22, KN23, KN24, KN25
Dikodougou (20 trees)	DN01, DN02, DN03, DN04, DN05, DN06, DN07, DN08, DN09, DN10, DN11, DN12, DN13, DN14, DN15, DN16, DN17, DN18, DN19, DN20
M'Bengué (20 trees)	MN01, MN02, MN03, MN04, MN05, MN06, MN07, MN08, MN09, MN10, MN11, MN12, MN13, MN14, MN15, MN16, MN17, MN18, MN19, MN20
Sinématiali (25 trees)	SN01, SN02, SN03, SN04, SN05, SN06, SN07, SN08, SN09, SN10, SN11, SN12, SN13, SN14, SN15, SN16, SN17, SN18, SN19, SN20, SN21, SN22, SN23, SN24, SN25

Evaluation of the Morphological Diversity of Mother Trees

In each of the four cities of the Poro region, five villages were selected based on the four cardinal points plus the center. In each village, 4 to 5 *P. biglobosa* trees were sampled. The selection of trees was based on their yield and regularity of production, as reported by local farmers. The chosen trees were marked with paint and GPS coordinates to prevent duplicate sampling. A total of 21 quantitative traits were measured on the trees and fruits. In the field, tree height and trunk circumference were recorded. On each tree, five clusters were randomly selected, and the peduncle length and thickness were measured. The number of fruits per cluster was counted, and the 100-seed weight, total seed weight per cluster, and number of seeds per cluster were recorded.

Evaluation of the morphological diversity of progeny

For the nursery experiment, pots were filled with a sand substrate, labelled, and arranged on a platform following a Fisher block design with five (5) replications. Each block included one tree from each city, totalling 90 pots per block and 450 pots across all five blocks. Seeds from each mother tree were sown in five pots, with five seeds per pot. Before sowing, a quality test was conducted by submerging the seeds in water to select the best ones.

After seed germination and seedling emergence, thinning was performed, leaving only one seedling per pot. Measurements were taken on each plant for three (3) months. Germination rate and germination duration were assessed. Each month, plant height, collar diameter, number of internodes, leaf length and width, petiole length (first leaf from bottom to top), and number of leaves were recorded.

STATISTICAL ANALYSIS

First, a descriptive analysis of the data collected from the mother trees in the field and the progeny in the nursery were conducted to obtain variation coefficients, highlighting the variability of the measured traits. After verifying data normality, an Analysis of Variance (ANOVA) was performed to determine differences among the progeny families based on the studied descriptors. If significant differences were found, a Newman-Keuls post-hoc test would be applied to classify them into groups. Additionally, Pearson's correlation coefficient (r) was used to measure the strength of the linear relationship between two variables, helping assess the degree of association between the descriptors. Finally, individual structuring was performed using Hierarchical Ascending Classification (HAC). The obtained classes were compared using ANOVA and the Newman-Keuls post-hoc test.

RESULT

Variability of morphological traits of parent Trees

Descriptive analysis reveals a high variability in traits such as tree circumference, trunk height, number of fruits per peduncle, seed weight per cluster, and number of seeds per cluster, with Coefficients of Variation exceeding 25% (Table 2). ANOVA indicated that the 21 tested traits significantly discriminate between trees.

Table 2. Mean value ± standard deviation of the quantitative traits of mother trees

Traits (SI unit)	Min	Max	Mean ± Standard deviation	CV (%)	P-value
Cir (cm)	76	385	187.85± 65.02	34.6	<0.001
Hf (m)	110	450	208.36 ± 66.35	31.8	<0.001
NFrPedon	1	12.64	3.72 ± 2.24	60.2	<0.001
L pedon (cm)	10.06	32.32	18.9 ± 4.85	25.6	<0.001
EpPedon (mm)	2.11	6.93	4.13 ± 0.76	18.4	<0.001
PGrGrap (g)	1.81	40.28	12.87 ± 8.22	63.9	<0.001
P100Grap (g)	12.60	36.67	23.83 ± 4.54	19.1	<0.001
NGrGrap	10.40	165.71	53.80 ± 32.39	60.2	<0.001
LFr (cm)	17.80	26.58	21.74 ± 1.93	8.9	<0.001
lFr (cm)	1.70	2.50	2.05 ± 0.13	6.2	<0.001
PFr (g)	8.27	16.24	12.34 ± 1.72	14	<0.001
EpFr (mm)	7.73	11.88	10.05 ± 0.77	7.7	<0.001
Lpédic (cm)	2.13	6.32	3.19 ± 0.65	20.5	<0.001
EpPédic (mm)	2.27	4.59	3.35 ± 0.35	10.4	<0.001

PGrFr (g)	1.95	5.26	3.55 ± 0.60	16.9	<0.001
Ppulpe (g)	1.56	5.13	3.45 ± 0.69	19.9	<0.001
NGr	8.15	19.04	14.96 ± 1.67	11.1	<0.001
LGr (mm)	6.53	10	8.79 ± 0.59	6.7	<0.001
lGr (mm)	5.17	8.35	7.25 ± 0.57	7.8	<0.001
EpGr (mm)	3.16	6,05	4.87 ± 0.47	9.7	<0.001

Cir : Tree circumference; **Ht**: Bole height; **NFrPedon**: Number of fruit per peduncle; **L pedon**: Peduncle length; **EpPedon**: Peduncle thickness; **PGrGrap**: Seed weight per cluster; **P100Grap**: Weight of 100 seeds per cluster; **NGrGrap**: Number of seeds per cluster; **LFr:** Fruit length; **lFr**: Fruit width; **PFr**: Fruit weight; **EpFr**: Fruit thickness; **Lpédic**: Pedicel length; **EpPédic**: Pedicel thickness; **PGrFr**: Seed weight per fruit; **Ppulpe**: Pulp weight; **NGr**: Number of seeds per fruit; **LGr**: Seed length; **lGr**: Width of seed; **EpGr**: Thickness of seed.

Relationships between measured variables in parent trees

The correlation matrix of the studied traits revealed a positive and highly significant correlation (≥ 0.5) between certain variables (Table 3). Trees producing a high number of fruits per inflorescence also produce the heaviest seeds per cluster, with thick peduncles (r PGrGrap/NFrPedon = +0.898; r NFrPedon/EpPedon = +0.578) and a high number of seeds per cluster (r NGGrap/NFrPedon = +0.941; r EpPedon/NGrGrap = +0.581, andr NGrGrap/NFrPedon = +0.943). Néré trees producing longer and broader fruits also yield the heaviest fruits with long seeds (r PFr/LFr = +0.747; r LFr/PFr = +0.526; r LFr/LGr = +0.588). The longest and heaviest fruits contain a high number of heavy seeds (r PGrFr/PFr = +0.716; r PGrFr/NGr = +0.642) as well as a high pulp weight (r Ppulpe/PFr = +0.873; r LFr/Ppulpe = +0.571). In néré, seed width and length growth are proportional (r lGr/LGr = +0.853). The weight of 100 seeds per cluster is correlated with seed weight per fruit (r = +0.696), fruit weight (r = +0.549), seed length (r = +0.54), seed width (r = +0.561), and seed thickness (r = +0.574).

Table 3. Correlations between variables measured in mother trees

Descriptor 1	Descriptor 2	r
Nfrpedon	EpPedon	0.578
Nfrpedon	PGrGrap	0.898
Nfrpedon	NGrGrap	0.943
EpPedon	PGrGrap	0.657
EpPedon	NGrGrap	0.581
PGrGrap	NGrGrap	0.941
P100Grap	PFr	0.549
P100Grap	PGrFr	0.696
P100Grap	LGr	0.54
P100Grap	lGr	0.561
P100Grap	EpGr	0.574
LFr	PFr	0.747
LFr	PGrFr	0.556
LFr	Ppulpe	0.571
lFr	PFr	0.526
lFr	LGr	0.588
PFr	PGrFr	0.716
PFr	Ppulpe	0.873
PGrFr	NGr	0.642
LGr	lGr	0.853

Cir : Tree circumference; **Ht**: Bole height; **NFrPedon**: Number of fruit per peduncle; **L pedon**: Peduncle length; **EpPedon**: Peduncle thickness; **PGrGrap**: Seed weight per cluster; **P100Grap**: Weight of 100 seeds per cluster; **NGrGrap**: Number of seeds per cluster; **LFr:** Fruit length; **lFr**: Fruit width; **PFr**: Fruit weight; **EpFr**: Fruit thickness; **Lpédic**: Pedicel length; **EpPédic**: Pedicel thickness; **PGrFr**: Seed weight per fruit; **Ppulpe**: Pulp weight; **NGr**: Number of seeds per fruit; **LGr**: Seed length; **lGr**: Width of seed; **EpGr**: Thickness of seed.

Structural diversity of parent trees

Hierarchical Ascending Classification (HAC) based on trait similarity identified three tree classes. Classes I and III include trees from all four cities, while Class II consists of trees from Dikodougou, Korhogo, and Sinématiali (Figure 1). ANOVA indicated significant differences between classes for tree circumference, trunk height, number of fruits per peduncle, peduncle thickness, seed weight per cluster, and number of seeds per cluster (Table 4).

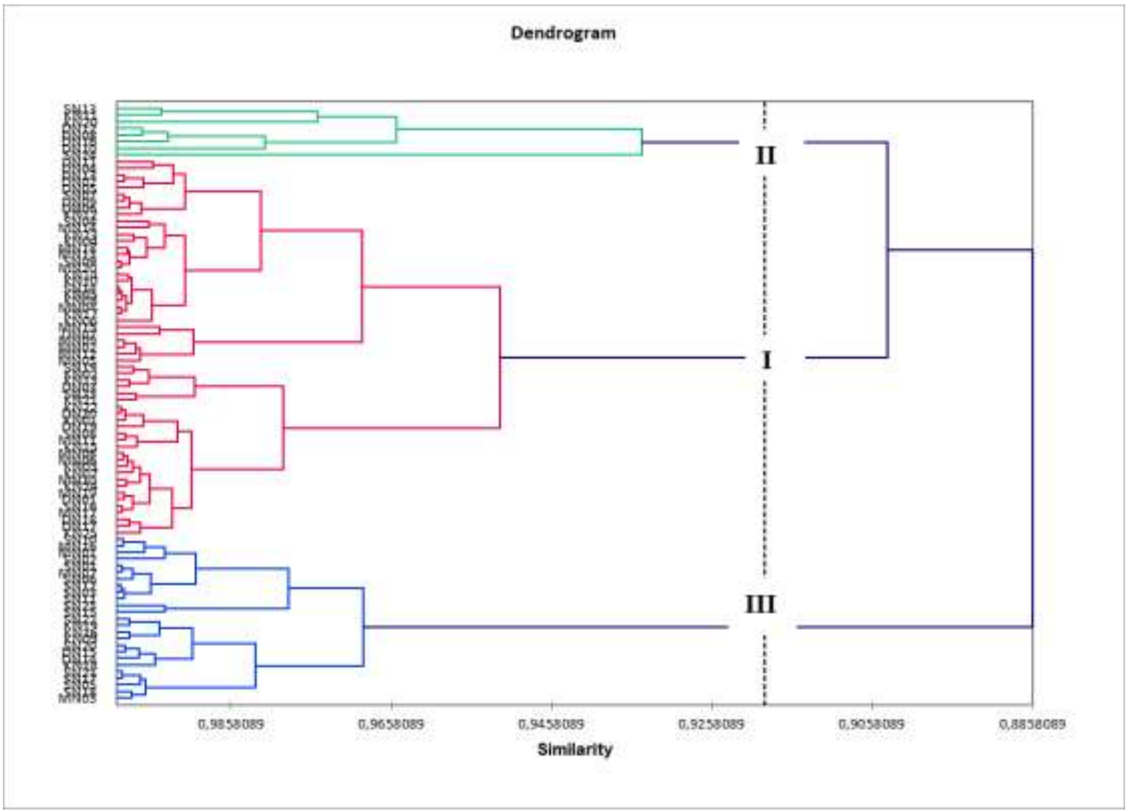

Figure 1. Dendrogram of the hierarchical ascending classification of the 90 mother trees of néré evaluated in the Poro region

Table 4. Comparison of the characteristics of the three classes of mother trees obtained by HAC

	Class I	Class II	Class III	P-value
Cir	**159.947 b**	**160.625 b**	**263.200 a**	**< 0.001**
Hf	**232.842 a**	**177.750 b**	**162.320 b**	**< 0.001**
NFrPedon	**3.212 b**	**7.668 a**	**3.631 b**	**< 0.001**
L pedon	18.968 a	18.059 a	19.008 a	0.879
EpPedon	**3.956 a**	**4.723 a**	**4.343 ab**	**0.006**
PGrGrap	**10.810 b**	**28.658 a**	**12.509 b**	**< 0.001**
P100Grap	24.092 a	24.041 a	23.178 a	0.702
NGrGrap	**44.509 b**	**117.412 a**	**54.639 b**	**< 0.001**
LFr (cm)	21.527 a	22.018 a	22.135 a	0.389
lFr en (cm)	2.053 a	2.111 a	2.032 a	0.324
PFr en (g)	12.386 a	12.560 a	12.155 a	0.799
EpFr en (mm)	10.107 a	9.600 a	10.080 a	0.217
Lpédic en (cm)	3.166 a	3.656 a	3.103 a	0.102
EpPédic en (mm)	3.329 a	3.395 a	3.395 a	0.691
PGrFr en (g)	3.538 a	3.873 a	3.469 a	0.25
Ppulpe en (g)	3.496 a	3.505 a	3.316 a	0.539
NGr	14.740 a	16.161 a	15.079 a	0.07
LGr en (mm)	8.797 a	8.707 a	8.811 a	0.907
lGr en (mm)	7.267 a	7.238 a	7.222 a	0.947
EpGr en (mm)	4.844 a	4.936 a	4.896 a	0.825

Cir : Tree circumference; **Ht**: Bole height; **NFrPedon**: Number of fruit per peduncle; **L pedon**: Peduncle length; **EpPedon**: Peduncle thickness; **PGrGrap**: Seed weight per cluster; **P100Grap**: Weight of 100 seeds per cluster; **NGrGrap**: Number of seeds per cluster; **LFr:** Fruit length; **lFr**: Fruit width; **PFr**: Fruit weight; **EpFr**: Fruit thickness; **Lpédic**: Pedicel length; **EpPédic**: Pedicel thickness; **PGrFr**: Seed weight per fruit; **Ppulpe**: Pulp weight; **NGr**: Number of seeds per fruit; **LGr**: Seed length; **lGr**: Width of seed; **EpGr**: Thickness of seed.

Variability of morphological traits in nursery seedlings

Descriptive analysis revealed variability in germination rate, germination duration, leaf length, and petiole length, with Coefficients of Variation exceeding 25%. ANOVA showed significant differences among seedlings for the nine measured traits (P< 0.0001) (Table 5).

Table 5. Mean value ± standard deviation of progenies' quantitative traits

Traits	Min	Max	Mean ± Standard deviation	CV (%)	P-value
Germination rate	0	100	80.444 ± 28.344	35.2	<0.001
Germination time	0	20	10.584 ± 3.043	28.7	<0.001
Height of the plant	3.9	16.2	10.1 ± 2.051	20.3	<0.001
Collar diameter	1.3	8.9	3.151 ± 0.643	20.4	<0.001
Number of nodes	2	12	4.657 ± 1.027	22.1	<0.001
Number of leaves	2	9	5.389 ± 1.000	18.5	<0.001
Leaves length	1.3	9	3.2 ± 0.990	30.9	<0.001
Leaves width	1.7	14.7	7.566 ± 1.689	22.3	<0.001
Petiole length	0.6	3	1.137 ± 0.352	31	<0.001

Relationships between measured variables in nursery progeny

Pearson's correlation test showed that the number of internodes is strongly positively correlated with the number of leaves (r = 0.89). There is also a positive correlation between plant height and the number of internodes (r = 0.59), plant height and the number of leaves (r = 0.59), as well as leaf length and petiole length (r = 0.636) (Table 6).

Table 6. Correlation matrix for parameters assessed on nursery plants

	GR	GD	PH	CD	NIN	NL	LL	LW	PL
GR	**1**								
GD	0.229	**1**							
PH	0.312	-0.004	**1**						
CD	0.227	0.173	0.496	**1**					
NIN	0.178	-0.229	**0.59****	0.215	**1**				
NL	0.244	-0.232	**0.587****	0.201	**0.89****	**1**			
LL	0.168	0.097	0.365	0.49	0.031	0.147	**1**		
LW	0.222	0.007	0.466	0.303	0.17	0.218	0.318	**1**	
PL	-0.06	0.15	0.266	0.309	-0.045	0.02	**0.636****	0.032	**1**

GR: Germination Rate; **GD**: Germination Duration; **PH**: Plant Height; **CD**: Collar Diameter; **NIN**: Number of Internodes; **NL**: Number of Leaves; **LL**: Leaf Length; **LW**: Leaf Width; **PL**: Petiole Length; **Significant at P < 0.01.

Structural diversity of nursery progeny

HAC identified three (3) classes based on trait similarity. Classes I and II consist of seedlings from all four cities in the Poro region, while Class III comprises seedlings from Dikodougou, Sinématiali, and M'Bengué (Figure 2). Significant differences were observed between classes for germination rate and leaf width following ANOVA (Table 7).

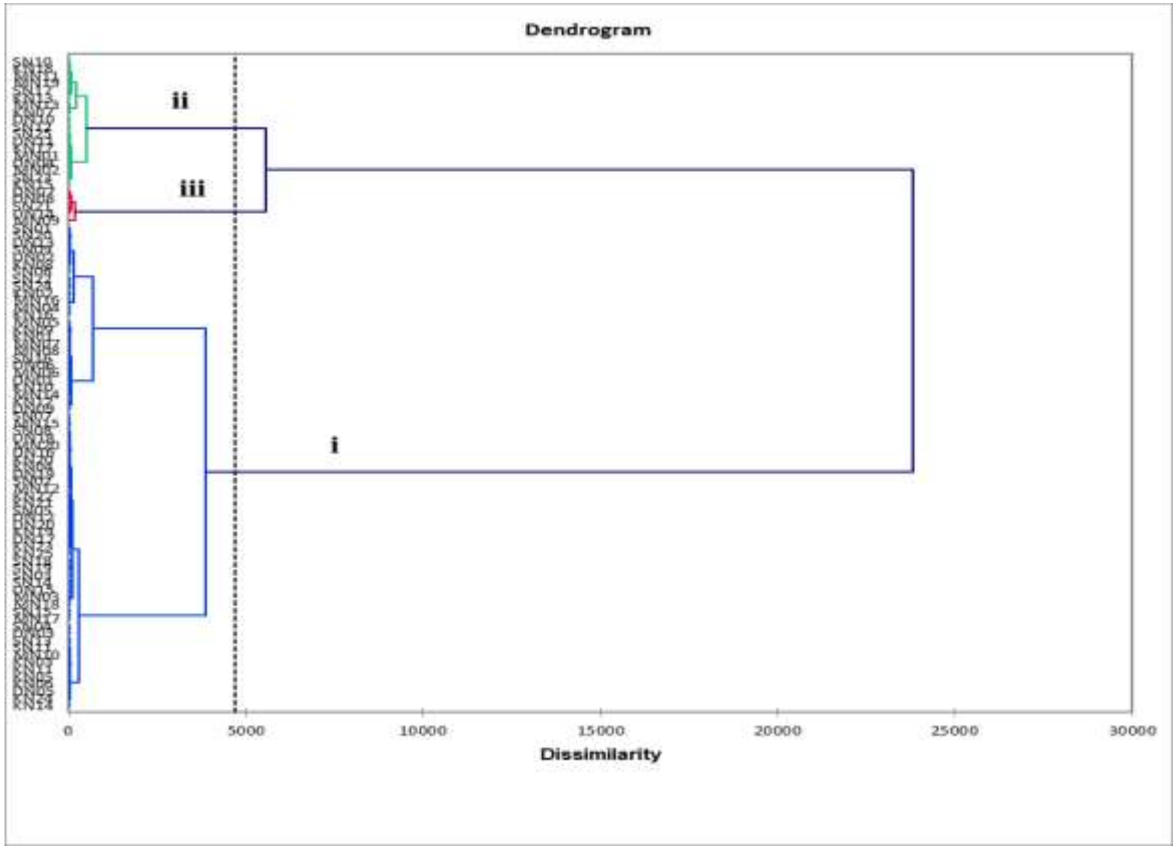

Figure 2. Dendrogram of the hierarchical ascending classification of progeny

Table 7. Average characteristics of the three groups obtained by HAC of progeny

Classes	**Germination rate**	**Germination time**	**Height of the plant**	**Collar diameter**	**Number of nodes**	**Number of leaves**	**Leaves length**	**Leaves width**	**Petiole length**
i	89.955 a	10.837 a	10.339a	3.180 a	4.753 a	5.478 a	3.259 a	7.714ab	1.133 a
ii	60.060 b	10.333 a	9.303ab	3.056 a	4.404ab	5.181ab	3.053 a	6.896 b	1.139 a
iii	22.483 c	9.673 a	8.534 b	3.118 a	4.058 b	4.771 b	2.827 a	7.864 a	1.090 a
P-value	<**0.001**	0.297	**0.001**	0.436	**0.014**	**0.010**	0.120	**0.010**	0.902

Selection of candidate genotypes for néré improvement: High-performing genotypes in both field and nursery

Cross-analysis of classes obtained for parent trees and their progeny shows that the trees exhibiting superior traits in both field and nursery include DN12, DN16, KN11, KN20, SN13, and SN24 (Table 8). These trees produce a high number of fruits per cluster, fruits borne on thick peduncles, and a high number of heavy seeds per cluster. In nurseries, they demonstrated high germination rates, greater plant height, a high number of internodes, and a high number of leaves. These trees are therefore candidate genotypes for néré improvement.

Table 8. Cross-tabulation of dwarf-tree classes identified in the field and those identified in the nursery

		Parent tree classes		
		Class I	**Class II**	**Class III**
Progeny classes	Class i	DN01, DN02, DN03, DN05, DN06, DN09, DN13, DN17, DN18, DN19, DN20, KN01, KN02, KN03, KN04, KN05, KN06, KN08, KN10, KN12, KN14, KN21, KN22, KN23, KN24, KN25, MN04, MN05, MN06, MN08, MN10, MN12, MN14, MN15, MN17, MN18, MN20, SN04, SN07, SN08, SN09, SN14, SN16, SN19	**DN12, DN16, KN11, KN20, SN13, SN24**	DN15, KN09, KN16, KN19, MN03, MN07, MN16, SN01, SN02, SN03, SN05, SN06, SN11, SN15, SN18, SN20, SN22
	Class ii	DN04, DN11, KN07, KN13, KN15, KN17, MN11, MN13, MN19, SN23, MN02	DN10	KN18, MN01, SN10, SN12, SN17, SN25
	Class iii	DN07, MN09	DN08	DN14, SN21

Codes in bold represent trees that have the best parent and progenies

DISCUSSION

Understanding the existing morphological and genetic diversity of a crop is essential for its genetic improvement. Morphological traits serve as primary markers for estimating genetic variability (Benhamada-Driouèche *et al*. 2021; Tripathi *et al*. 2024). Moreover, correlations between morphological descriptors refine the genetic improvement process. Several studies have highlighted the importance of positive correlations among morphological descriptors in plant improvement (Amegan *et al.* 2020; Madoșă *et al.* 2021). When descriptors are positively correlated, improving one leads to the enhancement of the other. Descriptive analysis revealed variability in the studied traits, indicating diversity within néré trees. The species' preferential allogamous reproduction mode is likely responsible for this diversity, as also noted by Oyerinde *et al.* (2018) and Kouonon *et al*. (2020).

Hierarchical Ascending Classification grouped parent trees and their progeny into three (3) morphological classes. Parent tree Classes I and III include trees from all four cities in the Poro region, while Class II consists solely of trees from Dikodougou, Korhogo, and Sinématiali. This structure suggests similarities among néré trees from Dikodougou, Korhogo, and Sinématiali. This clustering, independent of geographic origin, could result from gene flow caused by humans, migratory birds, or other pollinators. A similar analysis was conducted by Diallo *et al.* (2007) on tamarind trees in Burkina Faso and Senegal.

A significant difference was also observed between classes for tree circumference, trunk height, number of fruits per peduncle, peduncle thickness, seed weight per cluster, number of seeds per cluster, and peduncle thickness. This highlights variability among trees in different classes for these descriptors, as noted by Ouédraogo (1995). These classes likely comprise morphotypes with distinct genotypes that could serve as a foundation for an improvement program. Additionally, Class II parent trees produced the best progeny, grouped in Class I. The simultaneous performance of both parents and progeny suggests the transmission of specific genes, favoring Class II parents for variety creation or vegetative propagation. Selecting parents based on their progeny's performance is an effective method for improving various plant species (Yao *et al.* 2016; Zhang *et al.* 2020; Tano, 2021).

CONCLUSION

This study aimed at assessing the existing diversity of néré trees across four cities in the Poro region. Morphological characterization of parent trees identified three classes, with Classes I and III comprising trees from all four cities, and Class II consisting of trees from Dikodougou, Korhogo, and Sinématiali. Class II trees recorded the best performances, producing a high number of fruits per peduncle, with the highest seed counts and weights. In nurseries, seedlings were grouped into three classes, with Class I, containing progeny of Class II parent trees, showing the best performances. DN12, DN16, KN11, KN20, SN13, and SN24 from Class II parent trees, which produced the best progeny, are thus candidate genotypes for néré improvement.

Declaration by Authors

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