Morphological variability of *Detarium microcarpum* Guill. & Perr. (Caesalpiniaceae) in Benin, West Africa

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ABSTRACT

Aims: The main objective of this study is to evaluate the morphological diversity of *Detarium microcarpum* populations in Benin for a sustainable conservation.

Methodology: Twelve quantitative and two qualitative variables were used to evaluate the phenotypic diversity according to phytodistrict and soil origin of 78 trees of *D. microcarpum* sampled in six phytodistrict in Benin. In order to analyze the overall variability of trees according to phytodistrict and soil origin, the morphological variables were subjected to a one-way analysis of variance. These morphological variables were then subjected to a Ward ascending hierarchical classification in order to determine different phenotypic classes of *D. microcarpum* populations.

Results: The results obtained revealed a relatively high polymorphism of the leaves and fruits of *D. microcarpum*. A significant influence of the phytodistrict and soil origin on the variability of the studied morphological descriptors was noted. Three morphotypes were identified from *D. microcarpum* trees from the six phytodistricts, with an important inter-population variability for morphological descriptors.

Conclusion: *Detarium microcarpum* phenotypic variability would suggest a fairly large genetic diversity of species. *Detarium microcarpum* trees belonging to subpopulation I (trees from Bassila and north Borgou phytodistricts) with the best fruit characteristics could be used for varietal selection in Benin.

Keywords: Morphological variability, Detarium microcarpum, phytodistrict, Benin, West Africa.

1. INTRODUCTION

Forest ecosystems are a key indicator for the well-being of our planet. They contribute at preservation of the components of biological diversity, regulating the water cycle, soil conservation, sequestering carbon storage, and ensuring people's food security at local, regional and even global levels [1]. Through non-timber forest products (NTFPs), ecosystems are an important source of income for the well-being of local populations [2]. Among plant species of great importance to local populations in sub-Saharan Africa, there is *Detarium microcarpum* Guill. & Perr. (Caesalpiniaceae) deserves particular attention [3-5] The species is used in human food and livestock through its fruits, leaves and seeds, in the traditional pharmacopoeia and as good lumber and firewood.

In Benin, the species is present in six phytodistricts (Zou, Bassila, South Borgou, north Borgou, Mekrou-Pendjari and Atacora chain) belonging to the Sudanian and Sudano-Guinean climate zones [6]. Local people use it in food, traditional medicine, fodder, burning, crafts and medico-magic use [5, 7]. These multiple uses associated with the high frequency of use make the species over-exploited and becoming increasingly rare in some areas in Benin [7-9].

Given the critical role that non-wood forest products of *D. microcarpum* play for local communities and the threat to the survival of this species, it is imperative that strategies for its conservation be developed to avoid its extinction. The conservation of a forest species requires knowledge of its morphological variability in order to differentiate individuals and to target interesting morphotypes [10, 11]. Studies on the analysis of the morphological variability of *D. microcarpum* has been carried out in Mali and has shown a relatively high variability linked to a strong interaction between the genotype and the environment, but this work is almost non-existent in Benin [12]. The lack or absence of data makes efforts to identify the morphotypes of this forest species ineffective. One of the important steps in the characterization of trees is the determination of the most discriminating morphological descriptors [12, 13]. In addition, the consideration of soil parameters in the study of plant morphological variability is also essential in that the successful conservation of a forest species is largely related to the quality of the soil being used. support for its growth [12]. The morphological inter-population variation provides information on the variability due to the environment in the species' range, while it informs about the danger of genetic erosion if we look at genetic variability. The present study aims mainly to evaluate the morphological diversity of *Detarium microcarpum* in Benin. Specifically, this involved: (i) describing the morphological variability of *D. microcarpum*, (ii) analyzing the influence of the phytodistrict and soil origin on the morphological variability of *D. microcarpum*, (iii) characterizing the different morphotypes of *Detarium microcarpum* in Benin.

2. MATERIAL AND METHODS

2.1. Study area

The present study was carried out in Benin (West Africa between 1° and 3°40'E and 06°30' and 12°30'N) in six phytodistricts (Bassila, north Borgou, south Borgou, Atacora chain, Mekrou-Pendjari and Zou) selected on the basis of the presence of natural stands of *Detarium microcarpum* (Figure 1) [6]. These phytodistricts belonging to the Sudano-Guinean and Sudanian climatic zones are distinguished from each other by their climatic and biophysical conditions (Table 1) [14].

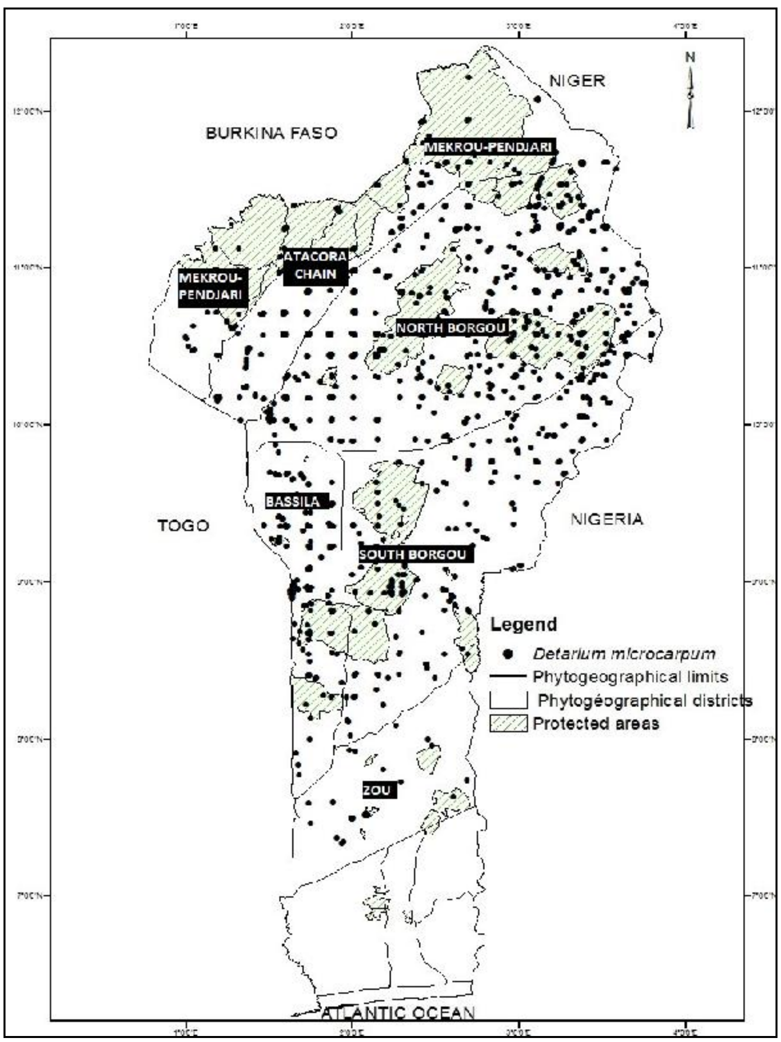

Figure 1: Geographic distribution of *D. microcarpum* occurrence across Benin included in this study (Agbo et al., 2018b).

Table 1: Biophysical characteristics of the phytodistricts surveyed.

Phytodistrict	Climatic zone	Rainfall regime	Rainfall (mm)	Major soil types	Major plant formation
Bassila	Guineo-Sudanian	Tendency to unimodal	Min: 1100 Max: 1300	Ferrallitic soils with concretions and breastplates	Semi-deciduous forest, woodland, and riparian forest
Zou			Min: 1100 Max: 1200	Ferruginous soils on crystalline rocks	Dry forest, woodland, and riparian forest
South Borgou					
North Borgou	Sudanian	Unimodal (1 rainy season)			
Atacora Chain			Min: 1100 Max: 1200	Poorly evolved & mineral soils	Riparian forest, dry forest, and woodland
Mekrou- Pendjari			Min: 900 Max: 1000	Ferruginous soils with concretions on sedimentary rocks	Tree and Shrub savannahs, dry forest and riparian forest

2.2. Data collection

Seventy-eight (78) trees of *D. microcarpum* were selected at thirteen (13) trees per phytodistrict spaced at least 50 meters apart. All individuals sampled in a phytodistrict were considered to be a population as well as those belonging to the same soil group. Each tree has been georeferenced using a Geographical Positioning System (GPS).

Twelve (12) quantitative and two (2) qualitative variables were measured on the trunk, leaves and fruits. The dendrometric variables used on each tree are the height of the plant (Hpl), the diameter of the trunk (Dbh), the height of the 1st basal branching with respect to the soil (Hpr) and the color bark of the trunk (Cec). The variables Hpl, Dbh and Hpr were taken using a decameter; a color chart (Royal Horticultural Society Color Chart) was used to take the color of the bark. On each tree, 3 fresh, well-developed, non-parasitic leaves were identified and variables such as: leaf length (Lfe) measured from the point of attachment of the petiole to the branch to the tip of the terminal leaflet, leaf width (lfe), leaf type (Tyf), leaf peduncle diameter (Dpf), leaflet length and width (Lfo and lfo) and number of leaflets (Nfo) were taken. On each selected tree, 5 fresh and ripe fruits were chosen at random. The variables estimated were the length of the fruit (Lfr) measured from the point of attachment of the peduncle to the end of the fruit, the width of the fruit (lfr) and the mass of the fruit (mfr) weighed by a balance of precision.

2.3. Data analysis

The geographical coordinates of *D. microcarpum* trees have been projected on the Harmonized World Soil Database v1.21 [15]. where the corresponding soils groups were considered in this study. The descriptive statistics (mean, standard deviation and coefficient of variation) were made on the morphological quantitative variables of trees by population and for all populations in order to evaluate the inter and intra-population variability of the species. Components analysis of variance was performed on all morphological descriptors collected in the six populations in order to analyze the share of global variability due to individuals, phytodistrict, and soils groups. A classification of variability was made on the one hand within and between phytodistricts and on the other hand within and between soil groups using a scale proposed by Ouédraogo et al. [16]. This scale, used successfully by Kouyaté et al. [17] and Sourou

Kuiga [11], is as follows: (1) low variation (CV = 0 - 10%); (2) average variation (CV = 10 - 15%); (3) quite significant variation (CV = 15 - 44%); (4) significant variation (CV> 44%). Morphological variables were subjected to Analysis of Variance one-way with Statistica 6 software [18] to test the variation of these variables within phytodistricts and soils groups. In order to determine different morphotypes of *D. microcarpum*, the morphological descriptors used were subjected to an Ascending Hierarchical Classification of Ward (Euclidean distances on the averages of the characters studied) with Minitab 16 software [19].

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Description of morphological variability of *D. microcarpum*

Tables 2 and 3 respectively showed the variations of twelve (12) quantitative morphological descriptors of the leaves, fruits and dendrometric of *D. microcarpum* according phytodistricts and soils groups of the collection sites.

3.1.1.1. Trunk and crown

The height of the *D. microcarpum* plant ranged from 3.10 to 12.30 m with an average of 6.42 (± 0.22) m, the height of crown from 1.01 to 3.60 m with an average of 2.08 (± 0.07) m. The trunk diameter varied from 20.50 to 129.00 cm with an average of 50.64 (± 2.27) cm.

Intra-phytodistrict variability of plant height and trunk diameter was greater (CV ≥ 44%) in south Borgou than in other phytodistricts (15% <CV < 44%). The height of the crown was quite high (15% <CV <44%) in all other phytodistricts.

Whatever the soil group, the intra-soils groups variability of plant height, trunk diameter and the height of the crown of the plant is quite significant (15% < CV <44%).

Inter-phytodistrict and inter-soils groups variability were quite high (15% <CV <44%) for all variables considered (plant height, trunk diameter and height of crown).

3.1.1.2. Leaves

The leaf length of *D. microcarpum* varied from 15.5 to 20.20 cm with an average of 17.70 (± 0.13) cm, its width is between 6.90 and 9.20 cm with an average of 8.13 (± 0.13). The leaf stalk diameter varied from 0.20 to 0.70 cm with an average of 0.45 (± 0.01) cm. The length of the leaflet varied from 5.80 to 10.50 cm with an average of 7.40 (± 0.13) cm, its width is between 3.10 and 5.40 cm with an average of 4, 34 (± 0.07). The number of leaflets per leaf is between 6 and 10 with an average of 8.54 (± 0.11) leaflets leading to paripinnate and imparipinnate leaves.

Intra-phytodistrict variability in leaf length and width was low (0% <CV <10%) in all phytodistricts. The length of the leaflet was small (0% <CV <10%) in Bassila, average in north Borgou, in Atacora chain and in Mekrou-Pendjari but quite high (15% <CV <44 %) in south Borgou and Zou. The intra-phytodistrict variability of leaflet width was low (0% <CV <10%) in Bassila, mean (10% <CV <15%) in north Borgou, in Atacora chain, Mekrou-Pendjari and Zou while it was quite important (15% <CV <44%) in south Borgou. The diameter of the leaf stalk is average (10% <CV <15%) in Bassila but quite important (15% <CV <44%) in the other phytodistricts. Intra-phytodistrict variability of the number of leaflets per leaf was low (0% <CV <10%) in south Borgou and Mekrou-Pendjari, mean (10% <CV <15%) in Bassila, north Borgou and in Atacora chain but quite important (15% <CV <44%) in Zou.

Intra-soils groups variability of the length and width of the leaf was low (0% <CV <10%) regardless of the group of soils. The soil variability of leaf stalk diameter was moderate (10% <CV <15%) in plinthosols but quite important in other soils groups. The size of the leaflet length was low (0% <CV <10%) on plinthosols, mean (10% <CV <15%) in the leptosols but quite important (15% <CV <44%) on luvisols and lixisols. The intra-soils groups variability of leaflet width was low (0% <CV <10%) on plinthosols and medium (10% <CV <15%) in other soil groups. The intra-soil variability in the number of leaflets per leaf was low (0% <CV <10%) on plinthosols and luvisols but average (10% <CV <15%) in leptosols and lixisols.

Inter-phytodistrict and soils groups variability was low (0% <CV <10%) for leaf length and width, mean (10% <CV <15%) for width and number of leaflets but quite important (15 < CV< 44%) for the length of the leaflet and the diameter of the leaf stalk.

3.1.1.3. Fruit

The length of the fruit of *D. microcarpum* varied from 2.70 to 5.60 cm with an average of 4.06 (± 0.08) cm, its width varied from 2.10 to 3.80 cm with an average of 2.89 (± 0.06) cm and mass of 8.70 to 13.80 g with an average of 11.07 (± 0.16) g.

Intra-phytodistrict variability of fruit length was low (0% <CV <10%) in Bassila, south Borgou and Zou while it was average (10% <CV <15%) in north Borgou, Atacora chain and Mekrou-Pendjari. The width of the fruit was medium (10% <CV <15%) in Mekrou-Pendjari and low ((0% <CV <10%) in other phytodistricts. The fruit mass was low (0% <CV <10%) in all phytodistricts.

The intra-soils groups variability of fruit length was low (0% <CV <10%) on plinthosols, medium (10% <CV <15%) on leptosols and quite important on lixisols and luvisols. The intra-soils groups variability of fruit width was low (0% <CV <10%) on leptosols and on plinthosols but was quite important on lixisols and luvisols. The fruit mass variability was average (10% <CV <15%) on lixisols but low (0% <CV <10%) on other soils groups.

Inter-phytodistrict and soils groups variability was moderate (10% <CV <15%) for the fruit mass but quite important (15<CV< 44%) for the length and width of the fruit.

Table 2: Morphological description of quantitative variables of *D. microcarpum* following phytodistricts.

Phytodistricts	**Parameters**	**Hpl (m)**	**Hpr (m)**	**Dbh (cm)**	**Lfe (cm)**	**lfe (cm)**	**Lfo (cm)**	**lfo (cm)**	**Dpf (cm)**	**Nfo**	**Lfr (cm)**	**lfr (cm)**	**mfr (g)**
Bassila	Mean	6.60	2.39	49.53	16.51	7.91	6.81	4.11	0.44	8.84	4.81	3.11	13.06
	SD	0.36	0.19	3.33	0.16	0.09	0.17	0.10	0.014	0.25	0.09	0.07	0.13
	CV (%)	19.92	29.60	24.27	3.68	4.51	8.91	8.69	11.63	10.16	6.61	7.95	3.56
North Borgou	Mean	6.77	2.01	53.52	17.32	8.24	7.62	4.44	0.46	8.61	4.70	3.52	11.74
	SD	0.63	0.16	5.93	0.28	0.14	0.28	0.14	0.03	0.24	0.16	0.06	0.16
	CV (%)	33.70	28.62	39.93	5.91	6.22	13.43	11.53	25.85	10.09	12.25	6.15	5.08
South Borgou	Mean	6.16	1.98	51.68	17.64	8.28	7.94	4.48	0.44	8.15	4.42	3.38	10.06
	SD	0.78	0.18	8.75	0.45	0.22	0.45	0.22	0.02	0.22	0.06	0.04	0.08
	CV (%)	45.83	32.68	61.03	9.26	9.74	20.55	18.00	19.84	9.82	5.23	4.86	2.86
Atacora chain	Mean	6.90	2.06	52.73	16.95	8.04	7.25	4.24	0.45	8.61	3.81	2.52	11.41
	SD	0.50	0.14	4.51	0.28	0.15	0.28	0.15	0.02	0.35	0.11	0.04	0.27
	CV (%)	26.18	24.05	30.84	5.99	6.76	13.99	12.81	19.33	14.63	11.01	5.87	8.68
Mekrou-Pendjari	Mean	6.96	2.30	56.70	16.74	7.98	7.04	4.18	0.48	8.61	3.12	2.43	10.88
	SD	0.46	0.17	5.92	0.23	0.13	0.23	0.14	0.02	0.21	0.09	0.08	0.25
	CV (%)	23.97	27.21	37.65	5.00	6.26	11.88	11.94	16.52	8.91	10.63	12.39	8.42
Zou	Mean	5.11	1.75	39.68	17.43	8.36	7.73	4.56	0.41	8.38	3.48	2.38	9.23
	SD	0.32	0.13	2.50	0.35	0.17	0.34	0.16	0.03	0.35	0.08	0.06	0.08
	CV (%)	22.23	25.88	22.68	7.16	7.17	16.13	13.14	25.72	15.04	7.93	8.87	3.26
Probability		0.13ns	0.08ns	0.35ns	0.087ns	0.254ns	0.08ns	0.25ns	0.52ns	0.59ns	0.000***	0.000***	0.000***
Minimum of population		3.10	1.01	20.50	15.50	6.90	5.80	3.10	0.20	6.00	2.70	2.10	8.70
Maximum of population		12.30	3.60	129.00	20.20	9.20	10.50	5.40	0.70	10.00	5.60	3.80	13.80
Mean of population		6.42	2.08	50.64	17.10	8.13	7.40	4.34	0.45	8.54	4.06	2.89	11.07
SD of population		0.22	0.07	2.27	0.13	0.06	0.13	0.07	0.01	0.11	0.08	0.06	0.16

CV (%) of population	30.71	29.27	39.62	6.69	7.08	15.46	13.28	20.18	11.59	18.02	17.74	12.50

Hpl: plant height; Hpr: height crown; Dbh: trunk diameter; Lfe: leaf length; lfe: leaf width; Lfo: leaflet length; lfo: leaflet width; Dpf: leaf peduncle diameter; Nfo: number of leaflets; Lfr: fruit length; lfr: fruit width; mfr: fruit mass; SD: standard deviation; CV: coefficient of variation; *** significant at the 0.1% threshold; ns: not significant.

Table 3: Morphological description of quantitative variables of *D. microcarpum* following soils groups.

Soils groups	**Parameters**	Hpl (m)	Hpr (m)	Dbh (cm)	Lfe (cm)	lfe (cm)	Lfo (cm)	Lfo (cm)	Dpf (cm)	Nfo	Lfr (cm)	lfr (cm)	mfr (g)
Leptosols	Mean	6.54	2.05	49.45	16.95	8.03	7.25	4.23	0.47	8.54	3.78	2.47	10.65
	SD	0.39	0.14	2.31	0.28	0.15	0.28	0.15	0.02	0.35	0.13	0.04	0.27
	CV (%)	22.20	24.96	17.65	6.03	6.83	14.10	12.96	18.22	14.83	12.62	6.69	8.70
Lixisols	Mean	6.11	2.06	47.12	17.07	8.13	7.37	4.33	0.45	8.46	3.94	2.94	10.54
	SD	0.38	0.14	3.95	0.25	0.13	0.25	0.13	0.02	0.25	0.16	0.11	0.29
	CV (%)	30.54	32.56	39.79	7.15	7.72	16.56	14.49	17.34	14.78	19.54	18.15	13.65
Luvisols	Mean	6.31	2.08	48.62	17.37	8.25	7.67	4.45	0.44	8.55	4.00	2.98	11.41
	SD	0.43	0.10	4.54	0.22	0.11	0.22	0.11	0.02	0.12	0.13	0.10	0.17
	CV (%)	35.90	28.58	46.78	7.02	7.23	15.90	13.40	25.17	7.90	18.18	19.35	9.15
Plinthosols	Mean	6.65	2.29	54.07	16.54	7.93	6.84	4.13	0.44	8.70	4.86	3.06	13.16
	SD	0.47	0.22	4.38	0.20	0.11	0.20	0.11	0.01	0.26	0.11	0.078	0.15
	CV (%)	22.70	30.34	28.03	3.93	4.53	9.51	8.70	11.74	9.46	7.14	8.03	3.71
Probability		0.78ns	0.71ns	0.67ns	0.23ns	0.39ns	0.23ns	0.39ns	0.86ns	0.94ns	0.001***	0.009**	0.000***
Minimum of population		3.10	1.01	20.50	15.50	6.90	5.80	3.10	0.20	6.00	2.70	2.10	8.70
Maximum of population		12.30	3.60	129.00	20.20	9.20	10.50	5.40	0.70	10.00	5.60	3.80	13.80
Mean of population		6.42	2.08	50.64	17.10	8.13	7.40	4.34	0.45	8.54	4.06	2.89	11.07
SD of population		0.22	0.07	2.27	0.13	0.06	0.13	0.06	0.01	0.11	0.08	0.06	0.16
CV (%) of population		30.71	29.27	39.62	6.69	7.08	15.46	13.28	20.18	11.59	18.02	17.74	12.50

Hpl: plant height; Hpr: height crown; Dbh: trunk diameter; Lfe: leaf length; lfe: leaf width; Lfo: leaflet length; lfo: leaflet width; Dpf: leaf peduncle diameter; Nfo: number of leaflets; Lfr: fruit length; lfr: fruit width; mfr: fruit mass; SD: standard deviation; CV: coefficient of variation; *** significant at the 0.1% threshold; ns: not significant.

3.1.2. Impact of the phytodistrict and soil origin on the morphological variability of *D. microcarpum*

Fruit variables of *D. microcarpum* such as length, width and mass showed highly significant differences between phytodistricts at 0.1% (P <0.001) following the Student-Newman-Keuls test (Table 2). The morphological descriptors that best discriminate the population of *D. microcarpum* based on phytodistricts are the length, width and mass of the fruit. The longest fruits (5.6 cm) and the largest (3.80 cm) were found in the north Borgou, while the shortest fruits (2.70 cm) were found in Mekrou-Pendjari. The smallest fruits (2.10 cm) were observed in Zou. While the fruits with the highest masses (13.80 g) were recorded in the Bassila and those with the lowest masses were recorded in Zou phytodistrict.

At soils groups, variables such as fruit length and mass showed highly significant differences at the 0.1% (P <0.001) level following the Student-Newman-Keuls test. While the width of the fruit showed a highly significant difference between soil types at the 1% threshold (P <0.01) following the Student-Newman-Keuls test (Table 3). This shows that the morphological descriptors that best discriminate the population of *D. microcarpum* according to soils groups are the length, width and mass of the fruit. The longest and largest fruits were found on plinthosols and luvisols, while the shortest and the smallest were recorded on lixisols and leptosols. The low trunk height and diameter of the tree were recorded on lixisols and luvisols. In contrast, the tallest and largest trees were noted on plinthosols and leptosols. Concerning of the effects of soil physico-chemical characteristics on the morphological characteristics of *D. microcarpum* trees. It has been observed that the most vigorous trees are found on soils rich in organic and mineral matter to high retention capacity and texture sandy-clay or clay-silty soil.

3.1.3. Characterization of different morphotypes of *D. microcarpum*

The Ascending Hierarchical Classification made from the descriptors of *D. microcarpum* revealed three morphotypes or phenotypic classes at the 50% similarity threshold (Figure 2): The morphotype GI consists of the *D. microcarpum* trees of the Bassila and north Borgou phytodistrict. This morphotype is characterized by individuals carrying large fruits with high mass, length and width, but small leaves with a short length and width. The morphotype GII grouped *D. microcarpum* trees from Atacora chain and Mekrou-Pendjari. This morphotype is characterized by trees bearing small fruits, leaves of medium length and width, a high number of leaflets per leaf and fruits of short length and width. The morphotype GIII collected trees from the south Borgou and Zou phytodistrict. This morphotype is characterized by trees bearing small fruits of low mass, length and width, but large leaves of considerable length and width.

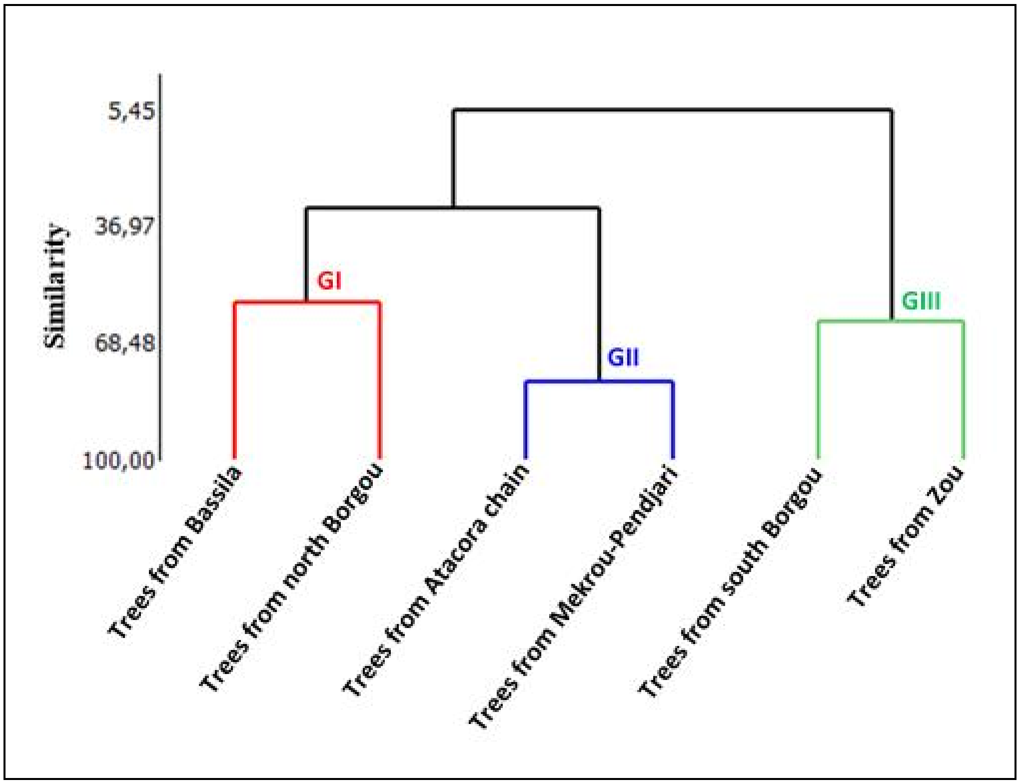

Figure 2: Morphotypes of *D. microcarpum* from the Ascending Hierarchical Classification.

3.2. DISCUSSION

3.2.1. Variation of phenotypic diversity of *D. microcarpum*

The results of the present study showed that the leaves of *D. microcarpum* measured in Benin contain 6 to 10 leaflets against 6 to 12 leaflets observed in other studies [12, 20-24]. The presence of paripinnate and imparipinnate leaves generally on the same tree corroborates the results of the study of several authors [12, 25]. However, some authors describe *D. microcarpum* as an exclusively paripinnate leaf species [20, 26] while they were only imparipinnate for others [27, 28]. This showed that leaf type characters and number of leaves was not influenced by the environment but would depend on the genotype of the plant. The average leaf length and width correspond to those obtained in southern Mali by Kouyaté [12] but remain slightly larger than those reported by Arbonnier [29] in other Sahelian countries of West Africa. This could be explained by an influence of the environment on the size of the leaves. In fact, to reduce evapotranspiration, trees in Sahelian environments have relatively smaller leaves than those in tropical environments [30]. The average length and width of *D. microcarpum* fruits are consistent with those reported in other West African countries, 2.5 to 5 cm [28]; 3 to 4 cm [20]; 3 to 8 cm [31]. These variations observed in fruit of this species were due to the plant's biology reproduction, climatic and soil conditions. Also, studies on *Tamarindus indica* [32, 33], *Adansonia digitata* L. [34, 35], *Pentadesma butyracea* Sabine [36, 37], have proved that the variation in fruit size and number of seeds per fruit depends significantly on the mode of plant reproduction, environmental and anthropogenic factors.

3.2.2. Effects of environmental and anthropogenic parameters on the morphological variability of *D. microcarpum*

Detarium microcarpum trees of small-diameter trunk and small height were found in Zou phytodistrict while those with large trunk diameter and highest were found in Mekrou-Pendjari. This was justified by the presence of very few protected areas (classified and sacred forests) in Zou contrary to Mekrou-Pendjari, and by the fact that Zou constitutes very few suitable habitats for the growth of *D.*

microcarpum as opposed to Mekrou-Pendjari [6]. Indeed, protected areas have a positive impact on the conservation of trees by curbing their overexploitation, especially in the juvenile state [9, 38]. At Zou phytodistrict, the species is overexploited for its timber, which is mainly used in the production of heating charcoal [7]. The observation that vigorous trees of *D. microcarpum* are found on soils rich in organic and mineral matter, with high retention capacity and sandy clay or clay-silty texture, is justified by the fact that this species is characteristic of tropical ferruginous soils usually sandy-loamy [12]. The difference in soil composition content justifies variations in the height and diameter of the trunk of the tree, and the fruit parameters observed from one soils groups to another [39]. In fact, plinthosols and leptosols are characterized by a relatively high content of silt and clay unlike luvisols and lixisols [40]. The effect of the environment on fruit length of *D. microcarpum* is confirmed by Vogt [24] in Sudan, where berries were observed in dryland savannas compared to wetlands. Morphological characterization studies carried out on Adansonia digitata [41] have shown that the morphological and production variabilities observed in baobab were mainly related to environmental conditions and its habitat. The morphological characterization of *D. microcarpum* carried out in Benin revealed a variability in the characteristics studied as well according to the origin of the trees as according to the soils groups. This confirms the study conducted in southern Mali by Kouyaté [12] on the morphological diversity of *D. microcarpum* where he observed a large inter-population morphological variability in the seize of trees, leaves, seeds and fruits according to the origin of the trees. The large intra-phytodistrict and intra-soils groups variability observed in this study in terms of fruit length, width and mass could be related to genotypic factors. This justification is based on the fact that there is a partial correlation between the quantitative morphological traits and the genetic data of the individuals of the species [11, 42]. To this main factor can be added other secondary factors including micro-variations of soil characteristics [43] and to a certain extent anthropogenic effects and parasitic attacks which can slow the growth of the plant [13, 44]. Assessment of morphological variability is an essential task for the identification of individuals responding to the interests of rural populations, varietal selection and conservation of the species [45]. The results of this study showed a variation in the morphological characteristics of *D. microcarpum* due to the environmental conditions but it would be interesting to study the molecular diversity of the species to assess the variation contributed by the genotype.

4. CONCLUSION

This first evaluation of the phenotypic diversity of *Detarium microcarpum* carried out in Benin highlight the polymorphism of the descriptors of the species, in this case those related to the fruits. Highlighting of the polymorphism of the morphological characters of *D. microcarpum* according to phytodistrict and soil origin constitutes one of the first methodological approaches to select, conserve, create and domesticate this wild species. The present study showed a significant influence of phytodistrict and soil origin on the variability of morphological descriptors studied. In all phytodistrict and soils groups, the morphological variability observed differed according to descriptors. Three different morphotypes (subpopulations) were identified from *D. microcarpum* trees from six phytodistricts, with inter-population variability quite important for the morphological descriptors which indicates a rather remarkable phenotypic variability. Such variability could suggest an important genetic diversity of *D. microcarpum*. It is found that trees of *D. microcarpum* of the morphotypes GI (Bassila and north Borgou) with the best fruit characteristics could be used for varietal selection in Benin.

CONSENT

The respondents were informed that their opinions were to be published in a scientific paper and gave their approval.

ETHICAL APPROVAL

No ethical approval was needed for this study. Prior to data collection, participants gave oral consent to participate in the study.

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