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

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Authors' contributions

This work was carried out in collaboration between all authors. Author AIR proposed the idea of research, carried out the field data collection, analysed and proposed the manuscript. Authors MAA and DAR read the protocol and improved the manuscript drafted. Authors AEA and AC validated the research project and significantly contributed to the manuscript. All authors have read and approved the final manuscript.

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ABSTRACT

Aims: The present study aims to evaluate the morphological diversity of *Detarium microcarpum* populations in Benin for the conservation purpose.

Methodology: Twelve quantitative and two qualitative variables were used in the phenotypic diversity based on the phytodistrict and soils groups of 78 *D. microcarpum* trees sampled in six phytodistrict of Benin. In order to access the phenotypic variability of the trees, the morphological variables were subjected to ANOVA one-way. Hierarchical ascending classification was also performed to group *D. microcarpum* populations based on the degree of similarity.

Results: Results showed that the leaves and fruits of *D. microcarpum* trees were highly polymorphic. The phytodistrict and soil group significantly influence the variability of the

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morphological descriptors used. Three morphotypes were obtained from *D. microcarpum* population used, with an important inter-groups variability for the descriptors.
Conclusion: The phenotypic variability observed suggested a fairly large genetic diversity of *Detarium microcarpum.* Trees belonging to subpopulation I (trees from Bassila and North Borgou phytodistricts) had the best fruit characteristics and 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 the planet. They contribute to the preservation of all components of biological diversity, regulate the water cycle, soil conservation. Forests also sequester the carbon storage, ensure people's food security at local, regional and 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 with great importance to local populations in sub-Saharan Africa, *Detarium microcarpum* Guill. & Perr. (Caesalpiniaceae) deserved a particular attention [3-5]. The species is used by human as food and livestock through the fruits, leaves and seeds. It is used in the traditional pharmacopoeia but also 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) located in Sudanian and Sudano-Guinean climate zones [6]. Local people of Benin use it in food, traditional medicine, fodder, burning, crafts and medico-magic [5,7]. These utilities associated to the frequency of use make this species over-exploited and becomes extremely rare in some areas in Benin [7-9].

Given the major role that phytogenetic resources of *D. microcarpum* play for local communities and the threat to the survival of this species, it is urgent to develop the strategies of conservation to avoid the extinction of the species. Therefore, the conservation of a forest species requires knowledge of the morphological variability in order to differentiate individuals and to target interesting morphotypes [10,11]. Preview studies on morphological variability of *D. microcarpum* were carried out in Mali and showed a high variability associated to a strong interaction between the genotypes and the environment [12]. The status of the variability of the species is still unknown in Benin. The lack or absence of data makes efforts to identify the morphotypes of this forest species inefficient. The first important step in the characterization of the trees is the determination of the most discriminated morphological descriptors [12,13]. In addition, the soil parameters related to morphological variability is also essential for successful conservation of a forest species. The morphological descriptors were largely related to the quality of the soil being used support for its growth [12]. The morphological variation between population provides information on the variability due to the environment of the species' range. This informs about the possibilities of genetic erosion according to the genetic variability. The present study aims mainly to evaluate the morphological diversity of *Detarium microcarpum* in Benin. Specifically, this involved: (i) describe the morphological variability of *D. microcarpum*; (ii) analyze the influence of the phytodistrict and soils groups on the morphological variability of *D. microcarpum*; (iii) characterize the different morphotypes of *Detarium microcarpum* in Benin.

2. MATERIALS 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 based on the presence of natural stands of *Detarium microcarpum* (Fig. 1) [6]. These phytodistricts amount the Sudano-Guinean and Sudanian climatic zones are distinguished from each other by their climatic and biophysical conditions (Table 1) [14].

2.2 Data Collection

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

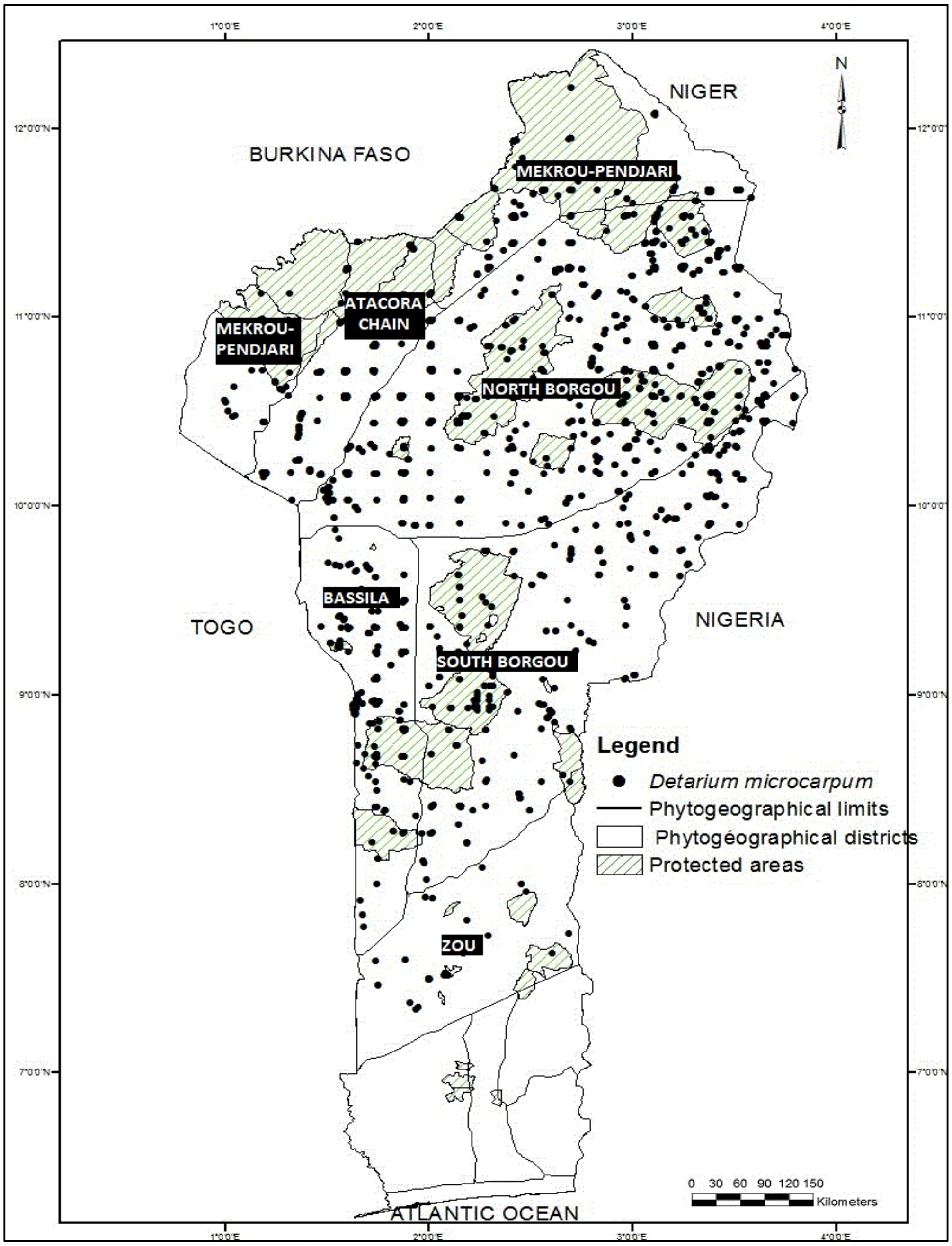

Fig. 1. Geographic distribution of *D. microcarpum* in Benin [6]

Twelve (12) quantitative and two (2) qualitative variables were measured on the trunk, leaves and fruits of species. The dendrometric variables used on each tree are: plant height (Hpl), trunk diameter (Dbh), crown height to the soil (Hpr) measured by a decameter, and color bark of the trunk (Cec) by a color chart (Royal Horticultural Society Color Chart). On each tree, 3 normal and non-parasitic leaves were identified and following variables were measured: leaf length (Lfe), leaf width (lfe) measured by a decameter, leaf peduncle diameter (Dpf), leaflet length (Lfo), leaflet width (lfo) measured by a calipers, number of leaflets (Nfo) and leaf type (Tyf). On each selected tree, 5 fresh and ripe fruits were randomly chosen. The variables estimated were: fruit length (Lfr), fruit width (lfr) measured by a calipers and the weight of fruit (mfr).

Table 1. Biophysical characteristics of the phytodistricts surveyed

Phytodistrict	Climatic zone	Rainfall regime	Rainfall (mm)	Types of soil (major)	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)	Min: 1100 Max: 1200		
Atacora Chain				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

2.3 Data Analysis

The geographical coordinates of *D. microcarpum* trees have been projected on Harmonized World Soil Database v1.21 [15] where the corresponding soils groups were considered in this study.

To describe the morphological variability of *D. microcarpum*, descriptive statistics (mean, standard deviation and variation coefficient) were performed on the morphological quantitative variables of the trees in all populations in order to evaluate inter and intra-population variability of the species. The test-T of Student-Newman-Keuls was performed to compare the means of each variables at the threshold of 5%. Principal components analysis of variance was performed on the morphological descriptors collected in the six sub-populations in order to analyze and share the global variability due to individuals, phytodistrict, and soils groups. Classification of the variability of the trees was performed based on phytodistricts and soils groups using the scale proposed by Ouédraogo et al. [16]. This scale was used successfully by Kouyaté et al. [17] and Sourou Kuiga [11], is as follows: (1) low variation (CV = 0 - 10%); (2) middle variation (CV = 10 - 15%); (3) high variation (CV = 15 - 44%); (4) significant variation (CV> 44%).

ANOVA one-way was performed to know the influence of phytogeographic and soils groups on morphological variability of *D. microcarpum* using Statistica_6 software [18].

Hierarchical Ascending Classification was performed to access the different morphotypes of *D. microcarpum* in Benin using 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 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 *D. microcarpum* tree varied from 3.10 to 12.30 m with an average of 6.42 (± 0.22) m and 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.

Within each phytodistrict, variability of height and trunk diameter of the trees was significantly (CV ≥ 44%) in south Borgou than in other phytodistricts (15% <CV < 44%) which in contrary have the height of crown was high (15% < CV < 44%).

The height, trunk diameter and the height of crown significantly varied inside each soils group (15% < CV < 44%).

Table 2. Morphological description of quantitative variables of *D. microcarpum* in 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 ab	2.39 a	49.53 ab	16.51 c	7.91 b	6.81 c	4.11 b	0.44 a	8.84 a	4.81 a	3.11 b	13.06 a
	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 a	2.01 ab	53.52 ab	17.32 abc	8.24 ab	7.62 abc	4.44 ab	0.46 a	8.61 a	4.70 ab	3.52 a	11.74 b
	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 ab	1.98 ab	51.68 ab	17.64 a	8.28 ab	7.94 a	4.48 ab	0.44 a	8.15 a	4.42 b	3.38 a	10.06 d
	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 a	2.06 ab	52.73 ab	16.95 abc	8.04 ab	7.25 abc	4.24 ab	0.45 a	8.61 a	3.81 c	2.52 c	11.41 b
	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 a	2.30 a	56.70 a	16.74 b	7.98 ab	7.04 b	4.18 ab	0.48 a	8.61 a	3.12 e	2.43 c	10.88 c
	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 ab	1.75 b	39.68 b	17.43 ab	8.36 a	7.73 ab	4.56 a	0.41 a	8.38 a	3.48 d	2.38 c	9.23 e
	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

*SD: Standard deviation; CV: Coefficient of variation; *** significant at 0.1% threshold; ns: Not significant.*

Table 3. Morphological description of quantitative variables of *D. microcarpum* in 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 a	2.05 a	49.45 a	16.95 a	8.03 a	7.25 a	4.23 a	0.47 a	8.54 a	3.78 b	2.47 b	10.65 bc
	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 a	2.06 a	47.12 a	17.07 a	8.13 a	7.37 a	4.33 a	0.45 a	8.46 a	3.94 b	2.94 a	10.54 bc
	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 a	2.08 a	48.62 a	17.37 a	8.25 a	7.67 a	4.45 a	0.44 a	8.55 a	4.00 b	2.98 a	11.41 b
	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 a	2.29 a	54.07 a	16.54 a	7.93 a	6.84 a	4.13 a	0.44 a	8.70 a	4.86 a	3.06 a	13.16 a
	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

*SD: Standard deviation; CV: Coefficient of variation; *** significant at 0.1% threshold; ** significant at 1% threshold; ns: Not significant.*

There is high variability in the tree height, trunk diameter and height of crown between the phytodistricts and soils groups (15% <CV <44%).

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 and the leaf width varied from 6.90 to 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 and the length of the leaflet varied from 5.80 to 10.50 cm with an average of 7.40 (± 0.13) cm. The width of the leaflet is between 3.10 and 5.40 cm with an average of 4, 34 (± 0.07). The number of leaflets per leaf varied from 6 and 10 with an average of 8.54 (± 0.11) leaflets leading to even pinnate and uneven pinnate leaves.

Within each phytodistricts, the leaf length and width variability were low (0% <CV <10%) in Bassila but middle in North Borgou, Atacora chain, Mekrou-Pendjari and high (15% <CV <44 %) in South Borgou and Zou. The leaflet width variation inside phytodistrict was low (0% <CV <10%) in Bassila, moderate (10% <CV <15%) in North Borgou, Atacora chain, Mekrou-Pendjari and Zou while it was high (15% <CV <44%) in South Borgou. The diameter of leaf stalk is moderate (10% <CV <15%) in Bassila but high (15% <CV <44%) in other phytodistricts. The number of leaflets per leaf was low (0% <CV <10%) in South Borgou and Mekrou-Pendjari, moderate (10% <CV <15%) in Bassila, North Borgou and in Atacora chain but high (15% <CV <44%) in Zou.

Within each soils group, the leaf length and width were low (0% <CV <10%) regardless the group of soils. The leaf stalk diameter variability was moderate (10% <CV <15%) in plinthosols but high in other soils groups. The size of leaflet length was low (0% <CV <10%) on plinthosols, moderate (10% <CV <15%) in leptosols but high (15% <CV <44%) in luvisols and lixisols. The variability of the leaflet width inside soil groups was low (0% <CV <10%) in plinthosols and moderate (10% <CV <15%) in other soil groups. The number of leaflets per leaf was also low (0% <CV <10%) in plinthosols and luvisols but moderate (10% <CV <15%) in leptosols and lixisols.

The leaf length and width variability between the phytodistricts and soils groups were low (0% <CV <10%), moderate (10% <CV <15%) for width and number of leaflets but high (15 < CV< 44%) for length of leaflet and the diameter of leaf stalk.

3.1.1.3 Fruit

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

Within each phytodistrict, the fruit length variability was low (0% <CV <10%) in Bassila, South Borgou and Zou while it was moderate (10% <CV <15%) in North Borgou, Atacora chain and Mekrou-Pendjari. The fruit width was medium (10% <CV <15%) in Mekrou-Pendjari and small (0% <CV <10%) in other phytodistricts. The fruit weight variability was low (0% <CV <10%) in all phytodistricts.

Within each soils groups, fruit length variability was low (0% <CV <10%) in plinthosols, moderate (10% <CV <15%) in leptosols and high in lixisols and luvisols. The fruit width was low (0% <CV <10%) in leptosols and plinthosols but was high in lixisols and luvisols. The fruit weight variability was moderate (10% <CV <15%) in lixisols but low (0% <CV <10%) in other soils groups.

Variability between phytodistricts and between soils groups was moderate (10% <CV <15%) for fruits weight but high (15<CV< 44%) for fruit length and width.

3.1.2 Impact of the phytodistrict and soils groups on the morphological variability of *D. microcarpum*

Fruit variables of *D. microcarpum* such as length, width and weight showed highly significant differences between phytodistricts (P <0.001) (Table 2). The morphological descriptors discriminated the population of *D. microcarpum* in the phytodistricts are the length, width and weight of fruits. The longest fruits (5.6 cm) and the largest (3.80 cm) were found in 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 high weight (13.80 g) were recorded in Bassila. The lowest fruits weight were recorded in Zou phytodistrict.

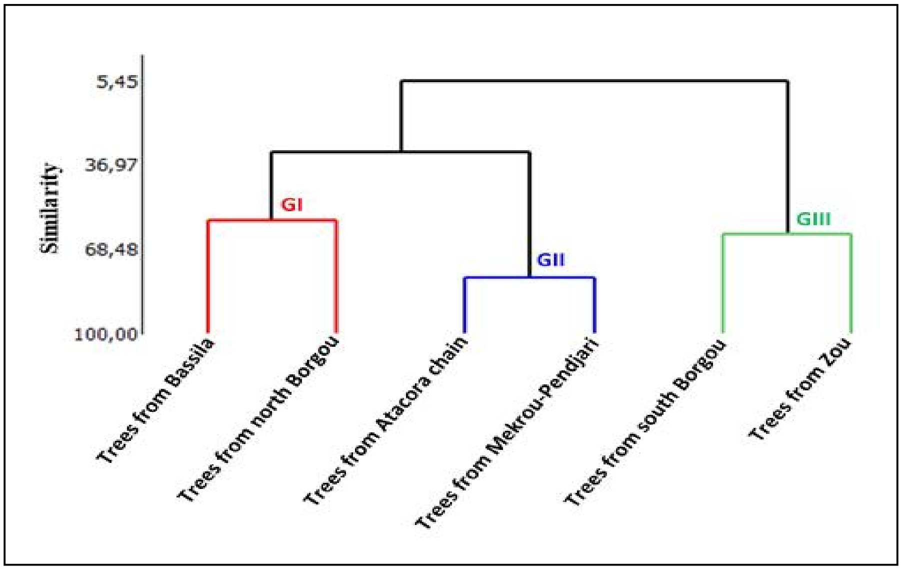

Fig. 2. Morphotypes of *D. microcarpum* from the hierarchical ascending classification

At soils groups, variables such as fruit length and weight showed highly significant differences (P <0.001). The fruit width showed a highly significant difference between the type soils (P <0.01) (Table 3). This showed that the morphological descriptors discriminated the population of *D. microcarpum* are the length, width and weight of fruits. The longest and largest fruits were found in plinthosols and luvisols, while the shortest and the smallest were recorded in lixisols and leptosols. The height of trunk and diameter of tree were recorded in lixisols and luvisols. In contrast, the maximum of height and diameter were noted in plinthosols and leptosols. Concerning the effects of soil physico-chemical characteristics on the morphological characteristics of *D. microcarpum* trees, it was observed that the most vigorous trees are found in soils rich in organic and mineral matter.

3.1.3 Characterization of different morphotypes of *D. microcarpum*

The Hierarchical Ascending Classification performed on the descriptors of *D. microcarpum* revealed three morphotypes or phenotypic classes at the 50% similarity threshold (Fig. 2): The morphotype GI contained *D. microcarpum* trees of Bassila and North Borgou phytodistrict. This morphotype is characterized by individuals with large fruits (high weight, 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 with small fruits, moderate length and width of leaves, high number of leaflets and fruits with short length and width. The morphotype GIII grouped trees from South Borgou and Zou phytodistricts. This morphotype is characterized by trees with small fruits and large leaves.

3.2 Discussion

3.2.1 Variation of phenotypic diversity of *D. microcarpum*

Results of the present study showed that the leaves of *D. microcarpum* contain 6 to 10 leaflets against 6 to 12 leaflets observed in other studies [12,20-24]. The presence of even pinnate and uneven pinnate leaves generally on the same tree corroborates with the results of preview studies [12,25]. However, some authors describe *D. microcarpum* as exclusive even pinnate leaf species [20,26] while they were only uneven pinnate for others [27,28]. This showed that number and characters of leaves were not influenced by the environment but would depend to 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 can be explained by an influence of environment on the leaves size. 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* (Caesalpiniaceae) [32,33], *Adansonia digitata* (Bombacaceae) [34, 35], *Pentadesma butyracea* Sabine (Clusiaceae) [36,37], have proved that the variation in fruit size and seeds number 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 with 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 few protected areas (classified and sacred forests) in Zou contrary to Mekrou-Pendjari, and by fact that Zou constitutes a few suitable habitats for the growth of *D. microcarpum* by opposite to Mekrou-Pendjari [6]. Indeed, protected areas have a positive impact on the conservation of trees by curbing their overexploitation, especially in the juvenile stage [9,38]. In Zou phytodistrict, the species is overexploited for its timber, which is mainly used to produce a charcoal [7]. The observation of vigorous trees of *D. microcarpum* found on soils rich in organic and mineral matter, with high retention capacity and sandy clay or clay-silty texture, is justified by characteristic of tropical ferruginous soils usually sandy-loamy [12]. The difference in soil composition content justifies variations in the height and trunk diameter 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 on *Adansonia digitata* (Bombacaceae) [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* in Benin revealed a variability in the characters 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 of the trees seize, 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 weight 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 species individuals [11,42]. To this main factor can be added other secondary factors including micro-variations of soil characteristics [43] to extent anthropogenic effects and parasitic attacks which can slow the growth of the plant [13,44]. Assessment of morphological variability is an essential task to identify 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 should be interesting to study the molecular diversity of the species to assess the variation contributed by the genotype.

4. CONCLUSION

The evaluation of phenotypic diversity of *Detarium microcarpum* highlighted the polymorphism of the morphological descriptors related to the fruits of the species. The present study showed a significant influence of phytodistrict and soils group on the variability of morphological descriptors studied. In the phytodistricts and soils groups, the morphological variability observed differed according to descriptors. Three different morphotypes (subpopulations) were identified from trees of *D. microcarpum* with high variability between populations of morphological descriptors. This polymorphism of morphological characters of *D. microcarpum* in phytodistricts and soils groups could be used to select, conserve and domesticate this wild species. Also the variability observed could be suggested to 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 will to be published in a scientific paper before 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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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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