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Morpho-physical Variation of Fruits and Impact on Almond Production of Djansang (*Ricinodendron heudelotii* Baill.) In West and Centre of Cameroon

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Abstract: The aim of this study were to describe different forms of fruits and the establishment of correlation between the different morpho-physical parameters in view of evaluating their incidence on production of almonds in *Ricinodendron heudolotii* in three localities (Balamba, Mbalmayo, Santchou) in Cameroon. Tropical forest trees belonging to the Euphorbiaceae family, *R. heudelotii* is used by the local population in traditional medicine and as lipidic source. Fruits randomly harvested in these three localities have revealed six types namely: one new type constitute of four seeded fruit with four lobes and five previous type constitute of single seeded fruit with one lobe; single seeded fruit with one aborted lobe; two seeded fruit with two lobes; two seeded fruit with unequally developed lobes; three seeded fruit with three lobes. This variability is expressed by differences at the level of morphological parameters (mass of fruit and seed) and physical parameters (thickness of shell, ratio of longitudinal diameter and cross diameter section of seeds, capacity to liberate almonds). Analyses of variance, correlation and principal component have showed that, seeds extracted from fruits of Mbalmayo have shell thicker whereby those of Santchou liberate much shell. In the same way, accession of Mbalmayo has a total mass for 1500 fruits estimated 1.5 times superior to those of Balamba and 1.19 time superior to those of Santchou. In fact, study of morpho-physical parameter shows that to choose the fruits having a high capacity to liberate almond, ellipsoid-oblate form of the seeds and thickness of shell are good indicators and for this effect, accession of Santchou is recommended. Accessions of Balamba and Santchou having less rate of seed abortion are more productive.

Key words: *Ricinodendron heudelotii*, fruits, production, morpho-physical variation

INTRODUCTION

The natural forests of west and central Africa are rich in natural resources and have tremendous particularly in trees (FAO, 2007). In Cameroon, *R. heudelotii* belonging to Euphorbiaceae family is found in the secondary forest between 130 and 1030 m above sea level. This tree is considered as plant having multipurpose because it provide food, medicines and various other products, including construction and building materials. In fact, its oiled almond constituted an important lipidic source for the populations (Fondoun *et al*., 1999; Tchiégang *et al*., 2005). The leaves, backs and roots are used in diversified medicinal preparations (Tchiégang *et al*., 2002). Domestication of *R. heudelotii* programme arose from the identification of farmer's priorities and trait preferences (Shiembo *et al*., 1997) using International Centre of Research in Agro Forestry (ICRAF) guidelines for priority setting among candidate species (Jaenicke *et al*., 1995; Franzel *et al*., 1996). The next step is to study the array of variation available in the species with particular reference to those traits identified by farmers as being the characteristics appropriate for genetic selection (Tchoundjeu *et al*., 2002). The Institute of Medical Research and Medicinal Plants Studies (IMPM) has organised with laboratory of Plant Physiology of Higher Teacher Training College (HTTC), a systematic collection of good quality seeds from the natural range of this species in Cameroon. This collection showed large variability of form, length and lobes configuration in different accessions. This situation result to dioecious status of this species with separated male and female trees and which give rise to the intra specific variability of population. Some studies have shown the extent of tree-to-tree variation in fruit and seed traits of others indigenous fruit tree species: *Irvingia gabonensis* (Leakey *et al*., 2000; Atangana *et al*., 2002); *Canarium schweinfurthii* (Kapchie *et al*., 2002) and

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Dacryodes edulis (Leakey *et al*., 2003). Very little is known about the extent of genetic variation in *R. heudelotii* although Fondoun *et al*. (1999) and Ngo Mpeck *et al*. (2003) provided descriptive accounts of the variation in fruit characteristics. Tchiegang *et al*. (1997) also previously describe large variability in lipid contain in different accessions. But at our knowledge impact of these variations at the level of almond production of *R. heudelotii* is undocumented. In fact, seeded fruit with aborted lobes are frequent. In addition, during the extraction process of almond in seeds, high quantities of these are damaged dues to hard shell that surround almonds. The aim of this study was to describe fruit types, established correlations between morpho-physical parameters and evaluate their impact on almond production of *R. heudelotii* in three localities of Cameroon (Balamba, Mbalmayo, Santchou)

MATERIALS AND METHODS

Plant material: This study was conducted during the period from October to November 2005 in the laboratory of Plant Physiology, department of Biological Sciences, High Teacher Training College of the University of Yaounde I in Cameroon. Fruits of *R. heudelotii* used were collected from two villages of centre province (Balamba and Mbalmayo) and one village of west province (Santchou) in Cameroon. Choice was made for these tree localities because previous works carried out by Fondoun *et al*. (1999) have showed that oil tenor of their almond are higher than those of others regions. Their geographical location and the number of sample were given in Table 1.

With the assistance of farmer, trees were selected at random in each population, with 150 m minimum distance between trees in order to reduce the probability of consanguinity. In each of these localities, two plots of 100 fruits were randomly harvested over 15 trees each of *R. heudelotii*. 15×100 = 1500 fruits per locality were used to determine morpho-physical parameters and another 15×100 = 1500 fruits per locality were used to evaluate capacity of seeds to liberate almonds.

Determination of morpho-physical parameters: Fruits were cluster according to the number and the form of their lobe. Their mass was weighted by balance (Sartorius

Table 1: Geographical localisation and number of sample per locality of collected material

Locality	Mean altitude (m)	North latitude	East longitude	No. of sample
Santchou	320	4° 37'	9° 50'	2×15×100
Balamba	400	4° 34' 2''	11° 6' 4	2×15×100
Mbalmayo	600	3° 31'	11° 30'	2×15×100

Basic) as well as those of almond after extraction. Cross and horizontal diameter of shell; thickness of shell were measured by calliper-square graduated to 0.1 mm.

Evaluation of seeds capacity to liberate almonds: The fruits were kept on stalls in numerical order, covered with jute bags for ten days under ambient temperature to allow mesocarp decomposition. At the end of ten days, seeds from each rotten mesocarp fruit were extracted, washed with tap water and dried during two days in sun light. The seeds were later on placed in magenta jar marked, filled with tap water. The magenta jars containing the seeds were then boiled in an autoclave (Sulzer) for 30 min twice at 121°C at an interval of 12 h. Almonds were then extracted in seeds with knife. According to fruit type and locality, seeds after being extracted from the shells were evaluated.

Analysis of the data: Data in relationship with different measured parameters were performed with software package SPAD 4.01 for windows by analyses of variances, correlation and principal components analysis.

RESULTS

Qualitative parameters of fruits: In the domestication of *R. heudelotii*, special attention needs to be placed on fruit shape. After clustered the fruits according to the number and the form of lobes, different types were recorded and described as follows: single seeded fruit with one lobe (F1 U); single seeded fruit with one aborted lobe (F1 D); two seeded fruit with two lobes (F2 S); two seeded fruit with unequally developed lobes (F2 D); three seeded fruit with three lobes (F3 S); Four seeded fruit with four lobes (F4 S). Spheroid fruits are predominant, but flat, dimple and arisen hilium configuration were also recorded. Invariably these hilium configurations appear with single, two, three or four seeded fruit lobes (Fig. 1).

Extracted seeds have also ellipsoid-oblate or ovoid form. More seeds are flattened, more their crack of dehiscence are important and almonds are easily extracted. According to frequency of distribution of different shapes of fruit, two seeded fruit with two lobes are much more represented with frequency of 71.86, 71.06 and 61.53%, respectively for the accession of Santchou, Balamba and Mbalmayo (Table 2). Out of fruit of four lobes sampling only in Santchou at a frequency of 0.73%; all the other fruits are scattered in the different regions.

Quantitative parameters of fruits: Different measure taken on 100 fruits per tree of *R. heudelotii* with a total of 15 individuals of each locality (Santchou, Balamba,

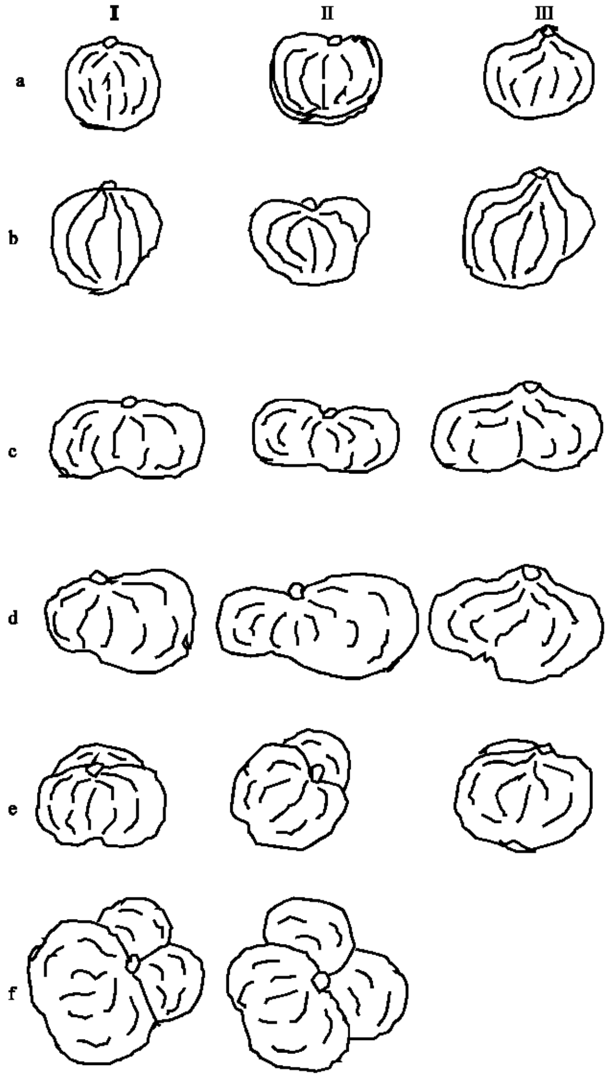

Fig. 1: Different morphological trends of fruits. a: single seeded fruit with one lobe (F1 U); b: single seeded fruit with one aborted lobe (F1 D); c: two seeded fruit with two lobes (F2 S); d: two seeded fruit with unequally developed lobes (F2 D); e: three seeded fruit with three lobes (F3 S); f: four seeded fruit with four lobes (F4 S); I: flat hilium; II: dimple hilium; III: arisen hilium

Table 2: Frequency of distribution of different types of fruits depending to the accessions

Types of fruits	Santchou	Balamba	Mbalmayo
F2 S	71.86 (1078)	71.06 (1066)	61.53 (923)
F2 D	18.20 (273)	23.93 (359)	33.60 (504)
F1 U	3.86 (58)	2.06 (31)	2.46 (37)
F1 D	3 (45)	2.4 (36)	1.3 (20)
F3 S	2.30 (35)	0.53 (8)	1.10 (16)
F4 S	0.73 (11)	0 (0)	0 (0)

* Values in bracket represent absolute frequency of fruit

Mbalmayo) namely: mass of fruit; mass of seed; thickness of shell; ratio of diameters (cross and horizontal) of fruits; capacity of seeds to liberate almonds have showed results in Table 3.

The mass of fruits is between 19.88±2.12 g (F1 U of Balamba) and 51.72±11.42 g (F3 S of Mbalmayo) and those of seeds between 2.30±0.23 g (F1 U of Balamba) and 9.28±0.30 g (F4 S of Santchou). However, seeds of Mbalmayo have a shell thicker (1.88±0.31 to 1.93±0.12 mm) than those of Balamba (1.78±0.24 to 1.82±0.18 mm) and those of Santchou (1.73±0.19 to 1.84±0.34 mm). Concerning the diameter of seeds, high values (range from 0.76 to 0.84) explain spheroid aspect of seeds; mean values (range from 0.68 to 0.76) explain ovoid aspect of seeds while low values (range from 0.60 to 0.68) explain ellipsoid-oblate aspect of seeds according own defined scale. Thus, the seeds of Mbalmayo (0.78 to 0.80) are

Table 3: Variation of different morphological parameters depending to the type of fruit and accession

Accessions	Type of fruit	Mass of fruit (g)	Mass of seed (g)	Thickness of shell (cm)	Ratio diameter of seeds	Capacity to liberate almonds (%)
Santchou						
(A1)	F1 U	21.43±1,77^{a}	2.89±0.20^{bc}	1.73±0.19^{a}	0.69	57.32
	F1 D	22.46±1.8^{a}	3.02±0.1^{c}	1.80±0.15^{a}	0.73	52.32
	F2 S	38.21±7,5^{d}	5.34±0.43^{e}	1.76±0.20^{ab}	0.67	58.21
	F2 D	23.91±3,05^{b}	3.07±0.26^{c}	1.77±0.21^{b}	0.66	59.41
	F3 S	40.25±8,63^{d}	6.90±0.51^{g}	1.81±0.21^{c}	0.71	47.86
	F4 S	45.35±3.1^{e}	9.28±0.3^{h}	1.84±0.34^{d}	0.75	-
Balamba						
(A2)	F1 U	19.88±2;12^{a}	2.30±0.23^{a}	1.78±0.24^{bc}	0.70	52.61
	F1 D	21.51±1.9^{a}	2.90±0.25^{a}	1.89±0.3^{c}	0.72	50.32
	F2 S	30.23±4.14^{c}	4.24±0.32^{d}	1.80±0.16^{c}	0.75	42.94
	F2 D	20.46±3.56^{a}	2.35±0.38^{a}	1.81±0.22^{c}	0.76	40.36
	F3 S	39.21±7.86^{d}	6.10±0.48^{f}	1.82±0.18^{cd}	0.81	31.33
	F4 S	-	-	-	-	-
Mbalmayo						
(A3)	F1 U	30.92±4.23^{c}	2.36±0.32^{ab}	1.90±0.15^{f}	0.80	28.82
	F1 D	23.56±3.2^{b}	3.12±0.31^{c}	1.80±0.10^{c}	0.78	51.32
	F2 S	46.28±10.12^{e}	4.75±0.38^{d}	1.93±0.12^{f}	0.79	38.17
	F2 D	33.61±6.18^{c}	2.45±0.30^{b}	1.92±0.14^{f}	0.78	34.54
	F3 S	51.72±11.42^{f}	6.21±0.39^{fg}	1.88±0.31^{c}	0.79	33.98
	F4 S	-	-	-	-	-

*Samplings having same letter(s) on the same column are not significatively different according to Duncan test at $p<0.05$

Table 4: Estimation of the mass of 1500 fruits and their seeds contain of different forms and per accessions

	Mass of fruits (g)			Mass of seeds (g)		
	Santchou	Balamba	Mbalmayo	Santchou	Balamba	Mbalmayo
F1 U	1242.79±72.26^{a}	616.28±58.34^{b}	1144.04±80.60^{c}	167.62±11.12^{a}	71.30±8.72^{b}	87.32±10.01^{b}
F1 D	1010.70±70.51^{a}	108.72±10.63^{b}	471.20±21.69^{c}	135.90±30.01^{a}	104.40±13.09^{b}	62.40±8.54^{c}
F2 S	41190.3±152.32^{a}	32225.18±125.71^{b}	42716.44±169.89^{a}	5756.52±86.45^{a}	4519.84±65.46^{b}	4384.25±70.12^{b}
F2 D	6527.40±85.96^{a}	6935.94±78.39^{a}	16939.44±116.08^{b}	838.11±19.99^{a}	796.65±17.65^{a}	1234.80±68.74^{b}
F3 S	1408.75±73.04^{a}	314.32±18.18^{b}	827.52±40.07^{c}	241.50±16.52^{a}	48.80±4.82^{b}	99.36±9.94^{c}
F4 S	498.85±25.46^{a}	-	-	102.08±11.16^{a}	-	-
Total	51878.86±479.55^{a}	40200.44±291.25^{b}	62098.64±428.33^{c}	7241.73±175.25^{a}	5540.99±109.74^{b}	5868.13±167.35^{b}

*Samplings having same letter(s) on the same line and per parameter are not significatively different according to Duncan test at $p<0.05$

Table 5: Coefficients of correlation between different morpho-physical parameters of fruits

Parameters	Mass of fruit (MF)	Mase of seed (MS)	Thickness of shell (TS)	Ratio of diameter of seeds (RDS)	Capacity to liberate almonds (CLA)
Mass of fruit (MF)	1				
Mass of seed (MS)	0.801**	1			
Thickness of shell (TS)	0.553	0.115	1		
Ratio of diameter of seeds (RDS)	0.457	0.174	0.801**	1	
Capacity to liberate almonds (CLA)	-0.493	-0.131	-0.816**	0.972**	1

** Correlation is significative at the level 0.01 (bilateral)

spheroid; those of Balamba (0.70 to 0.81) are ovoid or spheroid and those of Santchou (0.66 to 0.75) are ellipsoid-oblate or ovoid. The capacity of seeds to liberate almonds depends of the accession. It varies from 28.82 to 38.17% for Mbalmayo; from 31.33 to 52.61% for Balamba and from 47.86 to 59.41% for Santchou. Mass estimation of 1500 fruits and their seeds contain of different forms and by accession is presented in Table 4. Accession of Mbalmayo has a total mass of fruit estimated at 62098.64±428.33 g which is 1.5 time superior to that of Balamba (40200.44±291.25 g). At the level of seed, mass of Mbalmayo accession (5868.13±167.35 g) is no significatively different ($p<0.05$) to that of Balamba (5540.99±109.74 g). However, mass of Santchou. (7241.73±175.25 g) is significatively different ($p<0.05$) to those of Mbalmayo and Balamba.

These coefficients obtained permit to observe firstly, significant and positive correlation ($p<0.01$) between mass of fruit and mass of seed (Table 5); thickness of shell and ratio of diameter of seeds, capacity to liberate almond and ratio of diameter of seeds and another part, negative and significant correlation between thickness of shell and the capacity of seed to liberate almonds.

Else were, the study of Principal Component (PC) of eigenvectors superior to 1 which are represented in Table 6 have conducted to obtain an estimation of percentage of variability represent by each axe. In general, we consider only the principal components with proper value superior to 1 (Jeffer, 1967). The first and second components, which have been retained, represent 92.34%

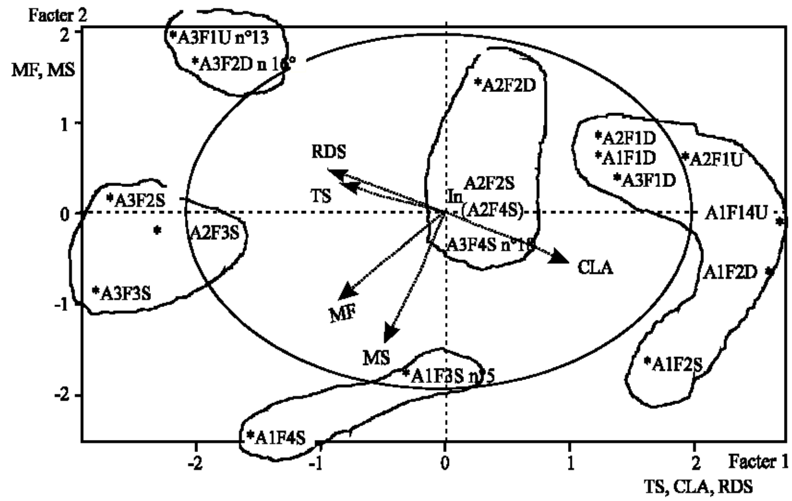

Fig. 2: Distribution of different types of fruits in 3 accessions of *R. heudelotii* defined by axes 1 and 2

Table 6: Eigenvectors and representation of variation by the first two principle components define by five morpho-physical parameters in the five types of fruit of 3 accessions in *R. heudelotii*

Principal component	PC1	PC2
Variables		
Eigenvectors	3.15	1.45
Inertia (%)	63.17	29.18
Total inertia (%)	63.17	92.34
Mass of fruit (MF)	- 0.74	- 0.62
Mass of seed (MS)	- 0.38	- 0.90
Thickness of shell (TS)	- 0.89	0.24
Ratio of diameter of seeds (RDS)	- 0.92	0.30
Capacity to liberate almonds (CLA)	- 0.91	0.34

of total variability. The first axe, which describes 63.17% of the total variation, is defined by two morphological descriptors (MF, MS). The second axe, which describes 29.18% of the total variation, is defined by three physical descriptors (TS, RDS, CLA). Principal Component Analysis (PCA) of different types of fruits of 3 accessions of *R. heudelotii* revealed 5 clusters (Fig. 2):

- Cluster I represented by A2F1D, A2F1U, A1F1U, A1F1D, A1F2D, A1F2S, A3F1D is characterised by more high capacity to liberate almonds
- Cluster II represented by A1F4S, A1F3S, is characterised by high mass of fruit and seed
- Cluster III represented by A2F2D, A3F4S, A2F2S, A2F4S is not influenced by any parameter
- Cluster IV represented by A3F1U, A3F2D and cluster V represented by A3F2S, A2F3S, A3F3S are characterised by small thickness of shell and a small ratio of diameter of seeds.

DISCUSSION

The study of fruits of *R. heudelotii* permit to obtain multiple variations, as well as the level of qualitative than the level of quantitative parameters. It is well known that considerable variation exists within and between populations of tropical trees (Ude *et al*., 2006). The patterns and extent of genetic diversity in forest trees are strongly determined by their mating system and gene flow. Previous works conducted by Fondoun *et al*. (1999) in *R. heudelotii* on different shapes did not mentioned four seeded fruit with four lobes that we have harvested and described in our study at a lower frequency of 0.73%. In Euphorbiaceae family, seed fruit with four lobes are rare and the number of lobes generally varies between 1 and 3. Similar studies were made on many woody plants: *Irvingia* spp. (Lapido *et al*., 1998); *Canarium schweinfurthii* (Kapchie *et al*., 2002); *Dacryodes edulis* (Leakey *et al*., 2003). Seed set, which is the development of viable seeds from the ovules of pollinated flowers, depends on endogenous factors and their interaction with the environment. All these factors are under genetic control but can be manipulated by management factors. Indeed, the percentage of fruit with two seeded with one aborted lobe is higher and up to 33.60% for the accession of Mbalmayo. This should be explaining by the incapacity of embryo to grow after fertilization and then modified responses on the process of growth (Mapongmetsem *et al*., 1998). It is also known that, deformations appeared on fruits could be caused by insect or disease attack (Lapido *et al*., 1998). Fruits from suspect trees in Santchou were therefore examined in situ throughout their developmental stages. Sample fruits were cut open but did not reveal disease or insect attack at any stage The ellipsoid-oblate form of seeds of *R. heudelotii* favours appearance of the crack of dehiscence. It is the less rigid zone of the shell where breaking can be influenced by the thickness and by the temperature of the medium. At the end of this study, it is discovered that a harvest of new type of four seeded fruit with four lobes proving that *R. heudelotii* possessed varying forms. These variations can be related to the factors of medium and reproductive pathway of individuals. Else were, the study of morpho-physical parameter has proven that in choosing fruits having high capacity to liberate almonds, the ellipsoid-oblate form of seeds and thickness of shell are the good indicators and to this effect, accession of Santchou is recommended. Accession of Balamba and Santchou having a weak rate of premature seeds are much more productive. In summary, the choice of accession of *R. heudelotii* in the project of multiplication and diffusion of plant material should take in consideration the phenomenon of seed abortion and morphological variation of fruits in modifying shell input of individual.

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