# Agronomic Characterization of Bambara groundnuts accessions (*Vigna subterranea* (L.)) on Sudano-guinnean zone, Adamawa-Cameroon


## ABSTRACT

**Aims:** Study aims to identify agronomic traits responsible of the variation between 20 accessions in order to retain adapted genotype on pedoclimatic conditions of the Sudano-sahelean area of Cameroon.

**Place and Duration of Study:** This study was carried in Dang on Sudano-guinnean zone of Cameroon in order to identify agronomic traits responsible for variation among 20 accessions of Bambara groundnuts.

**Methodology:** The experimental design in field is a block completely randomized with 3 repetitions. Eleven quantitative characters selected among the describer of Bambara groundnut have been evaluated by the multivariate analysis.

**Results:** The analysis of variance shows a significant difference for ten of the eleven studied characters among eleven characters studied which show an important variability between these characters. Seven characters are correlated on two prime of principles components which explaining 44.32 % of total variability. Dendrogram rising of hierarchical classification permit to differentiate 5 groups of morphological diversity. The fifth group gathers the earliest varieties with a time of 121 days maturity. Highly positive correlation is (r=0.72). Characters analyzed may constitute some base of criterion to differentiate the varieties from others regions and must be used on the program of improvement varieties of Bambara groundnut in Cameroon.

**Conclusion:** In all of 11 characters evaluated in this study, only one of them that not permit to differentiate the accessions. Important variability between these characters was observed. Rising of hierarchical classification showed one of important agronomic diversity and regroup the accessions in 5 groups.



*Keywords: Bambara groundnut, Analysis of principles components, rising of hierarchical classification, correlation.*


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## 1. INTRODUCTION

For their development, several African countries massively investigated in industrial crops to the detriment of food crops of which some of them are abandoned and threatened as

disappearance (Aké, 1988). The majority of annual culture has low yields due to climate change, but there are adapted on their middle (Altieri, 1986).

Bambara groundnut (Voandzeia subterannea (L.)) is the third food leguminous most important on terms of production and consummation in Africa, after peanut (Arachis hypogeae (L.)) and Cowpea (Vigna unguiculata (L.)) (Linnemann, 1992; Howell, 1994). Their seeds are rich in calories, mineral elements, vitamin and proteins (Amarteifio et al., 2006; Sévérin and Yao, 2011; Ndiang *et al.,* 2012). She have therapeutic property that for rural populations (Nacoulma, 1996; Sévérin and Yao, 2011). Bambara groundnut contributes on soil fertilization by their ability to fix nitrogen and ameliorate yield of plant around 350 to 800 kg/ha in region where soil is poor and rainfall is relatively low (Bonny and Djè, 2011; Touré *et al.,* 2013). This stability of production could be due to their adaptation traits on tropical climate and genetic diversity of seeds sowed (Azam-Ali *et al.,* 2001). Some morphotypes resist well on insect attack, diseases and on critical conditions of dryness (Mungate, 1997; Touré *et al.,* 2013). According to their importance, Bambara groundnut is considered like minor culture and not used on varietal selection program (Zerihun, 2009). However these cultures have several potentialities for genetic amelioration according to their diversity founded on many accessions collected around country (Basu et al., 2004; Ntundu et al., 2004; Djè *et al.,* 2005; Bonny et Djè, 2011).

In Sudano-sahelean area, the production of seeds is relatively low due to the decrease of soil ferility (Minader, 2012). However, in a agronomic context, acknowledge of genetical mechanisms could help to know strategies of selection in order to retain high genotype adapted on pedo-climatic conditions of Sudano-sahelean zone. Many accessions of Bambara groundnut collected on different area of Cameroon have different characters (Pasquet et Fotso, 1991; Ndiang *et al.,* 2012; Sobda *et al.,* 2013). Research or new knowledge on variety on high yield of Bambara groundnut is a principal objective of selection. General objective of this research is to identify agronomic traits responsible of the variation between 20 accessions in order to retain adapted genotype on pedoclimatic conditions of the Sudano-sahelean area of Cameroon.

## I- MATERIALS AND METHODS

### I.1. DESCRIPTION OF STUDY

Dominant trait of this area (Sudano-Sudano-sahelean climate type) of Cameroon is a massif of Adamawa with mountainous arch which separate northern and southern part of country. Adamawa plateau is dominated with a plain of Bénoué in the north and in west with Nigeria. This region extends to south-west by the high volcanic mountain with the altitude of 2460 m (Rippstein, 1985).

### I.2. EXPERIMENTAL SITE

The study was conducted in Dang situated at 700 m of Campus University of Ngaoundere at Bini-Dang, village situated at 15 kilometers of the town of Ngaoundere (1113 m of altitude with latitude of 7.28° North and longitude of 13.34° East). Climatic conditions of this site are

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characteristic of Sudano-guinnean zone. Geographic localization of this experimental site is 13°34'238" East and 7°24'671" North with altitude of 1155.8 m.

### I.3 VEGETAL MATERIALS

Biological material is constituted of 20 morphotypes of Bambara groundnuts (Vigna subterranea) obtained from laboratory team of biodiversity of University of Ngaoundere (**Figure 1**).

**Figure 1:** Accessions of Bambara groundnut.

## I.4 EXPERIMENTAL DESIGN

The experimental design for this study is a block completely randomized with 3 replications. Ridge distances are respectively 1m, with 0.5m of length and width. The total surface of ridge is 0.5 m2. A total of 60 ridges are materialized on a surface of 61.95 m² (4.2 m x 14.75 m). Distance among ridge is of 60 cm and 25 cm. Seeds are sowing in the soil at 3 cm of depth with a space of 20 cm between poquets. For each 20 morphotypes, twelve seeds were sowed by ridge. Each morphotype is represented by 36 plants. Sowing process was done 10 July 2015 at Bini-Dang. Data collection is made according to the list of describer of Bambara groundnut (IPGRI/IITA/BAMNET, 2000).

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## I.5. EVALUATION OF AGRONOMIC PARAMÈTERS

Eleven parameters were chosen within the describers of Bambara groundnut to characterize and evaluate different morphotypes (**Table 1**). All the measure is done on 5 plants of each morphotypes.

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**Table 1:** Parameters used to characterize the morphotypes.

| N° | **Parameters** |
|---|---|
| 1 | Germination rate (%) |
| 2 | Date of first flowering (DAS) |
| 3 | Date of 50 % flowering (DAS) |
| 4 | Height of plants (cm) |
| 5 | Number of leaves per plant |
| 6 | Number of stems per plant |
| 7 | Number of pods per plant |
| 8 | Number of seeds per pod |
| 9 | Weight of 100 seeds (g) |
| 10 | Yields of seeds per plant (g) |
| 11 | Cycle period (DAS) |

## I.6. STATISTICAL ANALYSIS

For the different characters studied, we had proceeded with a comparison of means within morphotypes by ANOVA test with software STATGRAPHICS PLUS Version 5.0. For a highest significant difference between morphotypes for one character given, ANOVA is completed by the test of small significant difference (ppds). Which permit to identify the different morphotypes that significant differed to others (Dagnelie, 1998). Different performances of morphotypes for each quantitative character were evaluated on determining the minimum, maximum, average, standard-error and variation index. Evaluation of morphological diversity structuration was done by a Principal Component Analysis (ACP), a rising of hierarchical Classification (CAH) in order to appreciate the degree of similarity between analyzed unities and understand the phylogenetic relationship existing between them with the software XLSTAT Version 2007.8.04. Correlation coefficient of Bravais Pearson was used to test and appreciate the degree of association between the different characters studied.

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## II. RESULTS AND DISCUSSION

### II.1 VARIABILITY ANALYSIS OF AGRONOMIC PARAMETERS

Exam's of the table 2a and 2b present the variability of different morphotypes for the eleven agronomic parameters. ANOVA reveal a significant difference ($p<0.05$) between variety used : germination rate, date of first flowering, date of 50 % of flowering, height of plants, number of stems per plant, number of pods per plant, number of seeds per pods, weight of 100 seeds, yields of seeds per plant and maturation time. Contrary, not significant difference for the number of leaves per plant.

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**Table 2a:** Genetic variability of 20 morphotypes for the 11 agronomic parameters.

| Variety | TG (%) | DFl (JAS) | DF50%l (JAS) | HaP (cm) | NFe | NTg |
|---|---|---|---|---|---|---|
| CM/EN/AE/O2 | 63,88±33,67$^{defgh}$ | 50,33±0,57$^{cdefg}$ | 65,33±2,51$^{bcde}$ | 22±1,8$^{ab}$ | 95±8,52 | 6,33±0,76$^{bcde}$ |
| CM/EN/DW/03 | 27,77±4,8$^{ab}$ | 46±2,00$^{abcd}$ | 62,33±1,52$^{bcd}$ | 22,68±3,48$^{ab}$ | 141,33±67,66 | 7,33±1,44$^{ef}$ |
| CM/AD/MC/04 | 19,44±4,81$^{a}$ | 52±6,08$^{fg}$ | 62,33±2,08$^{bcd}$ | 22,56±1,25$^{ab}$ | 138,5±57,82 | 6,16±0,76$^{abcde}$ |
| CM/AD/MC/05 | 33,33±14,43$^{abc}$ | 45,66±3,78$^{abc}$ | 62,33±1,52$^{bcd}$ | 24,25±4,02$^{ab}$ | 197,5±21,54 | 6,33±0,76$^{bcde}$ |
| CM/EN/DW/07 | 69,44±39,38$^{efgh}$ | 45,33±2,51$^{ab}$ | 62,33±1,15$^{bcd}$ | 23,1±0,4$^{ab}$ | 115,5±10,81 | 4,83±0,28$^{ab}$ |
| CM/EN/DW/09 | 47,22±4,8$^{abcdef}$ | 53±1,00$^{g}$ | 65,33±2,08$^{bcde}$ | 21,78±2,33$^{ab}$ | 118±43,53 | 4,66±0,76$^{a}$ |
| CM/EN/AE/10 | 75±8,33$^{fgh}$ | 43±0,00$^{a}$ | 61±0,00$^{bc}$ | 24,58±3,64$^{abc}$ | 151,5±13,74 | 6±1,32$^{abcde}$ |
| CM/EN/AE/13 | 66,66±22,04$^{efgh}$ | 48,33±3,51$^{bcdefg}$ | 64,66±3,51$^{bcde}$ | 21,58±2,96$^{ab}$ | 162,5±23,82 | 5,6±60,28$^{abcd}$ |
| CM/EN/DW/14 | 75±8,33$^{fgh}$ | 49,33±2,30$^{bcdefg}$ | 66,66±5,77$^{de}$ | 23,33±2,02$^{ab}$ | 158,5±83,37 | 6±0,86$^{abcde}$ |
| CM/AD/AE/15 | 77,77±12,73$^{gh}$ | 50,66±1,15$^{defg}$ | 54,33±8,08$^{a}$ | 30,13±2,87$^{d}$ | 191±45,92 | 6,66±1,75$^{cdef}$ |
| CM/AD/MC/16 | 66,66±36,32$^{efgh}$ | 52,66±1,52$^{fg}$ | 62,33±1,52$^{bcd}$ | 32,91±6,87$^{d}$ | 138,5±36,13 | 5,16±1,04$^{abc}$ |
| CM/AD/MC/17 | 72,22±9,61$^{fgh}$ | 51,66±1,52$^{efg}$ | 62,66±1,52$^{bcd}$ | 33,66±1,75$^{d}$ | 143,5±42,64 | 5,66±1,15$^{abcd}$ |
| CM/AD/MC/18 | 75±8,33$^{fgh}$ | 48±0,00$^{bcdef}$ | 60±0,00$^{b}$ | 29,16±1,66$^{cd}$ | 171,5±64,73 | 6,66±0,76$^{cdef}$ |
| CM/EN/DW/19 | 41,66±16,66$^{abcde}$ | 51,66±3,51$^{efg}$ | 68,66±1,52$^{e}$ | 20±2,94$^{a}$ | 150±68,73 | 5,33±0,76$^{abc}$ |
| CM/EN/DW/20 | 55,55±4,8$^{bcdefg}$ | 47,33±4,04$^{abcde}$ | 64,33±5,13$^{bcde}$ | 23,08±2,09$^{ab}$ | 186,5±36,81 | 7±0,86$^{def}$ |
| CM/EN/DW/21 | 80,55±12,72$^{gh}$ | 50,33±2,08$^{cdefg}$ | 66,33±2,51$^{cde}$ | 22,01±1,76$^{ab}$ | 161±50,58 | 6±1,00$^{abcde}$ |
| CM/EN/DW/23 | 58,33±8,33$^{cdefg}$ | 50,66±5,13$^{defg}$ | 62,66±4,61$^{bcd}$ | 21,58±2,4$^{ab}$ | 132±37,58 | 8±0,86$^{f}$ |
| CM/EN/DW/27 | 36,11±4,81$^{abcd}$ | 53±2,264$^{g}$ | 62,66±2,51$^{bcd}$ | 22,93±2,72$^{ab}$ | 202±42,46 | 7±0,86$^{def}$ |
| CM/EN/DW/28 | 61,11±9,62$^{cdefgh}$ | 45,66±3,05$^{abc}$ | 62,66±3,51$^{bcd}$ | 25,05±2,22$^{bc}$ | 140±29,63 | 6,66±1,6$^{cdef}$ |
| CM/EN/DW/29 | 88,89±4,81$^{h}$ | 48,66±3,51$^{bcdefg}$ | 62,66±2,51$^{bcd}$ | 23,48±1,34$^{ab}$ | 143±19,34 | 5,66±0,76$^{abcd}$ |
| **Moyenne** | **59,58±23,66** | **49,16±3,76** | **63,08±3,79** | **24,49±4,45** | **151,86±41,18** | **6,15±1,16** |
| **PPDS (5%)** | **30,55** | **5** | **6** | **5,03** | | **1,66** |

**NB:** On the same lines, means following by the same letter are not significantly different at the level of probability considered (P ≤ 0.05). **TG**=germination rate; **DFl**=date of first flowering; **DF50%l**=date of 50% flowering; **HaP**=height of plant; **NFe**=number of leaves; **NTg**= number of stems.

**Table 2b**: Genetic variability of 20 accessions for the 11 agronomic parameters.

| Accessions | NGs | NGr | P100gr (g) | RGr (g) | TEm (JAS) |
|---|---|---|---|---|---|
| CM/EN/AE/O2 | 15,83±5,00$^{abc}$ | 1,19±0,17$^{a}$ | 78,46±2,07$^{gh}$ | 15,7±4,85$^{abc}$ | 123,33±2,88$^{cde}$ |
| CM/EN/DW/03 | 25,16±4,85$^{ef}$ | 1,22±0,38$^{a}$ | 68,53±5,18$^{def}$ | 22,33±3,01$^{bcde}$ | 125±0,00$^{def}$ |
| CM/AD/MC/04 | 14,66±8,60$^{a}$ | 1,11±0,19$^{a}$ | 105,7±0,00$^{j}$ | 18,06±9,12$^{abcd}$ | 125±0,00$^{def}$ |
| CM/AD/MC/05 | 21±4$^{abcde}$ | 1,08±0,14$^{a}$ | 76,23±7,67$^{fgh}$ | 20,46±4,81$^{bcde}$ | 123,33±2,88$^{cde}$ |
| CM/EN/DW/07 | 14,33±1,52$^{a}$ | 1,80±0,17$^{bcde}$ | 93,46±7,82$^{i}$ | 20,13±3,03$^{bcde}$ | 126,66±2,88$^{ef}$ |
| CM/EN/DW/09 | 19±7,21$^{abcde}$ | 1,44±0,38$^{abc}$ | 55±12,12$^{ab}$ | 14,46±3,99$^{ab}$ | 125±0,00$^{def}$ |
| CM/EN/AE/10 | 17±6,08$^{abcd}$ | 1,00±0,00$^{a}$ | 60,6±6,00$^{abcd}$ | 10,76±4,29$^{a}$ | 118,33±5,77$^{ab}$ |
| CM/EN/AE/13 | 23,66±1,15$^{cdef}$ | 1,5±0,17$^{abc}$ | 55,36±3,70$^{ab}$ | 19,6±1,25$^{bcde}$ | 128,33±2,88$^{f}$ |
| CM/EN/DW/14 | 19±3,12$^{abcde}$ | 1,5±0,17$^{abc}$ | 51,46±4,04$^{a}$ | 18,1±2,26$^{abcd}$ | 123,33±2,88$^{cde}$ |
| CM/AD/AE/15 | 15,5±4,92$^{ab}$ | 1,89±0,19$^{cde}$ | 54,13±3,53$^{ab}$ | 18,93±7,44$^{bcde}$ | 121,66±2,88$^{bcd}$ |
| CM/AD/MC/16 | 14,83±2,02$^{a}$ | 2,33±0,33$^{e}$ | 60±4,47$^{abcd}$ | 21,16±1,94$^{bcde}$ | 125±0,00$^{def}$ |
| CM/AD/MC/17 | 16,66±5,75$^{abcd}$ | 2,22±0,69$^{de}$ | 52,76±5,10$^{a}$ | 16,13±9,13$^{abc}$ | 123,33±2,88$^{cde}$ |
| CM/AD/MC/18 | 16,33±2,92$^{abcd}$ | 1,77±0,38$^{bcd}$ | 62,66±2,05$^{bcde}$ | 16,4±6,2$^{abc}$ | 120±0,00$^{bc}$ |
| CM/EN/DW/19 | 24,16±6,00$^{def}$ | 1,77±0,38$^{bcd}$ | 54,76±2,21$^{ab}$ | 22,76±5,44$^{cde}$ | 126,66±2,88$^{ef}$ |
| CM/EN/DW/20 | 15,66±1,52$^{ab}$ | 1,5±0,17$^{abc}$ | 67,3±7,06$^{cdef}$ | 15,4±0,95$^{abc}$ | 120±5,00$^{bc}$ |
| CM/EN/DW/21 | 13,83±2,92$^{a}$ | 1,30±0,33$^{ab}$ | 66,5±9,10$^{cde}$ | 14,53±3,8$^{ab}$ | 120±5,00$^{bc}$ |
| CM/EN/DW/23 | 14±4,27$^{a}$ | 1,41±0,52$^{abc}$ | 83,6±2,00$^{h}$ | 16,43±4,62$^{abc}$ | 125±0,00$^{def}$ |
| CM/EN/DW/27 | 30,83±5,00$^{f}$ | 1,5±0,17$^{abc}$ | 61,06±2,55$^{abcd}$ | 26,76±3,06$^{e}$ | 125±0,00$^{def}$ |
| CM/EN/DW/28 | 23,33±5,00$^{bcdef}$ | 1,4±0,41$^{abc}$ | 58,73±9,20$^{abc}$ | 23,26±1,95$^{cde}$ | 115±0,00$^{a}$ |
| CM/EN/DW/29 | 19,83±5,34$^{abcde}$ | 1,41±0,22$^{abc}$ | 70,86±4,75$^{efg}$ | 25,36±4,21$^{de}$ | 120±5,00$^{bc}$ |
| **Moyenne** | **18,73±6,01** | **1,52±0,43** | **66.86±14,98** | **18,84±5,61** | **123±4,03** |
| **PPDS (5%)** | **8** | **0,55** | **9,8** | **8,23** | **5** |

**NB:** On the same lines, means following by the same letter are not significantly different at the level of probability considered ($P \leq 0.05$). **NGs**=Number of pods per plant; **NGr**=Number of seeds per plant; **P100gr**=Weight of 100 seeds; **RGr**=Yields of seeds per plant; **TEm**=Maturation time.

## II.1 VARIABILITY OF QUANTITATIVE PARAMETERS OF AGRONOMIC DIVERSITY

Results of **Table 3** indicates important standard between the minimum and maximum. Variation index are between 2.66 % (time of maturation) from 32.38 % (germination rate). High values (CV>20 %) was observed for 5 of 11 characters analyzed. All of results traduce the existence of important diversity within the species. This important phenotypic variability observed could result from the expression of high genotypic heterogeneity but also of the influence of some environmental factors. Theses different accessions have a germination rate that varying from 19.44 to 88.89 %

These results corroborate to works of results of Touré et al. (2013) in Côte d'Ivoire, were reported that germination rate on Bambara groundnut varying from 26.8 to 91.25 %. Contrary, theses results did not corroborate to works of Djé et al. (2005) were founded that germination rate varying from 64 to 88 % on fourth morphotypes. Variability response expressed within ours conditions may traduce heterogeneity of germinative quality of seeds that arising principally from state purity of seeds and their physiology.

Contrary to this observation, Massawe et al. (2002) showed a favor effect of height of seeds on appearance of plants. Theses different accessions of Bambara groundnut have a flowering at 50 % that varying from 54 to 89 days. Theses results are not similar to works obtained by Brink et al. (2006) and Amadou et al. (2015), reported respectively a period of 32 to 42 days and 33 to 40 days. Theses different results could be explain by the number of variety studied in this test and geographical provenance are unknown. Dimakatso (2006) reported that flowering on Bambara groundnut is undetermined. The date of flowering could be recorded like good trait agronomic in the program of amelioration of Bambara groundnut in Cameroon. Accessions of Bambara groundnut tested have a height around 20 and 33.66 cm with 5 to 8 stems.

Theses observations corroborate to the works obtained by Ndiang et al. (2012) in Cameroon, showed that the height of plants varies from 20 to 38 cm with 5 to 8 stems. Contrary, these values are different of those obtained by Sobda et al. (2013) in Cameroon that reported the number of stems per plant varying between 16 and 24. Number of pods per plants in this study varying respectively between 14 and 31. Theses results is different to works found by Ouédraogo et al. (2008) in Burkina Faso on 310 accessions and prove that the number of pods on Bambara groundnut varying from 4 to 50. The differences observed within ours conditions could explain by the difference between morphotypes, state of fertility of plots and local climatic conditions. Weight of 100 seeds varying from 51.46 to 105.7g. Theses results corroborate to works obtained by Bonny et Djè (2011) in Côte d'ivoire, reported that weight of 100 seeds on Bambara groundnut varying between 35.83 and 111.3g. Results are in contradiction of works of Ndiang et al. (2012) in Cameroun and Touré et al. (2012) in Côte d'ivoire that founded respectively 52 to 82g and 40.71 to 76.54g.

Theses differences obtained could be explained by the cultivation of accessions on a humid border on different climatic and ecologic conditions of the production area (on a high humidity of soil due to rain).Yield of seeds per plant in this study fluctuate from 10.76 to 26.76g. These results corroborate of works obtained by Shegro et al. (2013) in South Africa, reported that yield of seeds per plant on Bambara groundnut varying between 10.20 and 57g. Amplitude time for maturation varies from 115 to 128 days. Results correspond to

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works founded by Goli et al. (1997) in Burkina Faso that reported the duration of cycle of Bambara groundnut varying between 100 and 160 DAS. However, results differ of those obtained by par Ndiang et al. (2014) in Cameroon. These authors reported that the duration of cycle on Bambara groundnut is 90 days. Infact, numerous works showed that the length of day (Harris & Azam-ali, 1993; Linnemann *et al.,* 1995; Brink, 1999), temperature (Linnemann & Craufurd, 1994; Brink, 1998) and humidity (Collinson *et al.,* 1996) cause variable effects on vegetative and physiologic development of Bambara groundnut.

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**Table 3:** Performances of 11 quantitative characters measured for 20 accessions.

| Variables | Observations | Minima | Maxima | Means | Standard error | CV (%) |
|---|---|---|---|---|---|---|
| **TG (%)** | 20 | 19.44 | 88.89 | 59.58 | 19.30 | 32.38 |
| **DF1 (JAS)** | 20 | 43.00 | 53.00 | 49.16 | 2.92 | 5.94 |
| **DF50%1 (JAS)** | 20 | 54.33 | 68.66 | 63.08 | 2.93 | 4.64 |
| **Hap (cm)** | 20 | 20.00 | 33.66 | 24.49 | 3.85 | 15.72 |
| **Nfe** | 20 | 95.00 | 202.00 | 151.87 | 27.92 | 18.34 |
| **NTg** | 20 | 4.66 | 8.00 | 6.15 | 0.84 | 13.66 |
| **NGs** | 20 | 13.83 | 30.83 | 18.73 | 4.63 | 24.72 |
| **NGr** | 20 | 1.00 | 2.33 | 1.52 | 0.35 | 23.03 |
| **P100gr (g)** | 20 | 51.46 | 105.70 | 66.86 | 14.43 | 21.58 |
| **RGr (g)** | 20 | 10.76 | 26.76 | 18.84 | 4.02 | 21.33 |
| **TEm (JAS)** | 20 | 115.00 | 128.33 | 122.99 | 3.27 | 2.66 |

**TG**=germination rate; **DF1**=date of first flowering; **DF50%1**=date of 50% of flowering; **HaP**=height of plants; **Nfe**=number of leaves per plant; **NTg**=number of stems per plant; **NGs**=number of pods per plant; **NGr**=number of seeds per pods; **P100gr**=weight of 100 seeds; **RGr**= yield of seeds per plant; **TEm**=maturation time.

## II.2. STRUCTURATION OF AGRO-MORPHOLOGIC DIVERSITY BY PRINCIPAL COMPONENT ANALYSIS (ACP)

**Table 4** show proper values and contribution of characters on axis of analysis of principal component (ACP). ACP indicate that the fourth primary component explain respectively 23.53 %; 19.79%; 19.13 % and 12.15 % of the variability, with around 75.6 % of the total variability. The two primary components which recorded 44.31% of the variance are retained for analyzing the agronomic variability of accessions. **Axis 1** that explains 24.53 % of variability is highest correlated with height of plants, germination rate and yield of seeds per plant. **Axis 2** with 19.79 % of variance defines the phenology and yield parameters. The date of first flowering, the date of 50 % flowering, maturation time, number of pods per plant, number of seeds per pods and yield of seeds per plant are positively correlated in this axis. These characters that are positively correlated on two axes are factors most discriminant suggesting their consideration in the selection for the important agronomic traits.

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**Table 4:** Proper Values and contribution of characters on axis of component of principal analysis.

| | Axe 1 | Axe 2 | Axe 3 | Axe 4 |
|---|---|---|---|---|
| Valeur propre | 2,698 | 2,176 | 2,104 | 1,337 |
| Variabilité (%) | 24,528 | 19,786 | 19,129 | 12,150 |
| % cumulé | 24,528 | 44,314 | 63,443 | 75,593 |
| **caractères définissant les axes et leurs valeurs propres** | | | | |
| TG | 0,740 | -0,169 | -0,114 | -0,405 |
| DFl | 0,029 | 0,630 | -0,326 | 0,283 |
| DF50%l | -0,505 | 0,203 | -0,477 | -0,541 |
| Hap | 0,854 | 0,212 | 0,151 | 0,279 |
| Nfe | 0,070 | 0,154 | 0,778 | 0,022 |
| NTg | -0,194 | -0,345 | 0,622 | 0,314 |
| NGs | -0,520 | 0,516 | 0,542 | -0,295 |
| NGr | 0,667 | 0,632 | -0,133 | 0,154 |
| P100gr | -0,408 | -0,458 | -0,300 | 0,621 |
| RGr | -0,306 | 0,594 | 0,406 | 0,108 |
| Tem | -0,385 | 0,542 | -0,421 | 0,339 |

TG=taux de germination ; DFl=date de 1ère floraison ; DF50%l=date de 50% de floraison ; HaP=hauteur des plantes ; Nfe=nombre des feuilles par plante ; NTg=nombre des tiges par plante ; NGs=nombre de gousses par plante ; NGr=nombre des graines par gousse ; P100gr=poids de 100 graines ; RGr=rendement en graine par plante ; TEm=temps de maturation.

## II.3. ANALYSE DE LA DIVERSITÉ DES ACCESSIONS PAR LA CLASSIFICATION ASCENDANTE HIÉRARCHIQUE (CAH)

Dendrogram rising to hierarchical classification (**Figure 2**) reveal a repartition of 20 accessions in 5 groups. The **group 1** is constituted of 3 accessions (CM/EN/AE/02, CM/EN/DW/07, CM/EN/DW/23). The **group 2** that regroup 3 accessions (CM/EN/DW/03, CM/EN/DW/09, CM/EN/DW/19), characterized by a cycle of maturation of 126 days. Variety (CM/AD/MC/04) constitute the **group 3** with, with a weight of 100 seeds most high (105.7g). This variety could be selected for a food security. The **group 4** includes 3 accessions (CM/AD//04, CM/EN/DW/20, CM/EN/DW/27). This group is characterized by a yield of seeds per plant most high (20.7g). The **group 5** is composed of 10 accessions (CM/EN/AE/10, CM/EN/AE/13, CM/EN/DW/14, CM/AD/AE/15, CM/AD/MC/16, CM/AD/MC/17, CM/AD/MC/18, CM/EN/DW/21, CM/EN/DW/28, CM/EN/DW/29. It is characterized by a germination rate most high (73.88 %), a flowering between 48 and 62 days, with a height of 26.56 cm, these group is constituted of morphotype with earlier cycle. Precocity of cycle of these accessions made this culture interesting for rural farmers during weld period, because they achieve their maturity before others variety and constitute one important source of income for producers and reseller. Morphological and phenological difference observed between different groups of phenotypic diversity suggested that accessions are maintained

**Comment [O63]:** revealed

**Comment [O64]:** constituted

under evolutive processes which are different to their agro-ecosystem respectively. Agro-ecosystems are susceptible to exert variable selective pressure on genotypes (Doku & Karikari, 1971; Sadiki & Jarvis, 2005).

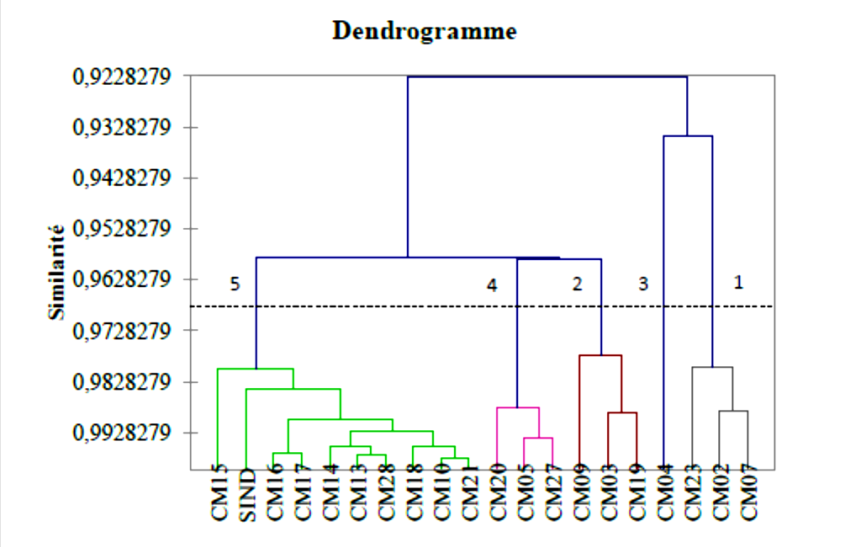


**Figure 2:** Dendrogram rising to hierarchical classification of accessions of Bambara groundnut.

Average performance of characters of different groups formed rising to hierarchical classification are represented on **Table 5.**

**Table 5:** Means performances of characters of different groups obtained by CAH.

| Groupes | TG | DFl | DF50%l | Hap | Nfe | NTg | NGs | NGr | P100gr | RGr | TEm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 63.87 | 48.77 | 63.44 | 22.22 | 114.16 | 6.38 | 14.72 | 1.46 | 85.17 | 17.42 | 124.99 |
| **2** | 38.88 | 50.22 | 65.44 | 21.48 | 136.44 | 5.77 | 22.77 | 1.47 | 59.43 | 19.85 | 125.5 |
| **3** | 19.44 | 52.00 | 62.33 | 22.56 | 138.50 | 6.16 | 14.66 | 1.11 | 105.70 | 18.06 | 125.00 |
| **4** | 41.66 | 48.66 | 63.10 | 23.42 | 195.33 | 6.77 | 22.4 | 1.36 | 68.19 | 20.87 | 122.77 |
| **5** | 73.88 | 48.82 | 62.32 | 26.58 | 156.10 | 6.01 | 17.99 | 1.63 | 59.30 | 18.42 | 121.49 |

**TG**=germination rate; **DF1**=date of first flowering; **DF50%1**=date of 50% of flowering; **HaP**=height of plants; **Nfe**=number of leaves per plant; **NTg**=number of stems per plant; **NGs**=number of pods per plant; **NGr**=number of seeds per pods; **P100gr**=weight of 100 seeds; **RGr**= yield of seeds per plant; **TEm**=maturation time.

## II.4 CORRELATIONS BETWEEN PARAMETERS STUDIED

**Table 6** shows the correlation concerning of 11 characters that represent the variability. High positive correlation r=0.72 is observed between the height of plant and number of seeds per plant. A correlation r=0.67 bind the number of pods per plant and the yields of seeds per plant. The high negative correlation (r=-0.58) is considerate between the height of plants and the date of 50 % flowering. The positive correlation observed between characters could facilitate the genetic amelioration of all others characters correlated positively. Contrary, negative correlation observed between the characters studied could limited the selection, possibility to obtain cultivar with earlier cycle and a high yield producing heavy seeds that producers and consumers needed. Correlations constitute an important tool for amelioration of characters on integrating on a program of selection.

**Comment [O65]:** among the 11 characters that presented

**Comment [O66]:** was

**Comment [O67]:** was

**Comment [O68]:** contrarily

**Table 6:** Correlation Matrix of Pearson of 11 agronomic parameters.

| Variables | TG | DFl | DF50%l | Hap | Nfe | NTg | NGs | NGr | P100g | RGr | TEm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **TG** | **1** | | | | | | | | | | |
| **DFl** | -0,149 | **1** | | | | | | | | | |
| **DF50%l** | -0,162 | 0,189 | **1** | | | | | | | | |
| **Hap** | 0,361 | 0,126 | **-0,576*** | **1** | | | | | | | |
| **Nfe** | -0,085 | -0,069 | -0,311 | 0,157 | **1** | | | | | | |
| **NTg** | -0,221 | -0,155 | -0,303 | -0,095 | 0,355 | **1** | | | | | |
| **NGs** | -0,426 | -0,013 | 0,197 | -0,293 | 0,338 | 0,130 | **1** | | | | |
| **NGr** | 0,344 | 0,406 | -0,173 | **0,712**** | 0,011 | -0,328 | -0,151 | **1** | | | |
| **P100g** | -0,361 | -0,115 | -0,067 | -0,318 | -0,321 | 0,142 | -0,370 | -0,391 | **1** | | |
| **RGr** | -0,261 | 0,126 | -0,013 | -0,058 | 0,211 | 0,051 | **0,674*** | 0,187 | -0,017 | **1** | |
| **Tem** | -0,406 | 0,425 | 0,263 | -0,218 | -0,166 | -0,266 | 0,156 | 0,191 | 0,185 | 0,188 | **1** |

**NB:***significatif (5%); **très significatif (1%); **TG**=germination rate; **DF1**=date of first flowering; **DF50%1**=date of 50% of flowering; **HaP**=height of plants; **Nfe**=number of leaves per plant; **NTg**=number of stems per plant; **NGs**=number of pods per plant; **NGr**=number of seeds per pods; **P100gr**=weight of 100 seeds; **RGr**= yield of seeds per plant; **TEm**=maturation time.

## CONCLUSION

Objective of these study were to identify agronomic traits responsible of the variation between 20 accessions of Bambara groundnut. In all of 11 characters evaluated in this study, only one of them that not permit to differentiate the accessions. Important variability between these characters was observed. Rising of hierarchical classification showed one of important agronomic diversity and regroup the accessions in 5 groups. Agro-morphological diversity observed in this study permit to explain that these accessions constitute a good reservoir for genetical characteristic of Bambara groundnut. Correlation observed between morphologic and agronomic parameters made the characters concerned as important index to use in the program of amelioration. The characters analyzed could constitute of base criteria to differentiate variety to others regions and could be used in the program of varietal amelioration of Bambara groundnut in Cameroon.

**Comment [O69]:** delete

**Comment [O70]:** did not

**Comment [O71]:** an

**Comment [O72]:** revealed

**Comment [O73]:** among

**Comment [O74]:** basic

**Comment [O75]:** in

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